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C O N T E N T S

THE SOLUTION OF THE INVERSE PROBLEM OF MOTION CONTROL OF A RIGID BODY, POP-UP IN A STRATIFIED INCOMPRESSIBLE VISCOUS FLUID UNDER THE INFLUENCE OF THE ARCHIMEDES FORCE

РЕШЕНИЕ ОБРАТНОЙ ЗАДАЧИ УПРАВЛЕНИЯ ДВИЖЕНИЕМ ТВЕРДОГО ТЕЛА, ВСПЛЫВАЮЩЕГО В СТРАТИФИЦИРОВАННОЙ НЕСЖИМАЕМОЙ ВЯЗКОЙ ЖИДКОСТИ ПОД ДЕЙСТВИЕМ СИЛЫ АРХИМЕДА

Prof., Dr. Tech. Sci. Firsov A.N.[1], MSc Kuznetsova L.V.[2], P.G. Sorokina N.V.[3]
Peter the Great St.Petersburg Polytechnic University – St.Petersburg, Russia
E-mail: [1]anfirs@yandex.ru, [2]lida.kuznetsova@gmail.com, [3]snv_special@inbox.ru

Abstract: *The report presents an analytical solution to the problem of ensuring access to the given point by a solid body moving in a stratified incompressible viscous fluid under the action of Archimedes' buoyancy. It is assumed that the body does not have its own propulsion system, but is equipped with controlled rudders. The basis of solving the problem is based on the hydrodynamic equations.*

***KEYWORDS**: MOTION OF SOLIDS IN A FLUID, STRATIFIED FLUID, ARCHIMEDES FORCE, ENSURING ACCESS TO THE GIVEN POINT*

1. Введение

Эффективность наблюдений и измерений, получаемых при исследовании подводного мира с помощью подводных, в частности, беспилотных, аппаратов, во многом зависит от минимизации степени влияния этих подводных аппаратов на окружающую подводную среду. В первую очередь, это относится к движущимся аппаратам, перемещение которых осуществляется посредством тех или иных энергетических установок (гребной винт или иной движитель). Таким образом, снижение или исключение подобного влияния представляет собой важную прикладную задачу. Очевидно, что идеальным вариантом было бы полное отсутствие двигателя. А это значит, что управление движением подобного тела может осуществляться только за счет естественных гидродинамических сил (например, силы Архимеда или эффекта подъемной силы крыла, которым можно оснастить рассматриваемый объект).

В настоящей работе предлагается математическая модель, которую можно положить в основу решения указанной выше задачи. Работа состоит из двух частей. В *первой части* приводится решение задачи о встрече твердого тела, всплывающего в вязкой стратифицированной (слоистой) жидкости под действием выталкивающей силы Архимеда, с объектом, движущимся по поверхности жидкости с заданной скоростью (например, с судном, осуществляющим сбор данных с подводного аппарата и/или его обслуживание). При этом предполагается, что в жидкости могут иметь место сдвиговые течения, и плотность жидкости может различаться в разных слоях. Вязкость жидкости косвенно учитывается через предположение о наличии лобового сопротивления при движении тел в жидкости. Задача состоит в отыскании момента, в который подводный объект должен начать всплытие для гарантированной встречи с объектом, движущимся по поверхности. Управление траекторией всплывающего тела после начала его движения в этом случае невозможно.

Во *второй части* работы решается задача об управлении траекторией всплывающего тела при условии, что оно оборудовано управляемыми крыльями. Под управлением здесь мы понимаем возможность изменения угла атаки крыла. В этом случае движение по вертикали осуществляется за счет выталкивающей силы Архимеда, а движение по горизонтали – за счет проекции подъемной силы крыла, возникающей при наличии угла между крыльями и вектором скорости тела (угол атаки). Для корректировки траектории достаточно изменить угол атаки крыльев, что не требует больших затрат энергии.

2. Решение задачи о встрече

В настоящем параграфе представлено решение первой из упомянутых выше задач, а именно задачи о встречном движении двух твердых тел в вязкой несжимаемой нетеплопроводной стратифицированной жидкости. Вязкость будем учитывать, предполагая наличие силы сопротивления Стокса. Будем считать, что водоем имеет достаточно большие размеры вдоль горизонтальной плоскости, что дает возможность не учитывать влияние границ. Пусть тело, прикрепленное в начальный момент времени ко дну водоема, (тело 1) имеет шарообразную форму. Тело 2 движется по поверхности водоема равномерно и прямолинейно с известной скоростью υ. Предположим, что все тела движутся параллельно одному и тому же вертикальному сечению. Кроме того предполагается, что жидкость в каждом слое водоема может двигаться прямолинейно и равномерно вдоль горизонтальной оси и имеет постоянную плотность, которую считаем известной. Размерами тел по сравнению с глубиной водоема пренебрегаем. Сдвиговые течения так же предполагаются параллельными указанному сечению. Значение скорости жидкости в каждом слое будем считать известной величиной (см. рис. 1).

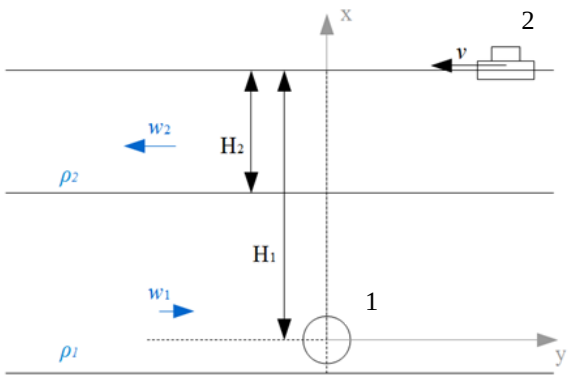


***Рис. 1.** Изображение двух объектов в двуслойной среде.*

Основной задачей является определение момента времени, в который тело 1 должно начать движение с тем, чтобы гарантированно встретиться на поверхности с заранее заданным телом 2. Данный момент времени определяем расстоянием между объектами, при котором тело 1 должно начать движение под воздействием выталкивающей силы для реализации встречи тел на поверхности водоема.

В основе работы лежит уравнение движения тела 1 в вертикальной плоскости с учетом гидродинамических эффектов:

$$\left(m+\frac{2}{3}\rho\pi R^3\right)\ddot{x}+c_0\frac{\rho\pi R^2}{2}\dot{x}^2-\left(\rho gV-mg\right)=0, \qquad (1)$$

а именно, силы лобового сопротивления шара и эффекта присоединенной массы [1, 3]:

$$\vec{P}=-c_0\frac{\rho\pi R^2}{2}\dot{x}^2\frac{\dot{\vec{x}}}{|\dot{x}|}\equiv -k\dot{x}^2\frac{\dot{\vec{x}}}{|\dot{x}|},$$

$$m\ddot{\vec{x}}+\frac{2}{3}\rho\pi R^3\ddot{\vec{x}}=\vec{F},$$

где R и V – радиус и объем шара соответственно, а $\vec{F}$ – суммарный вектор массовых сил, действующих на тело,.

При нулевых начальных условиях решение уравнения (1) принимает вид:

$$x=\sqrt{\frac{f}{k}}t+\frac{\tilde{m}}{k}\ln\left(1+\exp\left\{-2\frac{\sqrt{fk}}{\tilde{m}}\right\}\right)-\frac{\tilde{m}}{k}\ln 2, \qquad (2)$$

где $f=\rho gV-mg$, $\tilde{m}=m+\frac{2}{3}\rho\pi R^3$.

Пусть H_1 – глубина первоначального погружения первого тела, H_2 – толщина второго слоя. Полагая в соотношении (2) $x(t)=H_1-H_2$, получаем уравнение относительно t, решая которое находим значение времени всплытия тела 1 в придонном слое t_1. Дифференцируя (2) по времени и подставляя в полученное выражение t_1, рассчитываем υ_x – вертикальную составляющую скорости всплывающего тела в момент его перехода из первого слоя во второй.

При условиях $x(t_1)=H_1-H_2$, $\dot{x}(t_1)=\upsilon_x$ решение уравнения (1) имеет вид:

$$x=\sqrt{\frac{f}{k}}t+\frac{\tilde{m}}{k}\ln\left(1-\frac{\upsilon_x\sqrt{k}-\sqrt{f}}{\upsilon_x\sqrt{k}+\sqrt{f}}\exp\left\{-2\frac{\sqrt{fk}}{\tilde{m}}\right\}\right)+$$
$$+H_1-H_2-\frac{\tilde{m}}{k}\ln\left(1-\frac{2\sqrt{f}}{\upsilon_x\sqrt{k}+\sqrt{f}}\right), \qquad (3)$$

где $f=\rho gV-mg$, $\tilde{m}=m+\frac{2}{3}\rho\pi R^3$.

По аналогии с первым слоем, предполагая в соотношении (3) $x(t)=H_1$, вычисляем время всплытия тела 1 во втором слое – t_2.

Вектор перемещения вплывающего тела в придонном слое:

$$\vec{y}_{11}=\vec{w}_1t_1.$$

Пусть далее t' – время, в течение которого всплывающее тело меняет свою горизонтальную составляющую вектора скорости с $\vec{w}_1$ на $\vec{w}_2$.

В зависимости от соотношения значений времени t' и времени движения погруженного тела во втором слое (t_2) возможны два случая:

1. Если $t'<t_2$, вектор перемещения всплывающего тела во втором слое будет вычисляться следующим образом:

$$\vec{y}_{12}=\left(\vec{w}_1t'+\frac{\vec{a}(t')^2}{2}\right)+\vec{w}_2\left(t_2-t'\right),$$

где $\vec{a}=\frac{k}{\tilde{m}}|\vec{w}_2-\vec{w}_1|(\vec{w}_2-\vec{w}_1)$ – ускорение, возникающее при смене скорости.

2. Если $t'\ge t_2$: $\vec{y}_{12}=\vec{w}_1t'+\frac{\vec{a}(t')^2}{2}$.

Вектор перемещения движущегося по поверхности тела $\vec{y}_2$ имеет вид: $\vec{y}_2=\vec{\upsilon}(t_1+t_2)$.

При решении задачи о встрече в двуслойной жидкости со сдвиговыми течениями возможны четыре различных варианта траекторий движения, которые зависят от направлений векторов скорости $\vec{\upsilon}$ тела 2 и скоростей сдвиговых течений $\vec{w}_1$ и $\vec{w}_2$.

Во всех описанных случаях значение искомого расстояния определяется выражением:

$$\lambda=\sqrt{H_1^2+\left(\vec{y}_2-\vec{y}_{11}-\vec{y}_{12}\right)^2}.$$

Численный пример.

Для иллюстрации приведем следующий пример расчета, выполненного на основании полученных результатов. На рисунке 2 представлен один из вариантов, а именно, траектория движения тел, когда $\vec{\upsilon}\uparrow\downarrow\vec{w}_1$, $\vec{\upsilon}\uparrow\uparrow\vec{w}_2$.

В примере приняты следующие значения величин: диаметр всплывающего объекта равен 1 м, его масса рассчитывается как $m=0.98\rho V$, где ρ – усредненная плотность тела 1. Пусть изначально тело 1 находилось на глубине H_1 = 200 м. Глубину второго слоя H_2 положим равной 70 м, плотности жидкости в слоях равны $\rho_1=1050$ кг/м^3 и $\rho_2=1025$ кг/м^3; сдвиговые течения имеют скорости $|\vec{w}_1|=0.15$ м/с и $|\vec{w}_2|=0.3$ м/с, а тело, движущегося по поверхности, – скорость v, равную 15.42 м/с.

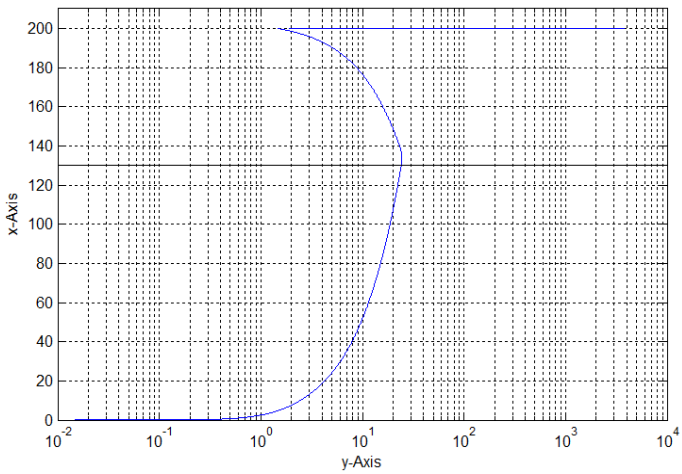


Рис. 2. *Траектории движения тел в случае, когда* $\vec{w}_1\uparrow\downarrow\vec{\upsilon}$, $\vec{w}_2\uparrow\uparrow\vec{\upsilon}$.

3. Уравнения движения всплывающего шара, оборудованного крыльями

3.1. Постановка задачи и вспомогательные результаты

В этом параграфе мы построим математическую модель управления траекторией всплывающего однородного шара при условии, что он оборудован двумя одинаковыми крыльями, симметрично расположенными относительно центра шара. Под управлением здесь мы будем понимать возможность изменения угла атаки крыла. В основу построения соответствующей математической модели мы положим классическую теорию тонкого крыла конечного размаха Жуковского – Прандтля, подробное изложение которой, включая необходимые формулы, можно найти, например, в [1 – 3]. Крылья мы будем рассматривать как дополнительный «самостоятельный источник» внешних объемных сил, действующих на шар. Варианты возможного взаимного расположения шара и крыльев влекут за собой необходимость специального, в частности, экспериментального исследования дополнительных гидродинамических эффектов, возникающих при том или ином варианте технической компоновки соответствующей конструкции. В этой работе мы такие варианты рассматривать не будем, считая это отдельной инженерной задачей. При любом варианте взаимного расположения шара и крыла (крыльев), предлагаемая нами математическая модель может быть взята за основу. Подчеркнем, наконец, что под траекторией системы «шар с крыльями» мы будем понимать траекторию центра масс этой системы, т.е. траекторию центра шара.

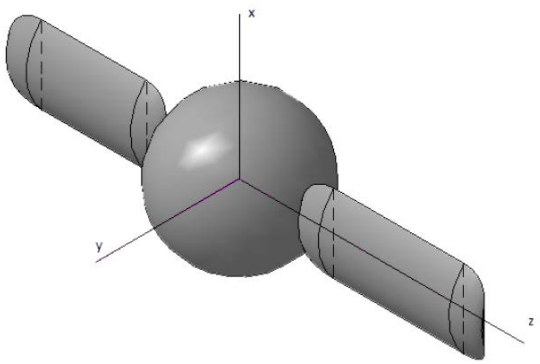


Рис. 3. *Шар с крыльями.*

Далее мы примем следующие упрощения:

1. Жидкость, в которой всплывает тело, несжимаемая, а эффект вязкости проявляется только через наличие лобового сопротивления;
2. Крылья у рассматриваемого объекта тонкие и имеют большое удлинение;
3. Применима гипотеза плоских сечений;
4. Справедлива схема «жидкого крыла».

Кроме того, форму крыльев объекта будем выбирать таким образом, чтобы минимизировать индуктивную силу сопротивления.

В основе теории крыла конечного размаха лежат следующие гипотезы (см, например, [1, 2]):

- Рассматриваемое крыло тонкое,
- Крыло имеет большое удлинение,
- Применима гипотеза плоских сечений,
- Справедлива схема жидкого крыла.

Напомним суть этих гипотез.

1) Первое предположение означает, что профиль, полученный в сечении крыла плоскостью тонкий и хорда профиля образует малый угол с направлением скорости.

2) Для крыла произвольной формы за удлинение принимают отношение квадрата размаха крыла к его площади. Обычно принимают, что величина удлинения должна быть больше четырех, то есть крыло длинное и узкое.

3) Гипотеза плоских сечений, оправданием которой служит второе предположение, позволяет в плоскости $z = const$ скорости и давления строить так же, как в случае крыла бесконечного размаха.

4) Гипотеза о справедливости схемы жидкого крыла предполагает возможность подобрать такую систему вихрей, которая может заменить действие твердого крыла на поток и вызвать такое же движение жидкости, которое вызывалось бы действием крыла.

Следствием этих гипотез является, как известно, возможность вместо пространственного течения около крыла (см рис. 3), рассматривать для каждого сечения $z = const$ плоское обтекание профиля потоком, скорость которого зависит от $z, -l \le z \le l$. Величина $2l$ называется *размахом крыла*.

Итак, задача обтекания крыла конечного размаха в нашем случае разделяется на две:

1. Задача обтекания профиля поступательным потоком;
2. Определение изменения циркуляции по размаху крыла.

На рис.4. изображены силы, действующие на тело.

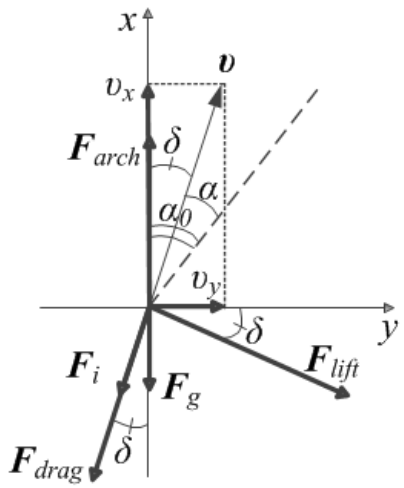


Рис. 4. *Главные векторы гидродинамических сил, действующих на систему шар – крылья.*

F_{arch} – выталкивающая (архимедова) сила, F_g – сила тяжести, F_{drag} – суммарная сила лобового сопротивления (шара и крыльев), F_{lift} – подъёмная сила, F_i – сила индуктивного сопротивления.

Если считать циркуляцию известной, то силовое воздействие на одно крыло определяется следующими формулами (см., например, [1]):

$$\begin{cases} F_{lift} = \rho v \int_{-l}^{l} \Gamma(z)dz, \\ F_i = \rho v \int_{-l}^{l} \alpha_i \Gamma(z)dz, \end{cases} \qquad (4)$$

где α_i – так называемый угол скоса потока. В нашем случае F_{lift} играет роль «подъемной» силы, а F_i – индуктивного сопротивления. Известно [1-3], что минимальное индуктивное

сопротивление будет иметь место в том случае, когда циркуляция распределена по эллиптическому закону

$$\left(\frac{\Gamma}{4\upsilon l A_1}\right)^2+\left(\frac{z}{l}\right)^2=1,$$

где $2l$ – размах крыла (по оси z), а величина $4\upsilon l A_1 \equiv \Gamma_0$ представляет собой максимальное значение циркуляции, которое, очевидно, имеет место в среднем сечении профиля крыла. Можно также показать [1, 2], что циркуляция будет распределена по эллиптическому закону тогда и только тогда, когда профиль имеет эллиптическую форму. Напомним, что в этом случае индуктивное сопротивление крыла будет минимальным, и им, иногда, можно пренебречь.

В этом случае выражение для циркуляции можно записать в следующем виде [2]:

$$\Gamma=\Gamma(z,\alpha)=\Gamma(\theta,\alpha)=\frac{4lkb_0}{4l+kb_0}\upsilon\alpha\sin\theta\ . \qquad (5)$$

Здесь b_0 – хорда среднего сечения крыла, α – угол атаки, θ – новая переменная, связанная с z формулой

$$z=-l\cos\theta,\ 0\le\theta\le\pi\ .$$

Величина k обычно определяется экспериментально.

Обозначим далее

$$\mu_0=\frac{kb_0}{4l}\ .$$

Из (4) и (5) для подъемной силы и индуктивного сопротивления одного крыла получаем [2]:

$$F_{lift}=\rho u^2 S\frac{k\alpha}{1+m_0},$$
$$F_i=\frac{\rho}{2}u^2 S\frac{m_0\left(2k\alpha+\alpha^2\right)}{2k\alpha\left(1+m_0\right)}, \qquad (6)$$

где S – площадь крыла в плане.

Отметим, что в нашем, конкретном, случае реальный угол атаки α будет, вообще говоря, зависеть от направления скорости $\vec{u}$ центра масс системы. Точнее, как видно из рис. 4, $\alpha=\alpha_0-\delta,\ tg\,\delta=\frac{\upsilon_y}{\upsilon_x}=\frac{\dot{y}}{\dot{x}};\ 0\le\delta\le\alpha_0$. Здесь через α_0 обозначен исходный угол атаки (когда шар начинает всплытие под действием выталкивающей силы, т.е. угол между вертикальной осью и хордой крыла). При малых δ можно приближенно принять $\delta\approx\frac{\dot{y}}{\dot{x}}$. Здесь и далее – координаты центра шара. Иными словами, можно считать, что $a=a(\dot{x},\dot{y},t)$ – известная функция своих аргументов.

Что касается силы лобового сопротивления, то, как известно [4], она существенно зависит от числа Рейнольдса и формы обтекаемого тела. Так, для шара при малых числах Рейнольдса сила лобового сопротивления подчиняется закону Стокса: $F_{drag}=6\pi\mu R\upsilon$ (здесь R – радиус шара, μ – динамическая вязкость жидкости). При числах Рейнольдса $\mathrm{Re}>10^2$ зависимость от скорости будет уже квадратичной:

$$F_{drag}=C_X\cdot S\cdot\frac{\rho\upsilon^2}{2},$$

где C_X – коэффициент лобового сопротивления для тела данной формы, ρ – плотность жидкости, S – характерная площадь обтекаемого тела (для шара $S=\pi R^2$). В общем случае, для расчета силы лобового сопротивления можно использовать единую формулу [4]

$$F_{drag}=C_X(\mathrm{Re})\cdot S\cdot\frac{\rho\upsilon^2}{2} \qquad (7)$$

Характерная зависимость силы и коэффициента лобового сопротивления от числа Рейнольдса представлены на рис. 5 и 6 соответственно (см. [4]).

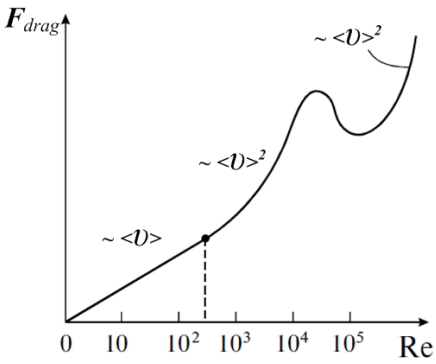


Рис. 5. *Зависимость силы лобового сопротивления от числа Рейнольдса*

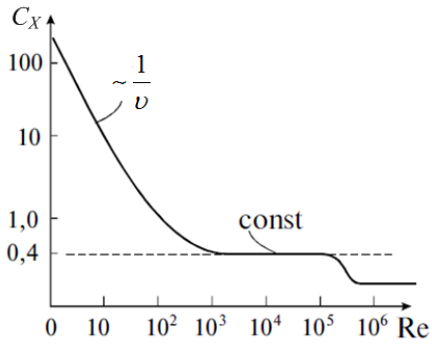


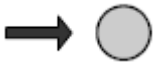
Рис. 6. *Зависимость коэффициента лобового сопротивления от числа Рейнольдса*

В частности, при малых числах Рейнольдса $C_X\approx 24/\mathrm{Re}$, что дает нам закон Стокса, при «не слишком больших» Re можно использовать формулу Озеена:

$$C_X\approx\frac{24}{\mathrm{Re}}\left(1+\frac{3\mathrm{Re}}{16}\right)$$

(подробно об этом можно прочитать в [5, 6], критику можно найти в книге [7]). Характерная зависимость коэффициента лобового сопротивления от формы обтекаемого тела представлена в таблице 1 (см. [4]).

Таблица 1

	Тело	C_X
	Диск	1,11
	Полусфера	1,35…1,40
	Полусфера	0,30…0,40
	Шар	0,4
	Каплевидное	0,045
	Каплевидное	0,1

3.2. Уравнения движения шара с крыльями

$$\left.\begin{aligned}\left(m+\frac{2}{3}\rho\pi R^3\right)\frac{d^2x}{dt^2} &= F_{arch}-2F_i\cos\delta-(F_{drag}^{(1)}+2F_{drag}^{(2)})\cos\delta-2F_{lift}\sin\delta-F_g;\\ \left(m+\frac{2}{3}\rho\pi R^3\right)\frac{d^2y}{dt^2} &= -2F_i\sin\delta-(F_{drag}^{(1)}+2F_{drag}^{(2)})\sin\delta+2F_{lift}\cos\delta.\end{aligned}\right\}$$

Здесь m – суммарная масса системы «шар-крылья», $F_{drag}^{(1)}$ и $F_{drag}^{(2)}$ – силы лобового сопротивления шара и крыла соответственно. При этом надо учесть формулы (6) и (7). Выталкивающая сила Архимеда задается обычным образом. Отметим также следующие соотношения:

$$\sin\delta=\frac{\dot y}{\sqrt{\dot x^2+\dot y^2}},\quad \cos\delta=\frac{\dot x}{\sqrt{\dot x^2+\dot y^2}}.$$

При малых δ можно приближенно принять

$$\sin\delta\approx\delta\approx\frac{\dot y}{\dot x},\quad \cos\delta\approx 1.$$

Начальные условия в нашей задаче, очевидно, нулевые.

4. Выводы

В работе представлены решения двух задач, связанных с исследованием возможности управления движением тел, всплывающих в несжимаемой вязкой жидкости под действием выталкивающей силы Архимеда, и не имеющих иных активных движителей. В *первой части* работы приводится решение задачи о встрече твердого тела, всплывающего в вязкой стратифицированной (слоистой) жидкости под действием выталкивающей силы Архимеда, с объектом, движущимся по поверхности жидкости с заданной скоростью. Именно, решена задача отыскания момента, в который подводный объект должен начать всплытие с заданной глубины для гарантированной встречи с объектом, движущимся по поверхности. Во *второй части* работы построена математическая модель движения центра масс всплывающего однородного шара при условии, что он оборудован двумя одинаковыми крыльями, симметрично расположенными относительно центра шара. Траектория движения описывается системой квазилинейных дифференциальных уравнений второго порядка, в правую часть которых в явном виде входит угол атаки крыльев, которыми оборудован всплывающий шар. Под управлением здесь понимается возможность изменения угла наклона крыльев по отношению к вертикальной плоскости. Таким образом, построенная математическая модель позволяет, в принципе, решить, как задачу прогнозирования траектории центра масс шара при заданном законе изменения угла наклона крыльев по отношению к вертикальной плоскости, так и задачу отыскания возможного закона изменения упомянутого угла с целью достижения шаром заданной точки пространства.

Уравнения движения центра масс рассматриваемого объекта в проекциях на оси x и y имеют, следовательно, вид:

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THE INVERSE PROBLEM OF THE STABILITY OF PROCESSES IN THE DYNAMIC SYSTEM UNDER SMALL PERTURBATIONS OF ITS PARAMETERS

ОБРАТНАЯ ЗАДАЧА УСТОЙЧИВОСТИ ПРОЦЕССОВ В ДИНАМИЧЕСКОЙ СИСТЕМЕ ПРИ МАЛЫХ ВОЗМУЩЕНИЯХ ЕЁ ПАРАМЕТРОВ

professor, doctor of technical science Firsov A.N., e-mail: anfirs@yandex.ru
MSc Gladush A.I., e-mail: gladush@protonmail.ch
Peter the Great St. Petersburg Polytechnic University – Saint-Petersburg, Russia

Abstract: *The report presents the problem of maintaining the stability of processes in a dynamic system in the presence of perturbations of its parameters. This result relies on the solution of the inverse problem of perturbation of eigenvalues of finite-dimensional linear operator in the case of the two perturbation parameters. The proposed method based on decomposing the original problem into two tasks, each of which represents a problem with only one perturbing parameter. This allows us to use the results of Kato's perturbation theory of linear operators.*

***KEYWORDS**: PERTURBATION OF EIGENVALUES, DECOMPOSING, OCTANE NUMBER, STABILITY MAINTAINING*

1. Введение

При конструировании различных технических систем невозможно избежать возникновения малых отклонений параметров элементов системы от расчётных номиналов. В этом случае представляется целесообразным иметь возможность оценить, в какой мере сохраняются основные характеристики системы. Одним из таких случаев может быть задача о ремонтопригодности технической конструкции.

Одной из основных качественных характеристик динамической системы является её устойчивость в процессе функционирования. Обычно вопрос устойчивости динамической системы характеризуется условием отрицательности вещественных частей собственных значений матрицы. Таким образом, возникает задача исследования поведения собственных значений матрицы системы как функций возмущающих параметров.

2. Анализ устойчивости при двухпараметрическом возмущении

Рассмотрим уравнение состояния динамической системы, представленной однородным дифференциальным уравнением первого порядка:

$$\dot{\mathbf{x}} = A\mathbf{x} = (A_0 + A_1\varepsilon + A_2\delta)\mathbf{x}, \qquad (1)$$

где:

$\mathbf{x}$ – вектор состояния динамической системы;

ε , δ – параметры возмущения;

A – возмущённая матрица системы;

$A_0 < 0$ – отрицательно определённая невырожденная матрица системы, соответствующая её невозмущенному состоянию, т.е. при $\varepsilon = \delta = 0$;

A_1, A_2 – матрицы, отображающие воздействие возмущающих параметров на элементы системы.

Цель – анализ устойчивости возмущённой системы, задача – приближённо определить допустимые интервалы изменения параметров ε и δ возмущения.

Как показано в [3], аналогичная задача может быть решена для динамических систем с одним возмущающим параметром, однако используемый подход не масштабируется даже на случай двух возмущающих параметров. В связи с этим, в настоящей работе предложен и обоснован метод, позволяющий свести двухпараметрическую задачу к двум однопараметрическим.

Основной идеей данного метода является приближённое разложение возмущённой матрицы системы, зависящей от обоих параметров возмущения, в произведение двух матриц, зависящих от каждого параметра возмущения в отдельности: $A(\varepsilon, \delta) \cong G(\varepsilon)L(\delta)$. Представив систему в таком виде, можно воспользоваться результатами из [1], а именно:

Теорема 1. [1] Матрица A отрицательно определена $(A < 0)$ тогда и только тогда, когда существуют такие матрицы G, L, что $A = GL$ и при этом

$$\begin{cases} G + G^T < 0 \\ L > 0 \\ L - \text{симметричная} \end{cases}.$$

Как видно, условия накладываются отдельно на матрицы G и L, а следовательно, отдельно на параметры возмущения ε и δ.

Будем искать анонсированное разложение в следующем виде:

$$A(\varepsilon, \delta) = A_0 + A_1\varepsilon + A_2\delta \cong G(\varepsilon)L(\delta) = (G_0 + \varepsilon G_1)(L_0 + \delta L_1).$$

Далее покажем, как построить такое разложение. Имеем:

$$G(\varepsilon)L(\delta) =$$

$$=(G_0 + \varepsilon G_1)(L_0 + \delta L_1) =$$

$$= G_0L_0 + G_1L_0\varepsilon + G_0L_1\delta + G_1L_1\varepsilon\delta \cong$$

$$\cong G_0L_0 + G_1L_0\varepsilon + G_0L_1\delta.$$

Как видно, пренебрегая нелинейным членом более высокого порядка $\varepsilon\delta \in o(\varepsilon + \delta)$, можно представить исходную матрицу системы $A_0 + A_1\varepsilon + A_2\delta$ в виде произведения $(G_0 + \varepsilon G_1)(L_0 + \delta L_1)$, если при этом

$$\begin{cases} G_0L_0 = A_0 \\ G_1L_0 = A_1. \\ G_0L_1 = A_2 \end{cases}$$

Далее, для того, чтобы воспользоваться результатом теоремы 1, необходимо потребовать выполнения условия

$$\begin{cases} G_0 + \varepsilon G_1 + (G_0 + \varepsilon G_1)^T < 0 \\ L_0 + L_1\delta > 0 \\ L_0 + L_1\delta - \text{симметричная} \end{cases},$$

или, после элементарных преобразований,

$$\begin{cases} \left(G_0 + {G_0}^T\right) + \left(G_1 + {G_1}^T\right)\varepsilon < 0 \\ L_0 + L_1\delta > 0 \\ L_0, L_1 - \text{симметричные} \end{cases}.$$

Последняя система есть не что иное, как совокупность неравенств, определяющих две однопараметрические задачи. Единственным оставшимся условием, которое необходимо потребовать для того, чтобы иметь возможность их разрешить, является знакоопределённость соответствующих невозмущённых матриц:

$$\begin{cases} G_0 + {G_0}^T < 0 \\ L_0 > 0 \end{cases}.$$

Итак, итоговая совокупность условий для построения описанной выше декомпозиции выглядит следующим образом:

$$\begin{cases} G_0L_0 = A_0 \\ G_1L_0 = A_1 \\ G_0L_1 = A_2 \\ G_0 + {G_0}^T < 0 \\ L_0 > 0 \\ L_0, L_1 - \text{симметричные} \end{cases}, \qquad (2)$$

а для приближённого определения допустимых интервалов изменения параметров ε и δ необходимо разрешить неравенства

$$\begin{cases} \left(G_0 + {G_0}^T\right) + \left(G_1 + {G_1}^T\right)\varepsilon < 0 \\ L_0 + L_1\delta > 0 \end{cases}. \quad (3)$$

Используя результаты Като [3], можно представить собственные числа возмущённых матриц как степенные ряды, зависящие от параметра возмущения. Решая получающиеся неравенства системы (3) относительно параметра возмущения, в обоих уравнениях получаем допустимый непрерывный интервал (содержащий нулевое значение) изменения параметров ε и δ соответственно.

Таким образом, осталось непосредственно привести схему декомпозиции возмущённой матрицы A исходной системы, удовлетворяющую условия, приведённые в системе (2).

Будем искать матрицы G_0, L_0, G_1, L_1 в следующем виде:

$$\begin{cases} G_0 = A_0 P \\ L_0 = P^{-1} \\ G_1 = A_1 P \\ L_1 = P^{-1}{A_0}^{-1}A_2 \end{cases}. \quad (4)$$

Нетрудно убедится, что

$G_0 L_0 = A_0 P P^{-1} = A_0,$

$G_1 L_0 = A_1 P P^{-1} = A_1,$

$G_0 L_1 = A_0 P P^{-1} {A_0}^{-1} A_2 = A_2.$

Поскольку матрица L_0 должна быть симметричной, то и обратная матрица $P = {L_0}^{-1}$ должна быть симметричной. Но тогда, т.к. $PL_1 = {A_0}^{-1}A_2$ и L_1 тоже должна быть симметричной, то задача нахождения P и L_1 является задачей разложения матрицы ${A_0}^{-1}A_2$ в произведение двух симметричных, и при этом P должна быть невырожденной. Как известно из [2], такое разложение возможно для любой действительной матрицы.

Теорема 2. [2,464] Любая действительная матрица является произведением двух действительных симметричных матриц, по крайней мере одна из которых является невырожденной.

Такое разложение в общем случае не является единственным. Если $Q, Q_1, Q_2 \in Mat(n \times n)$ и при этом $Q = Q_1 Q_2$, где каждая из матриц Q_1 и Q_2 имеет $n(n+1)/2$ независимых элементов, то имеем n^2 нелинейных уравнений с $n^2 + n$ неизвестными. Следовательно, в общем виде будем получать n-параметрическое семейство решений.

Пользуясь рассуждениями из доказательства теоремы 2, рассмотрим структуру факторизации:

$$Q = DJD^{-1} = DSCD^{-1} = [DSD^T][(D^{-1})^T C D^{-1}] = Q_1 Q_2,$$

где J – Жорданова нормальная форма матрицы Q; S, C – разложение матрицы J в произведение действительной и комплексной симметричной матрицы соответственно; D – матрица подобия, построенная на основе собственных векторов матрицы Q (подробнее см. в [2]).

Рассуждения, близкие к доказательству теоремы 2, позволяют заключить, что семейство всевозможных допустимых матриц D в общем виде можно представить в виде линейной комбинации его базисных матриц. Подбирая соответствующие коэффициенты при этих базисных матрицах, можно получить всевозможные допустимые матрицы D, а следовательно, и всевозможные разложения матрицы ${A_0}^{-1}A_2$ на произведение симметричных P и L_1. При этом $L_0 = P^{-1}$ также будет симметричной, поэтому выполняется условие из системы (2), что матрицы L_0 и L_1 должны быть симметричными.

Осталось среди параметризированного семейства пар матриц $\{P, L_1\}$ выбрать такие матрицы, чтобы выполнялись оставшиеся условия на знакоопределённость матриц из системы (2), а именно:

$$\begin{cases} G_0 + {G_0}^T < 0 \\ L_0 > 0 \end{cases},$$

что при выбранной схеме декомпозиции (4) матрицы A эквивалентно

$$\begin{cases} A_0 P + P{A_0}^T < 0 \\ L_0 > 0 \end{cases}. \quad (5)$$

Численный эксперимент показал, что такой подбор матриц P и L_1 как правило возможен, однако это не обосновано с точки зрения теории. Поэтому для того, чтобы сформулировать более строгий результат, попробуем потребовать дополнительные условия, отражающиеся на исходных матрицах. А именно, потребуем, чтобы для матриц A_0 и A_2 выполнялось следующее условие: спектр матрицы ${A_0}^{-1}A_2$ состоит из попарно различных действительных собственных значений.

Данное условие говорит о существовании полного набора собственных векторов и возможности спектрального разложения матрицы ${A_0}^{-1}A_2$, а значит, позволяет найти матриц P и L_1 в следующем виде:

$${A_0}^{-1}A_2 = V^{-1}JV = (V^T V)^{-1} \cdot (V^T JV) = PL_1,$$

где V – матрица, строки которой являются собственными векторами матрицы ${A_0}^{-1}A_2$; J – Жорданова нормальная форма матрицы ${A_0}^{-1}A_2$.

При этом матрица $P = (V^T V)^{-1}$ всегда получается положительно определённой, т.е. выполняется одно из условий знакоопределённости невозмущённых матриц в системе (5).

Как и в общем случае, семейство всевозможных разложений матрицы ${A_0}^{-1}A_2$ может быть параметризировано. Для этого матрица V может быть составлена из собственных векторов матрицы ${A_0}^{-1}A_2$ как из строк, умноженных на соответствующие коэффициенты. Таким образом, остается из -параметрического семейства всевозможных разложений матрицы ${A_0}^{-1}A_2$ в произведение симметричных P и L_1 выбрать такое, чтобы выполнялось единственное оставшееся условие из системы (5), а именно $A_0 P + P{A_0}^T < 0$.

Полученный результат можно сформулировать в следующем виде.

Теорема 3. Для уравнения (1) допустимые интервалы изменения параметров возмущения можно приближённо получить из неравенств

$$\begin{cases} \left(G_0 + {G_0}^T\right) + \left(G_1 + {G_1}^T\right)\varepsilon < 0 \\ L_0 + L_1\delta > 0 \end{cases},$$

где

$$\begin{cases} G_0 = A_0 P \\ L_0 = P^{-1} \\ G_1 = A_1 P \\ L_1 = P^{-1}{A_0}^{-1}A_2 \end{cases},$$

а симметричные матрицы P и L_1 получены разложением матрицы ${A_0}^{-1}A_2$ в произведение PL_1 таким образом, что для матрицы P выполняются следующие условия:

$$\begin{cases} A_0 P + P{A_0}^T < 0 \\ P > 0 \end{cases}.$$

Если же матрица ${A_0}^{-1}A_2$ допускает спектральное разложение, то достаточно потребовать лишь выполнения условия $A_0 P + P{A_0}^T < 0$.

Заключение. Представленный в настоящей статье метод, позволяющий получить приближённое разложение возмущённой матрицы системы, зависящей от обоих параметров возмущения, в произведение двух матриц, зависящих от каждого параметра возмущения в отдельности, не является вполне строгим, поскольку показывает лишь схему разложения. Однако, данный метод нашёл успешное применение в конкретной практической задаче, и это даёт надежду, что в дальнейшем возможно обосновать существование и предоставить явные формулы для соответствующего разложения.

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COMPUTER-AIDED DESIGN OF POWER SUPPLY SYSTEMS OF VEHICLES

АВТОМАТИЗИРОВАННОЕ ПРОЕКТИРОВАНИЕ СИСТЕМЫ ЭЛЕКТРОСНАБЖЕНИЯ ТРАНСПОРТНЫХ СРЕДСТВ

Cand. Sci. (Tech.), Senior researcher Ferenets A., Cand. Sci. (Tech.) Fedorov E.
Institute of Automation and Electronic Engineering, Kazan National Research Technical University named after A.N.Tupolev – KAI (KNRTU-KAI), Russian Federation
E mail: ferenec.electro@kstu-kai.ru, zhenek_fed@mail.ru

Abstract: *The article describes software modules of computer-aided design of vehicle power supply systems: analysis of modes of power supply systems operation, optimal choice of wire sizes, selection and verification of protective devices.*
***KEYWORDS**: COMPUTER-AIDED DESIGN, VEHICLE, POWER SUPPLY SYSTEM, OPTIMIZATION*

1. Introduction

Designing of power supply systems of vehicles is currently impossible without use of software products of CAD, CAM, CAE, CALS systems and (PLM) technology.

The market of information technologies in the design of power supply systems is widely presented by multi-purpose tool systems of computer-aided design: ElectriCS, E3.Series, Catia, Siemens NX, Cimatron, Cimacable, Solid Works, and others. [1,2,6]. These systems allow us to solve in the single project space the full spectrum of electrical design of modern vehicle, from development of schematic diagrams to formation of bundles and output of all design documentation in electronic form. But most of them are graphical - information tools to support the design process. The quality of the design decisions here depends largely on the readiness of personnel and expertise. Optimization problems, analysis of quality and reliability of the designed electrical systems are not solved by existing CAD systems. To solve these problems it is necessary to create algorithms and specialized software that solves the optimization problems.

2. Means for resolving the problem, discussion and results

The composite structural parts of CAD of power supply systems, reflecting the design problems [2-5] are the following projecting modules: electrical equipment layout, placement of electrical equipment, wiring the electrical circuits, formation and tracing the bundles, analysis of operation modes of electric energy distribution, choice of protection devices, optimization of cross sections of wires, calculation of the balance of electrical energy and other. By present, the Department of Electrical equipment completed by-stage implementation in practice of the following software modules: «Analysis of operation modes of electrical systems of vehicles», «Optimal choice of cross sections of wires», «Selection and testing of protective devices».

Module «Analysis of operation modes of electrical systems of vehicle». In the course of performing the analysis the following problems are solved:

- Calculation of the currents in the sections of power circuits and voltages in the nodes for normal modes, taking into account the change of current distribution as to the modes of consumption;
- Determination of maximum currents of circuit sections and minimum node voltages of the scheme;
- Calculation of the short-circuit current in different places;
- Checking as to permissible nominal voltage at the terminals of consumers;
- Determination of maximum time off by fuse of the short circuit place.

Module «Optimal choice of the cross sections of wires». During the optimal choice of wire sections the following problems were solved:

- Calculation of the currents in the circuit sections of calculation scheme for normal and directive modes taking into account the changes in the current distribution as to the modes of consumption;
- Determination of maximum currents of circuit sections for normal and directive regimes;
- Checking the wires as to the maximum permissible current;
- Checking as to permissible rated voltage at the terminals of consumers;
- Checking the protection ability of wires by protection devices.

Module «Selection and testing of protective devices». During the selection and testing of devices of protection the following problems are solved:

- Calculation of currents in the circuit sections of calculation scheme for normal and directive modes taking into account the changes in the current distribution as to the modes of consumption;
- Calculation of the currents in the circuit sections of design scheme for short-circuit modes;
- Checking the correct choice of protection devices as to the rated current;
- Checking the correct selection of protection device in overloads in case of electric motor loads;
- Determining the sequence of triggering of protection devices in the modes of short-circuit and checking the selectivity of protection;
- Checking the protection devices for resistance to short-circuit currents.

The developed modules are identified parts of computer-aided design to ensure obtaining the completed design solutions and appropriate design documents. Structural integration of modules in the system is carried out with the help of connections between the components of computer-aided design of electrical complexes of vehicles. Fig. 1 is CAD block diagram of vehicle with the existing and new special software. Information interconnection of generated specialized modules with other programs and system database is carried out by means of data exchange programs.

The scheme is based on the analysis of the design process for various types of vehicles, generalization of experience of research works on creation of computer-aided design of electric-technical complexes of vehicles [4,5].

According to the proposed scheme, the pilot design of electrical systems of trucks was carried out. The developed software modules were studied on a number of modified electrical circuits of trucks under various constraints. As a result, the defects (errors) and recommendations are identified: protection devices, through which the current flows exceeding the nominal; wires, in which the current

exceeded the permissible value; nonselectivity of triggering of protection devices. Analysis of the results of implementation shows that shortening the terms of design of electrical systems in the modification of truck is about 8,5 hours.

3. Conclusion

The introduction of this technique and developed software in industrial operation allowed us to significantly reduce computational time and laboriousness in designing the electrical systems, to increase the reliability of calculations because of elimination of mechanical errors of non-automated designing, operatively make changes to documents, to release the engineers from routine work. In addition, the use of design and project information as input data for the programs to obtain product documentation for manufacturing and control of components of electric systems of vehicles also helps to speed up the development of product by manufacturer. Thus, the certain economic benefits are achieved, which are provided by reducing the design time by 8-12%.

4. Acknowledgements

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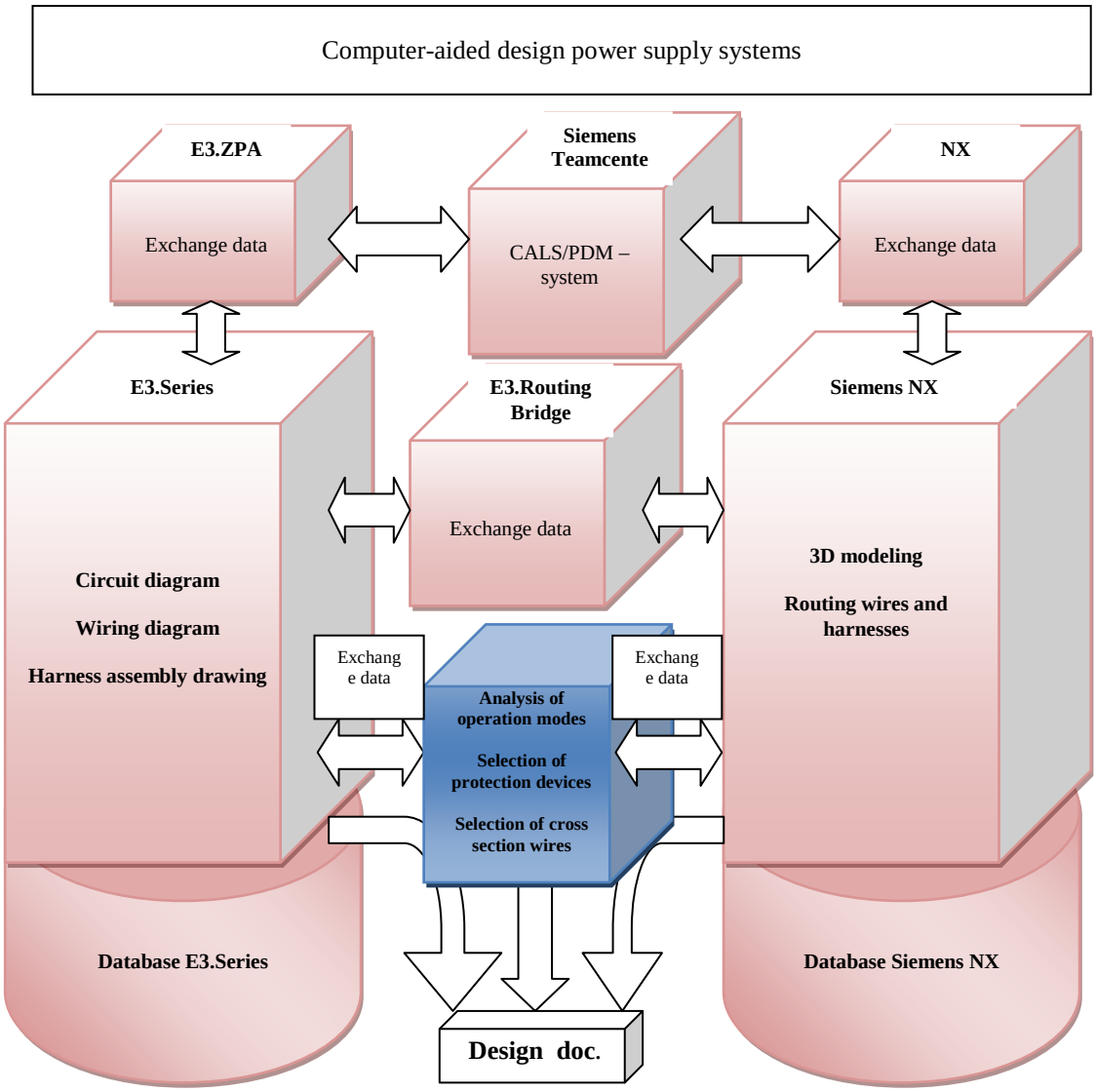

Fig. 1. *Computer-aided design of power supply systems of truck*

STUDY OF THE CAPACITY OF A FANUC M430i-A/4FH ROBOT TO PERFORM TECHNOLOGICAL OPERATIONS

ИЗСЛЕДВАНЕ ВЪЗМОЖНОСТИТЕ НА РОБОТ FANUC M430i-A/4FH ЗА ИЗПЪЛНЕНИЕ НА ТЕХНОЛОГИЧНИ ОПЕРАЦИИ

Prof. D.Sc. Guergov S.[1], M.Sc. Beevski L.[2]
Technical University Sofia, Bulgaria
sguergov@tu-sofia.bg [1], beevsky@tu-sofia.bg [2]

Abstract: *A work environment for modelling, simulating and performing various technological operations (milling, drilling, etc.) has been created using hardware developed to include a Fanuc M430i-A/4FH robot and specialised software Roboguide. As a result of the study, guidelines have been developed for the software and hardware improvement of the system in order to enhance its use both for the purposes of training and research.*

Keywords: INDUSTRIAL ROBOT, OPERATIONAL ROBOT, VIRTUAL MODEL, TECHNOLOGICAL OPERATION

1. Introduction

The kinematic and dynamic capabilities, the level of control systems, and using of a high quality and reliable element base of the modern industrial robots provide great opportunities for the realization of complicated trajectories with high accuracy. This tendency provides the expansion of robot functionalities which are not frequently mentioned in the documentation.

The goal of the present article is to study the capacity of a FANUC M430i-A/4FH robot to perform a various technological operations (grinding/polishing, milling, boring/turning, drilling, etc.). An additional unit [1] and specialised software (ROBOGUIDE [2]) are used to support the robot. In other words, can a universal robot work as a operational? If "yes" – to what extent? If "not" – what is missing and can it be done?

In the Fig. 1 the CAD model of a test part is shown. As can be seen from it, suitable operations for creation of that geometry features are drilling, milling and grinding. The work piece material is polyethylene PE, Fig. 2, it is chosen in accordance with the allowable payload of the robot wrist.

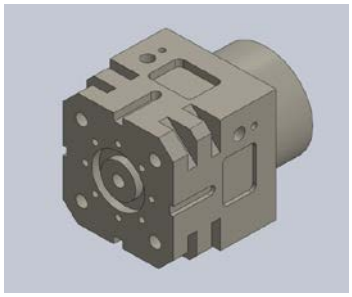

Fig. 1 *CAD model of the test part.*

Fig. 2 *Work piece.*

2. Setting the experiment

To make the process simulation possible, first thing to be done is to create a virtual model of the real facility in ROBOGUIDE (Fig. 3). That model provides the ability to define all objects around the robot and create an accurate visualization of the whole system. Setting relations between the objects facilitates process planning, programming, and verification via computer animation. The software [2] includes capability to create a trajectory, based on CAD model features, providing an automated path generation which is very helpful for welding, dispensing and other applications.

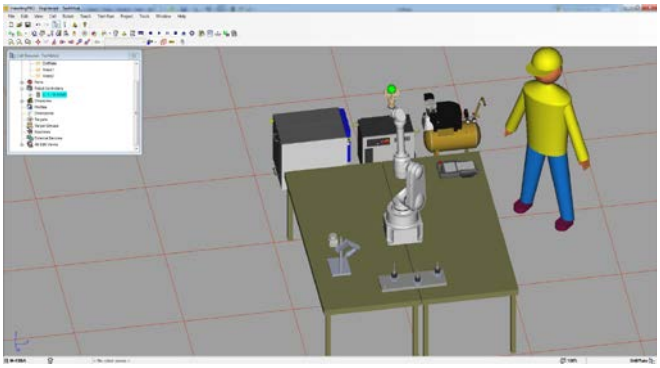

Fig. 3 *Virtual model of the work scene.*

From other side, to ensure environment space equivalence and correct distances between the objects, a calibration of the virtual model is required. There are a few ways to accomplish this task. In the particular case, a gripper reference point is visualized, using an additional device and reading data from motor pulse coders of each axis. Then the coordinates are imported to the ROBOGUIDE model.

After completion of the calibration procedure, the development of the programs can start. The method of the path planning begins with the part geometry features recognition (holes, channels, pockets, etc.). Then from part documentation, cutting feed rates and other technology information must be collected.

The robot's work motions, and the logical structures of the programs, are dependent from the part geometry. The required operations should be divided in the groups by the tool type, feed rate, recurrent features or patterns in the different planes. Usage of a logic statement for iterative operations increases the time and efficiency of programming, improving the readability of the programs. Conditional compare instruction, such as IF and SELECT, compares the value stored in register with another value, which can be specific parameter for the operation (number of features, cutting speed, etc.) and after the comparison a specific processing can be executed. With this capability to indirect defining parameters, a single logical program can be used for multiple operations by specifying of required arguments.

According to the initial conditions of the experiment, the tools are mounted stationary on a plate and robot carries the work piece. To perform the motion over the programmed trajectory a set of points and type of the motion trough them must be specified. There are a few transition types between the stored points of a trajectory. In Fig. 4 a way for specifying the transition trough adjacent points over programmed trajectory via approximation factor is shown.

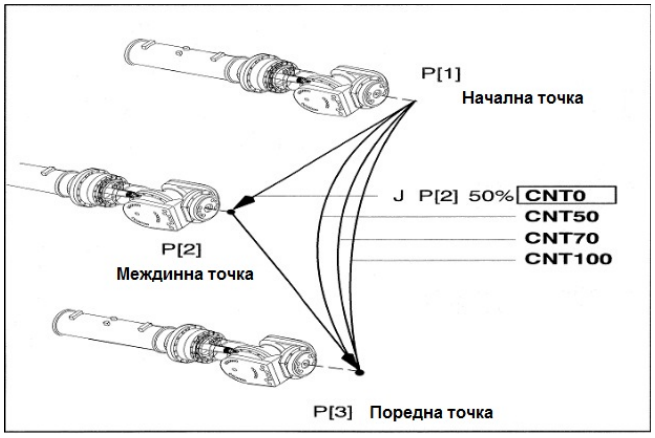

Fig. 4 *Transition types between adjacent points.*

Other motion instructions are also required to establish the desired behavior of the robot. Such instructions can be speed definition and additional motion instructions, which are related with the overall performance of the arm.

It is important to note that transition from point to point of the trajectory must have a consistent configuration, otherwise it can cause inability to execute the motion instruction because of the control unit generates errors. The configuration of the robot refers to the actual construction of the arm, desired location to move, and system variables of the controller. A member of the construction constraints, for example, is the number of controlled axes (Fig. 5). The program in depth is a set of instructions, defining the points forming the path, and branch instructions to control the order of execution of movements depending on specific requirements for the task. Every movement of the robot is determined form the origin of the robot (the crossing point of first two axes). By the data collected via encoder of every axis and the dimensions of the arm links, which are known, the controller obtains the location of the robot effector. To fully define the desired trajectory two additional points should be taught. First one is related to the device attached to the end-effector, representing the tool centre point, and second – point which specifies the instrument centre point. Thus, the control unit computes all displacements for the each axis. The procedures for definition of an instrument and tools are integrated in the controlling unit. There are 3 methods, by teaching 3 or 6 points and direct input for coordinates. For the particular case, the last method is chosen, because the CAD model of the gripper is available. The instrumental coordinate systems are trained via 3 point method. All coordinates are in a Cartesian representation.

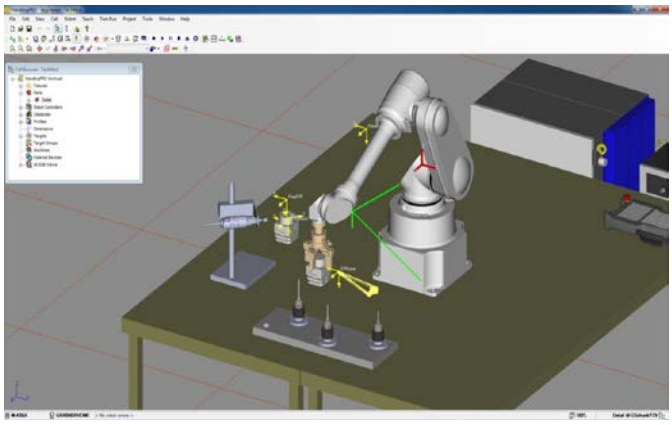

Fig. 5 *Taught positions in ROBOGUIDE.*

Three cutting tools are used for the experiment. That requires teaching of 6 user frames (Cartesian). The reason for use 6, instead of 3 user frames, is that the end-effector cannot keep constant the attitude of the work piece when J5 axis is lying in XY plane.

The creation of the robot's programs is performed via teach pendant (teach pendant programming). The programming language, developed by FANUC, includes high-level integrated functions. This enhances the ease of the reading programs. The controller provides the subsequent translation of the instructions, sended to the axes drives.

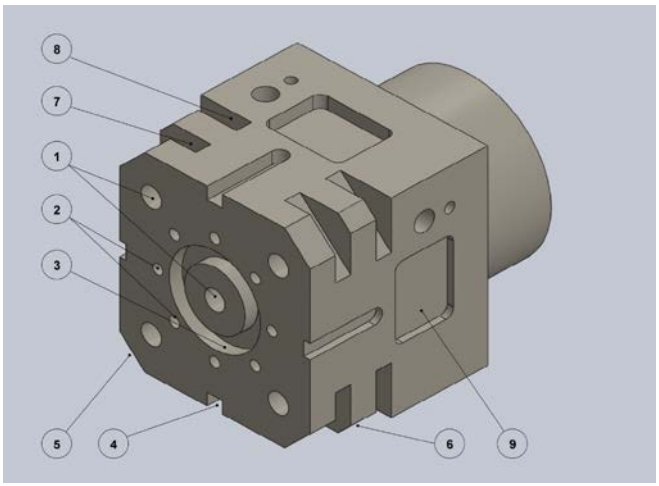

Fig. 6 *Operation sequence.*

A machining experiment was conducted to the test the robot [2] capabilities for operational proposes. Sixteen programs were developed in total:

- Supporting programs: GRAB; DROP; PICKnDPHOME; DPHOMEnDROP - for operating the gripper, pick (or place after machining) work piece in specified place and positioning above the cutters.

- Drill operation programs: DRILLG, DRILLF, SD8, SD5 (№ 1 and 2, Fig. 6).

- Operations for channel milling: CHANTF, SIDECH, CHANSTEP1, CHANSTEP2 (№ 3, 4, 7 and 8, Fig. 6).

- Chamfering programs: CHANT, CHANT2 – (№ 5 and 6, Fig. 6).

- A program for machining pocket in the side surface of the work piece: POCK (№ 9, Fig. 6).

- The main program is TECHPROCES, which specifies the sequence of the operations.

In Fig. 7, 8 and 9 are shown the logical structure, a part of the program and the real execution of CHANSTEP1 operation.

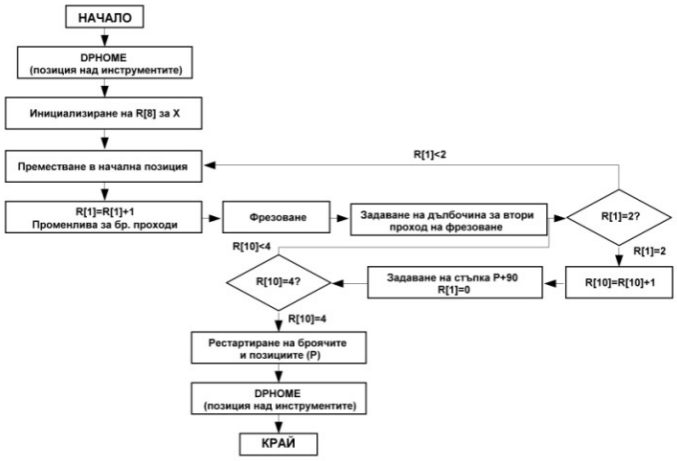

Fig. 7 *CHANSTEP1 block-logic.*

```
/PROG  CHANSTEP1
/ATTR
OWNER           = MNEDITOR;
COMMENT         = "CHAMF 1";
PROG_SIZE       = 1544;
CREATE          = DATE 14-07-19  TIME 01:46:54;
MODIFIED        = DATE 14-07-19  TIME 18:59:08;
FILE_NAME       = CHANSTEP;
VERSION         = 0;
LINE_COUNT      = 47;
MEMORY_SIZE     = 1984;
PROTECT         = READ_WRITE;
TCD:  STACK_SIZE        = 0,
      TASK_PRIORITY     = 50,
      TIME_SLICE        = 0,
      BUSY_LAMP_OFF     = 0,
      ABORT_REQUEST     = 0,
      PAUSE_REQUEST     = 0;
DEFAULT_GROUP   = 1,*,*,*,*;
CONTROL_CODE    = 00000000 00000000;
/APPL
/MN
   1:  !FANUC Robotics America ;
   2:  !ROBOGUIDE Generated This TPP ;
   3:  !Run SimPRO.cf to setup frame and ;
   4:  UTOOL_NUM[GP1]=1 ;
   5:  UFRAME_NUM[GP1]=4 ;
   6:  PR[24,1:STEP1 STP]=R[8:CHAMF1 X]    ;
   7:  PR[25,1:STEP1 EP]=R[8:CHAMF1 X]    ;
   8:  PR[26,1:STEP1 STP ABOVE]=R[8:CHAMF1 X]    ;
   9:  PR[27,1:STEP1 EP ABOVE]=R[8:CHAMF1 X]    ;
  10:J P[1] R[11:Vfast]% FINE    ;
  11:L P[2] R[11:Vfast]mm/sec FINE    ;
  12:J P[3] R[11:Vfast]% FINE    ;
  13:L P[4] R[11:Vfast]mm/sec FINE    ;
  14:  R[1]=0    ;
  15:  LBL[1] ;
```

Fig. 8 *Code segment of CHANSTEP1 program.*

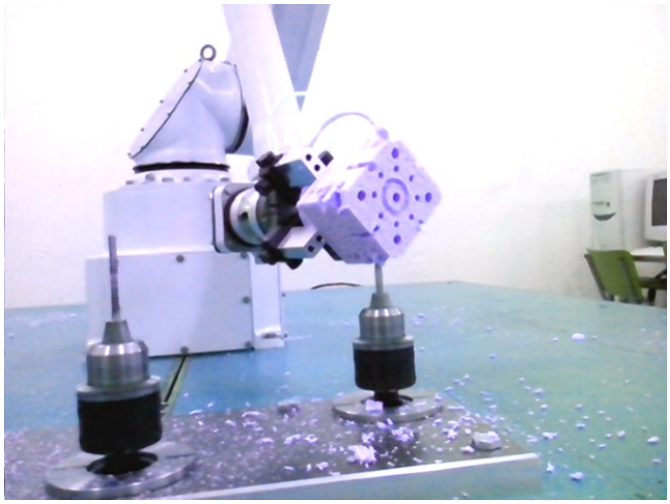

Fig. 9 *CHANSTEP1 execution.*

After the completion of teaching and calibration procedures a test execution is performed (Within ROBOGUIDE and in a real controller test mode). Any corrections are implemented if necessary. All programs and variables used should be transferred from the software to the robot controller via the communication interface (RS-232 or Ethernet) or an USB drive.

The results from the tests conducted allow a primary evaluation of the implementation capabilities of a FANUC M430i-A/4FH robot for technological operations, and guidelines for system improvement.

3. Conclusions

1. With certain limitations, a FANUC M430i-A/4FH robot can be used for various machining applications (milling, boring/turning, drilling, grinding/polishing, etc.).

2. The developed system, based on a FANUC M430i-A/4FH robot can be used both for the purposes of training and research.

3. To expand the robot capabilities for technological operations is required: establishing end-effector to execute continuous rotation about J5 axis (>540^0); improving the arm stability for cutting forces above 40N (4kgf) to increase the feed rates and improvement of repeatability as well.

4. To establish capabilities for complete process execution is required to expand the system functionality by using active control peripheral subsystems.

5. To create, or modify, path planning algorithms for automation of the programming.

6. To expand software [3] capabilities is required to develop software integration for some existing CAD/CAM products (e.g. SolidWorks).

7. To establish a direct robot control via the communication interface between PC and the robot controller.

8. To develop databases containing algorithms for optimizing the system capabilities during the development of new technological processes, programming and their realization.

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ПРИЛОЖЕНИЕ ЗА БАЗИРАНЕ НА ДЕТАЙЛИ, ИНТЕГРИРАНО В SOLIDWORKS

AN INTEGRATED ADD-IN FOR LOCATING PARTS IN SOLIDWORKS

Проф. Николчева Г., Маг. Инж. Михайлов О.
Технически университет – София, България

ginic@tu-sofia.bg, omihaylov@tu-sofia.bg

Abstract: *A fixture is a special tool used to accurately and stably locate the workpiece during machining process. Proper fixture design improves the quality and production of parts and also facilitates the interchangeability of parts that is prevalent in much of modern manufacturing. Traditionally, fixture design has been carried out manually and extensive heuristics knowledge from the designer is needed. This is time-consuming and reduces the productivity. An automated fixture design system is one that automates the selection of fixturing points and elements by the use of certain design techniques such as rule-based design, case-based design, or other AI tools. In the process of design automation, CAD technology plays a vital role in modeling the fixtures geometrically and rendering the design solution graphically.*
In this paper is presented a locating module in the format of add-in for SolidWorks which uses rule-based reasoning. Its functions are to determine the locating points, to select one of three locating methods (3-2-1 point locating, plane and pin-hole locating or V-block locating) and to create assembly with the part (prismatic or cylindrical).
Keywords: FIXTURES, COMPUTER-AIDED FIXTURE DESIGN, SOLIDWORKS, ADD-IN

1. Увод.

Приспособленията за установяване на заготовки и детайли са от голяма важност, както в традиционното, така и в гъвкавото производство, тъй като директно влияят върху качеството на обработка, производителността и цената на продукта. Времето, прекарано в проектиране и производство на приспособленията, е значителна част от времето за производство на крайните продукти [16].

Приспособленията се използват в единичното, серийното и масовото производство за точно позициониране и сигурно закрепяне на заготовката, за да се гарантира, че обработките са изпълнени съгласно конструкторските изисквания [7]. При машинната обработка геометричната точност на обработваният детайл зависи основно от относителното положение между заготовката и обработващия инструмент[15]. От приспособленията се изисква да осигурят това положение, за да се гарантира качество на производството.

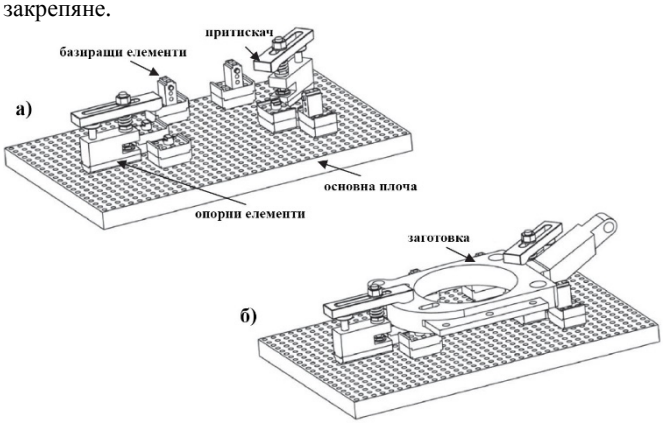
Позиционирането на детайла влияе пряко върху качеството на обработката, продуктивността и цената на продукта. Всъщност разходите, свързани с конструирането и производството на приспособления, възлизат на 10-20% от общата цена на производствената система [2]. Тези разходи включват не само производството, сглобяването и използването на приспособленията, а и тяхното конструиране, така че има значителни плюсове от намаляването на разходите за проектиране, свързани с приспособленията. За да се гарантира, че един детайл ще бъде изработен съгласно специфични размери и изисквания за точност, той трябва да бъде правилно базиран, което прави много важно разработването на инструмент, който ще елиминира метода проба-грешка при проектирането и производството на приспособленията [3].

В момента модулният тип приспособления са най-широко използваните гъвкави приспособления в индустрията. Базирани на стандартизирането на елементите, изграждащи приспособленията, те са проектирани като групи от предварително изработени стандартни елементи и единици. Те имат относително тесни геометрични допуски, които могат да бъдат сглобени бързо в различни конструкции за базиране и закрепяне на детайли с различна геометрия и изисквания. След приключване на всички обработки, модулните приспособления могат да бъдат разглобени и използвани отново за други детайли и обработки [19]. По този начин те се различават от специализираните приспособления, които след приключване на производството се бракуват.

С годините прилагането на модулни приспособления е довело до значителни технологически и икономически ползи, включително следните 4 аспекта [16]:

1. Значително се намалява подготвителното време. Използването на модулни приспособления може да намали времето за подготовка с над 80%.
2. Намаляват се производствените разходи, тъй като модулните приспособления се използват многократно.
3. Използването на модулни приспособления помага за осигуряване на качеството на продуктите. След като бъдат сглобени, модулните приспособления имат възможността да бъдат пренастроени и така да подобрят качеството на продукцията.
4. Използването на модулни приспособления може да разшири възможностите на производствената екипировка и да подобри производителността.

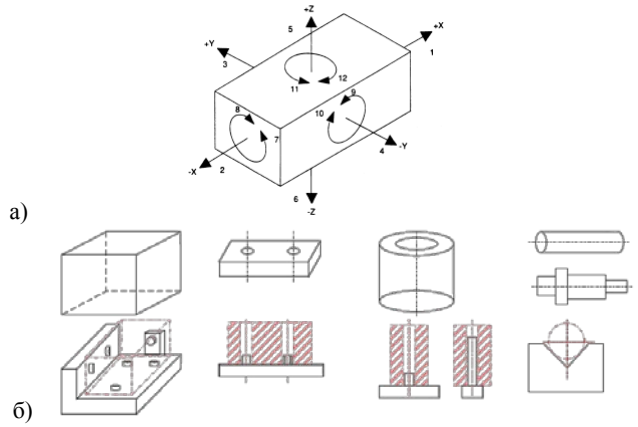
Приспособленията, използвани при машинна обработка, представляват системи от елементи, включващи базова плоча и устройства за базиране и закрепване на детайла/заготовката. На фиг. 1 е представен пример за приспособление, при което детайлът е базиран върху базиращи елементи, определящи точно местоположението му [4]. Затягащите устройства притискат детайла към тях и гарантират положението му по време на обработките. Те се състоят от опорни елементи и притискачи, които контактуват с детайла и предават сила за закрепяне.



Фиг. 1. *Приспособление със и без заготовка [4].*

Обикновено процесът на проектиране на приспособления се състои в определянето на положенията на притискачите, базиращите и опорните елементи и правилният им избор.

Броят и положението на базиращите елементи трябва да бъдат такива, че на заготовката да ѝ бъдат отнети $6^{-те}$ степени на свобода по време на обработките (фиг. 2а), например чрез базиране по три равнинни повърхнини (метод 3-2-1), една равнинна повърхнина и два отвора (два щифта – цилиндричен и изрязан), една равнинна повърхнини и един отвор (с дълъг щифт) и по цилиндрична повърхнина(с дълги или къси V-блокове) (фиг. 2б).



Фиг.2. *Степенни на свобода на детайл [4] и отнемането им [14].*

3. Компютърно подпомогнато проектиране на приспособления (CAFD).

Процесът на проектиране на приспособления е времепоглъщащ и може да се окаже много скъп, поради честото използване на метода проба-грешка. Поради тези причини разработването на автоматизирани системи за проектиране на приспособления е много важен проблем. С използването на такива системи може да се съкрати времето за проектиране, чрез използване на бази данни с готови приспособления, използване на универсални сглобяеми приспособления на базата на модули, по-бързо нанасяне на корекции в дизайна на приспособленията, бърза и точна проверка на стабилността на дизайна (напр. чрез използване на Метод на крайните елементи) и др. Освен това се съкращават разходите и материалите за производство на предварителни (грешни) конструкции.

Автоматизацията на процеса се извършва успешно с използването на системи за компютърно подпомогнато проектиране на приспособления (Computer Aided Fixture Design - CAFD). Тези системи се използват за частично или пълно автоматизиране на процеса на проектиране на приспособления, като целта е генериране на подходяща конструкция за кратък период от време, като се сведе до минимум субективното влияние на конструктора. Като се вземе предвид структурната и функционалната организация на една автоматизирана система за конструиране/проектиране, както и всичките ѝ свойства, може да се каже, че всички такива системи се характеризират от наличието на 6 основни конструктивни елементи [17]:

- технически основи – хардуерът, който трябва да има висока работна скорост, голяма памет, да бъде качествен, надежден и т.н.;
- база данни – стандартизирани елементи, универсални приспособления, предишни решения и др.;
- софтуерна система – състояща се от две части: оперативна и приложна;
- човешки ресурси – за разработване, използване и поддръжка на системата;
- входяща информация – конструктивна информация за детайла, технологична информация и информация относно организацията на работата;
- изходяща информация – информация (чертежи, физически данни, икономически резултати и др.) за приспособлението като цяло и за всеки отделен елемент.

Автоматизацията на проектирането на приспособления чрез използването на CAFD системи е особено важно за конкурентоспособността и влиянието им нараства с подобряването на възможностите CAD/CAM системите и внедряването на методи, използващи изкуствен интелект (AI) [6]. Въпреки че CAM системите покриват много от производствените дейности (напр. генериране на пътя на инструмента), пълната автоматизация на CAFD все още не е постигната. Основното предизвикателство тук е как да се компютъризират човешките знания и опит, така че да бъдат използвани от системата. Множество методи се използват за постигането на тази цел, като един от най-често използваните е с помощта на правила тип АКО-ТОГАВА-ИНАЧЕ (IF-THEN-ELSE). При задаване на данни за проблема, чрез серия от въпроси и отговори, основани на тези правила, се генерира решение. Kumar представя рамка, с която да се автоматизира процесът на проектиране на приспособления. Тя комбинира математически анализи и експертни системи[12]. Резултатът, извеждан от системата, е последователност за сглобяване на елементите в приспособлението. Nnaji и Aladin предлагат структура на експертна система за CAFD [13]. Те прилагат IF-THEN правилата, за да развият знанията, и системата PROLOG като експертен подход за създаване на правилата за проектирането.

Друг често използван метод е Логика, базирана на предишни случаи (CBR), при който се използва база данни от готови решения. Те се използват за генериране на нови решения, които след това се добавят в базата данни. Kailing и др. го прилагат в CAFD система, като са добавили правила и база от знания (експертна система) за проектиране на подходящ дизайн [8]. Boyle и Kevin са представили методология, наречена CAFixD, в която е приложен CBR метода. Целта им е обхващането на пълния процес на проектиране на приспособления[3].

Много често се използват методи с размита логика. Тя е използвана от Martin и Lombard в техния метод, който определя подходящи системи за позициониране [11]. Те определят че размерите на основната плоча и материала за детайлите са главните критерии за една позициониращa система. При този метод правилата IF-THEN са използвани за определяне на критериите за позициониране. Zhang и Peng представиха система, комбинираща размита логика и логика, базирана на правила (RBR) [18]. Тяхната система е разделена на две подсистеми – подсистема, планираща установките и подсистема проектираща приспособленията.

Освен изброените методи съществуват и много други, както самостоятелни, така и свързани с широко използвани CAD, CAM и CAPP системи. Farhan представя своята CAFD система за полуцилиндрични детайли, интегрирана в SolidWorks[5]. Babu и сътрудници представят автоматизирана система за проектиране на модулни приспособления, използваща AutoCAD платформа и програмата AutoLISP [1]. Този подход се основава на 2D чертежи. Ма и др. разработват система, наречена FIX-DES, разработена с помощта на C и C ++ програми и специфична CAD среда [10]. Конг и др. представят база данни от стандартизирани елементи и CAFD система на базата на AutoCAD, VC++ и AutoLISP [9].

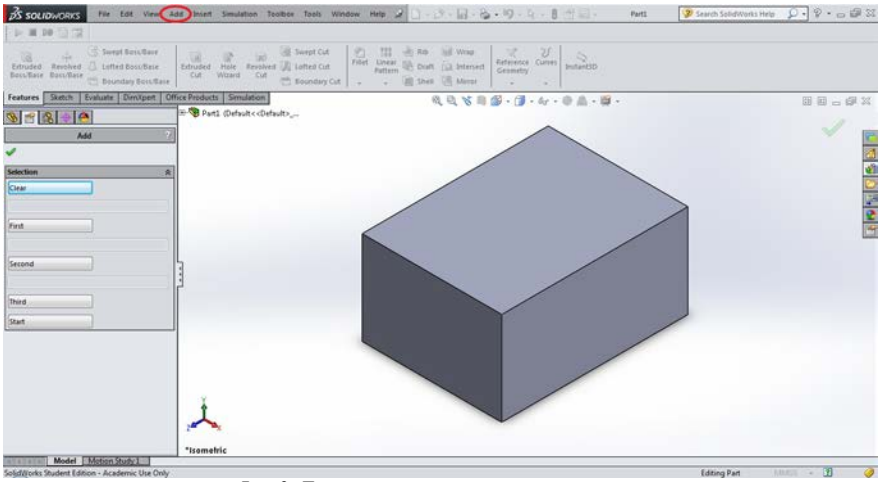
В тази статия се представя модул за автоматизирано базиране на детайли, използващ правила и интегриран в SolidWorks. Той е създаден като приложение тип „add-in“ в средата на Visual Studio на езика VB.NET и е интегриран в SolidWorks чрез

неговия API. Целта на този модул е улесняване проектирането на модулни приспособления, като е фокусиран единствено върху базирането на детайлите. С негова помощ се намалява времето за проектиране и се позволява лесна промяна на установката при незадоволителен резултат.

4. Работа с модула за базиране.

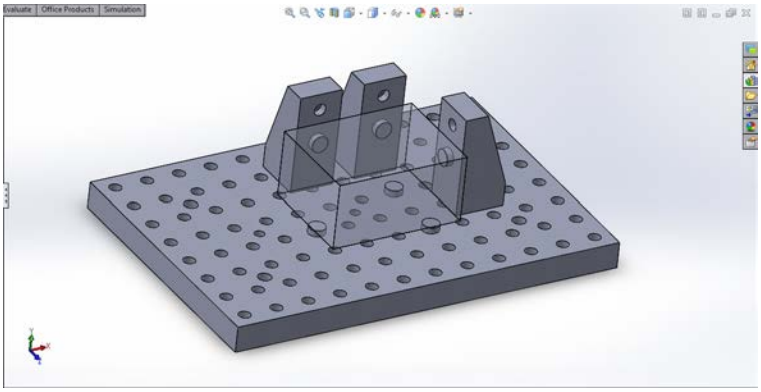
SolidWorks е една от CAD системите поддържащи интерфейс за програмиране на приложения (API), който позволява автоматизирането на множество проектантски дейности, както на единични детайли, така и на сглобени единици. Това се извършва чрез създаване на код от потребителя на някой от поддържаните програмни езици (C++, C#, Visual Basic и др.).
С помощта на API и езика Visual Basic .NET е създадено модул, интегриран в SolidWorks, позволяващ автоматизиране процеса на базиране на призматични и цилиндрични детайли. Базирането е по един от три метода – 3-2-1, по равнинна повърхнина и два отвора или по цилиндрична повърхнина, с което модула има по-широко приложение от други системи, фокусиращи се върху един метод или върху един вид детайли. Автоматизирането не е пълно, тъй като в началото се изисква потребителя да избере ръчно базиращите повърхнини.
При отворен детайл тип „PART“ приложението се стартира от съответния бутон в Toolbar менюто. Стартира се страница в левия край на екрана (Property Manager Page), с помощта на която се извършва избора на повърхнини. Тя съдържа (фиг.3):

- бутон за изчистване на избраните повърхнини – изтрива зададените имена и допълнително създадени равнини, за да позволи нов избор;
- 3 бутона за избор на повърхнини – потребителя избира повърхнина и натиска съответния бутон, за да потвърди избора си и да провери дали повърхнината не е вече избрана за база;
- 3 полета за избор на повърхнини – текстови полета в които се потвърждава избора на потребителя или се съобщава, че избраната повърхнина е заета или неподходяща;
- бутон START – за стартиране автоматизираната дейност на приложението.



Фиг.3. *Детайл със стартирано приложение.*

Когато потребителят избере бутон програмата проверява кой той и, като използва правила, изпълнява съответното действие. Ако избраният бутон е „First“ се използват правила, за да се определи дали избраната повърхнина е равнинна плътна, равнинна с отвори или цилиндрична. Ако бутонът е “Second” или “Third” с правила се проверява дали избраната повърхнина е равнинна и перпендикулярна с първата (и втората). Когато потребителят избере бутон “Start”, програмата използва правила, за да избере вида на базирането на база на вида и броя на избраните повърхнини. След това с помощта на функции, предоставени от API, се определят размерите им и положението на базиращите елементи. Позициите на палците и щифтовете се определят от приложението според размерите на детайла, разположението на отворите и схемата на разпределение на отвори върху плочата. В този смисъл минималното разстояние между два палеца/щифта за използваната базова плоча е 50 mm във всяка посока, което налага ограничение върху минималните размери на детайлите и разстоянието между осите на отворите. Програмата приключва работа като създава нов файл тип „ASSEMBLY“, в който разполага базова плоча, базиращи елементи, съответстващи на вида базиране (базиращи палци, щифтове, V-блокове) и детайла (фиг.4). Моделът остава активен за по-нататъшни действия от страна на потребителя.



Фиг.4. *Сглобено приспособление с детайл.*

Използваните правила са от вида IF-THEN-ELSE с множество аргументи и включени правила в правилата. Всички те са част от кода на програмата.

Пример за такива правила е при избора на първата повърхнина:

АКО избраната повърхнина е равнинна ТОГАВА

АКО повърхнината е плътна ТОГАВА

Активира се бутон „Second“ за избор на втора повърхнина

ИНАЧЕ АКО повърхнината има два отвора ТОГАВА

Активира се бутон „Second“ за избор на втора повърхнина и бутон “Start” за създаване на сглобена единица.

ИНАЧЕ АКО повърхнината е цилиндрична ТОГАВА

Активира се бутон “Start” за създаване на сглобена единица.

Като се позволи избора на втора повърхнина при избрана първа равнинна с два отвора се дава избор на потребителя дали детайлът да се базира по метод 3-2-1 или по равнинна повърхнина и два отвора. Така потребителя може да сравни визуално двата метода за един и същи детайл, без да се налага да променя модела като премахва отворите.

5. Изводи.

Представен е модул за автоматизиране на процеса за базиране на призматични и цилиндрични детайли в средата на SolidWorks. То е написано на езика VB.NET и използва възможностите на вграденият интерфейс за приложения (API). С негова помощ се съкращава времето за определяне позициите на базиращите елементи и за сглобяване на приспособлението за базиране на детайла. Той позволява сравняването на различни варианти за базиране – по различни повърхнини или по различни методи (3-2-1 или по два отвора и равнинна повърхнина). Модулът е в процес на развитие за по-сложни детайли (напр. базиране по стъпаловидна повърхнина). Той е част от автоматизирана CAFD система, разделена на модули – за базиране, за затягане, за верификация.

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КОМПОНЕНТНО-БАЗИРАНО УПРАВЛЕНИЕ НА ОБСЛУЖВАЩИЯТ МОДУЛ PIC ALFA НА СТАНЦИЯ FESTO MPS HANDLING

Христо Карамишев, Георги Попов
Технически Университет – София, МТФ, България
hristo_karamishev@tu-sofia.bg, gepop@tu-sofia.bg

Abstract: *The IEC 61499 standard defines control architecture and models for develop of distributed control applications. The base model of IEC 61499 standard is Functional Block model. The report aims to present the development of IEC 61499-based control of PicAlfa module for FESTO handling station.*

Keywords: IEC 61499, FESTO HANDLING STATION

1. Увод

Съвременните индустриални системи трябва да притежават управление, което да е в състояние динамично да промени структурата си в реално време. Системите за управление, базирани на стандарта IEC 61499 [1] създават възможност за динамично, отдалечено и реконфигуриращо се управление на индустриални системи и процеси. За да се постигне реконфигуриращa се способност на системите за управление, като същевременно отговарят на необходимите изисквания на системите от ниско ниво, е необходимо разработката на реконфигуриращо се приложение и подкрепа в средата за изпълнение [2]. Реконфигуриращото се приложение трябва да осигурява необходимите реконфигуриращи се услуги. Средата за изпълнение трябва да осигури условия, в реално време да бъде изпълнено приложението за управление [3].

Стандартът IEC 61499 дефинира следните основни модели: модел на приложение, модел на система, модел на устройство, модел на ресурс и модел на функционален блок. Всички тези модели дават възможност да се разработват разпределени приложения за управление в графичен вид [4]. Централно място в концепцията на стандарта IEC 61499 заема моделът на основен функционалния блок (ФБ) [5]. Той може да бъде използван за дефиниране на преизползваеми софтуерни компоненти [6].

Цел на настоящата статия е разработката на модел на основен ФБ за управление на обслужващ модул на станцията ***Festo MPS Handling*** [7], предназначена за преместване и сортиране на детайли между няколко станции, включени в индустриална система.

2. Обслужващ модул PicAlfa на станция Festo MPS Handling

А) Обслужваща станция Festo MPS Handling

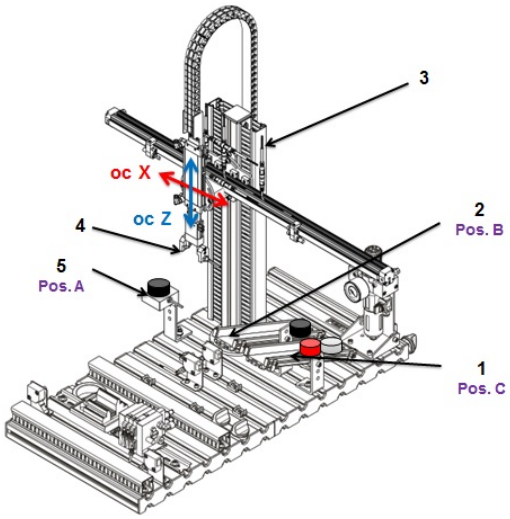
Обслужващата станция ***Festo MPS Handling*** е екипирана с двуосно обслужващо устройство **PicAlfa** (фиг. 1, позиция ***3***), което разпознава детайлите, поставени на входната позиция ***5*** чрез оптичен сензор.

Обслужващото устройство взема детайлите, поставени на входната позиция с помощта на пневматично устройство за захващане ***4*** (захват). Детайлите се разпознават от устройството чрез сензор, който ги класифицира като „черен детайл“ и „нечерен детайл“. В съответствие с този критерий, обслужващото устройство подрежда детайлите в съответния улей.

Б) Последователност при работа на станцията

Стартиране и инициализация

- Постъпване на детайл Д във входната позиция ***5*** (**Pos.A**);
- Линейната ос е в позиция „предишна станция“;
- Пневмоцилиндърът е изтеглен (захватът е повдигнат в горно положение);
- Захватът е отворен.



Фиг. 1: *Обслужваща станция* ***Festo MPS Handling*** *[7]*

Последователност при работа

1. Пневмоцилиндърът се издига при наличие на детайл във входната позиция.
2. Захватът е затворен. Цветовата идентификация на детайла е включена.
3. Пневмоцилиндърът е изтеглен.

Поставяне на черен детайл

4. Линейната ос доближава позицията ***2*** „улей 1“ (**Pos. B**).
5. Пневмоцилиндърът се придвижва.
6. Захватът се отваря и детайлът се поставя върху улея.
7. Пневмоцилиндърът се изтегля.
8. Линейната ос се премества на позицията „предишна станция“.

Поставяне на червен/метализиран детайл

9. Линейната ос доближава позицията ***1*** „улей 2“ (**Pos. C**).
10. Пневмоцилиндърът се придвижва.
11. Захватът се отваря и детайлът се поставя върху улея.
12. Пневмоцилиндърът се изтегля.
13. Линейната ос се премества на позицията „предишна станция“.

В) Модул за обслужване на детайлите ***PicAlfa***

Основният модул на станция ***Festo MPS Handling*** е обслужващия модул ***PicAlfa*** (фиг. 2), който е двуосно устройство за обслужване, разпознаване и преместване на детайли. Чрез модула се взема детайл от една позиция и се премества на друга. Позициите могат да са предходна или следваща станция, улеите на обслужващата станция или „вх/изх“ позиция (в зависимост от конфигурацията на станцията).

Фиг. 2: *Пневматично устройство за обслужване на детайлите* ***PicAlfa*** *[7]*

Фиг. 3: Оптичен дифузен сензор [7]

Детайлите се откриват от обслужващия модул чрез оптичен дифузен сензор (фиг. 3), който прави разлика между "черни" и "нечерни" детайли.

Дължината на хода, наклона на осите, както и разположението на сензорите за крайните положения на хода на модула се настройват при монтаж в зависимост от задачите за изпълнение на станцията. Модулът **PicAlfa** има следните основни параметри:

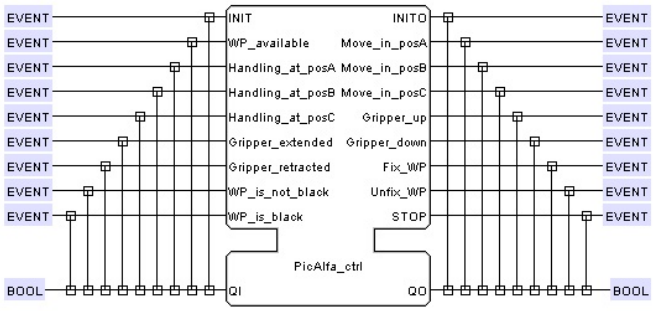
- линейно задвижване (хоризонтална ос **X**): дължина на хода 600 mm, включени са три сензора за крайно положение;
- пневматичен плосък цилиндър (вертикална ос **Z**): дължина на хода 80 мм, включени са два сензора за крайно положение;
- пневматичен захват/грипер (gripper);
- височина 700 mm;
- широчина 220 mm;
- дължина 730 mm.

3. IEC 61499-управление на обслужваща станция Festo MPS Handling

На фиг. 1 е даден сценарият, за който е разработено управлението на обслужващият модул на станцията ***Festo MPS Handling***. Детайлите постъпват в позиция 5 (**Pos. A**) откъдето обслужващият модул ги взема и ги сортира по следния критерий:

а) черните детайли – в улей 2 (**Pos. B**);

б) нечерните детайли (червените и метализираните) – в улей 1 (**Pos. C**).



Фиг. 4: *Интерфейс на ФБ „PicAlfa_ctrl” за управление на модула за обслужване на детайлите*

На фиг. 4 е представен интерфейс на ФБ **„PicAlfa_ctrl”** за управление на модула за обслужване на детайлите на станция ***Festo MPS Handling***. Моделът на IEC61499-базирания блок е разработен в средата на софтуерния инструмент **FBDK.** В табл. 1 са описани входните и изходните събития на блока. Той се активира при настъпване на входни събития **INIT**, **WP_available**, **Handling_at_posA**, **Handling_at_posB**, **Handling_at_posC**, **Gripper_extended**, **Gripper_retracted**, **WP_is_not_black** и **WP_is_black**. Изходни събития за блока са **INITO**, **Move_in_posA**, **Move_in_posB**, **Move_ in_posC**, **Gripper_up**, **Gripper_down**, **Fix_WP**, **Unfix_WP** и **STOP**.

Табл. 1: Входни и изходни събития на ФБ **„PicAlfa_ctrl”**

ВХОДНИ СЪБИТИЯ	
INIT	Инициализация на ФБ
WP_available	Постъпил детайл върху станцията, настъпва входно събитие **WP_available**. Получава се сигнал от сензор **PART_AV**.
Handling_ at_posA	Обслужващото устройство е достигнало позиция **A**. Получава се сигнал от сензор **1B1**.
Handling_ at_posB	Обслужващото устройство е достигнало позиция **B**. Получава се сигнал от сензор **1B2**.
Handling_ at_posC	Обслужващото устройство е достигнало позиция **C**. Получава се сигнал от сензор **1B3**.
Gripper_ extended	Захватът на обслужващия модул е достигнал крайно долно положение, при което сортира или взима детайлите. Получава се сигнал от сензор **2B1**.
Gripper_ retracted	Захватът на обслужващия модул е достигнал крайно горно положение. Получава се сигнал от сензор **2B2**.
WP_is_not_ black	Постъпилият детайл върху станцията е нечерен. Получава се сигнал от сензор **3B1**.
WP_is_black	Постъпилият детайл върху станцията е черен. Получава се сигнал от ФБ за време.
ИЗХОДНИ СЪБИТИЯ	
INITO	Потвърждение за инициализацията на ФБ
Move_in_posA	Обслужващото устройство да се премести в позиция **A**.
Move_in_posB	Обслужващото устройство да се премести в позиция **B**.
Move_in_posC	Обслужващото устройство да се премести в позиция **C**.
Gripper_up	Преместване на захвата към крайно горно положение.
Gripper_down	Преместване на захвата към крайно долно положение.

Fix_WP	Фиксиране на детайла в захвата (вземане на детайла).
Unfix_WP	Освобождаване на детайла от захвата (оставяне на детайла).
STOP	Спиране на устройството.

Графът за изпълнение на управлението на ФБ за управление на разпределителния модул на станция ***FESTO MPS Sorting*** е представен на фиг. 5. Когато постъпи детайл върху станцията, оптичен сензор **PART_AV** създава сигнал, настъпва входно събитие **WP_available**, активира се състоянието **Grip_det** и се генерира изходно събитие **Gripper_down**. Захватът (фиг. 1, поз. 4) се премества по ос **Z**, като достига детайла, съответно и крайното си долно положение. Тук е монтиран сензор **2B1**, който създава сигнал и активира входното събитие **Gripper_extended**, активира се състоянието **Fixing_det** и се генерират последователно двете изходни събития **Fix_WP** (захващане на детайла) и **Gripper_up** (включване на преместването по ос **Z** към крайно горно положение). Към захвата е монтиран оптичен сензор **3B1**, чрез който се разпознават детайлите вид „нечерен“. В зависимост от вида на детайла (черен или нечерен (червен или метализиран/сив)), в графа за изпълнение на управлението са включени следните два паралелни клона на графа за изпълнение на управлението, които са алтернативни.

А) Ако в обслужващото устройство е захванат червен или метализиран детайл, то от сензора **3B1** се създава сигнал, като се активира входното събитие **WP_is_ not_black**. Активира се състоянието **Move_Handling_ in_posC** и се генерира изходно събитие **Move_in_posC**. Обслужващият модул се премества по ос **X** и достига **улей 1** (**pos. C**). Сензорът в позицията **1B3** създава сигнал, активира се входното събитие **Handling_at_ posC**, активира се състоянието **Sort_not_black_det** и се генерира изходното събитие **Gripper_down** за включване на вертикалното преместване на детайла.

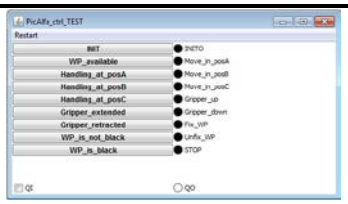
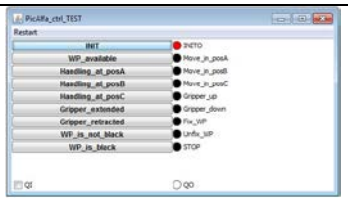
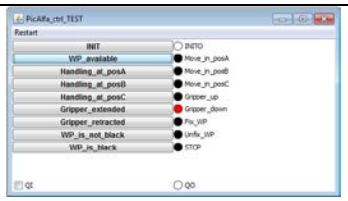
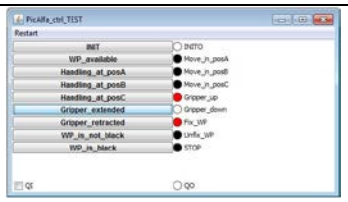
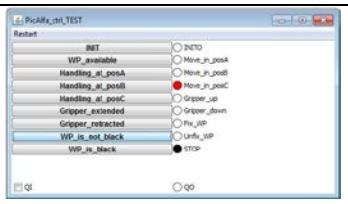
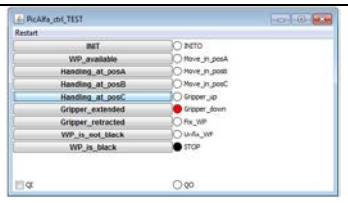
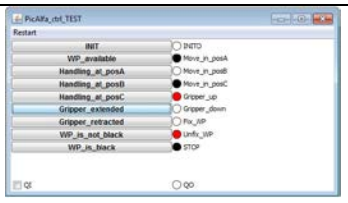
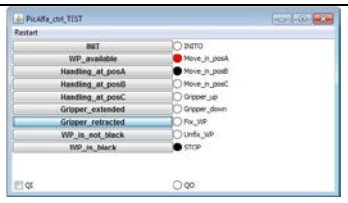
Б) Ако в обслужващото устройство е захванат черен детайл, се създава сигнал от специализиран функционален блок, активира се входното събитие **WP_is_ black**. Активира се състоянието **Move_Handling_ in_posB** и се генерира изходно събитие **Move_in_posB**. Захватът с детайла се премества по хоризонталната ос, като достига **улей 2** (**pos. B**). Сензорът в позицията **1B2** създава сигнал, активира се входното събитие **Handling_at_posB**, активира се състоянието **Sort_black_det** и се генерира изходното събитие **Gripper_down**.

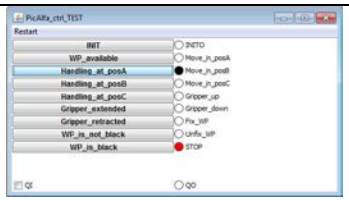
Обслужващото устройство с детайла достига крайно долно положение. Сензор **2B1** който създава сигнал, настъпва входното събитие **Gripper_extended**, активира се състоянието **Unfixing_det** и се генерират двете изходни събития **Unfix_WP**, за освобождаване/оставяне на детайла в съответния улей, и **Gripper_up**, за изтегляне на захвата по ос **Z** в крайно горно положение. Тук е монтиран сензор **2B2**, който създава сигнал и настъпва входното събитие **Gripper_retracted**, активира се състоянието **Move_Handling_at_initial_pos**, генерира се изходното събитие **Move_in_posA** и се включва преместването на обслужващото устройство към позиция **A**. При достигането ѝ настъпва входното събитие **Handling_at_posA**, активира се състоянието **Stop_device** и се генерира изходното събитие **STOP**. Станцията е в състояние на изчакване на постъпването на нов детайл.

В табл. 2 е представена симулация на функционалния блок **„PicAlfa_ctrl”** за управление на обслужващия модул на станцията ***Festo MPS Handling***. При натискане на софтуерен бутон съответстващ на дадено входно събитие, се активира свързаното с него едно или две изходни събития.

Симулацията на ФБ **„PicAlfa_ctrl”** съответстват на последователността от действия при обслужване на детайл тип „нечерен“.

Табл. 2: *Симулация на ФБ* ***„PicAlfa_ctrl”***

Входно събитие	**Симулационен прозорец**	**Изходно събитие**
Начално състояние		
INIT		**INITO**
WP_available		**Gripper_ down**
Gripper_ extended		**Fix_WP** **Gripper_up**
WP_is_ not_ black		**Move_in_ posC**
Han-dling_at_ posC		**Gripper_ down**
Gripper_ extended		**Unfix_WP** **Gripper_up**
Gripper_ retracted		**Move_in_ posC**

Handling at_posA		**STOP**

5. Заключение

Проведеното изследване постига следните резултати:

- извършен е анализ на възможностите и работата на станцията за обслужване на детайли ***Festo MPS Handling***;
- в средата на софтуерния инструмент **FBDK** е създаден модел на основен функционален блок за управление на обслужващия модул **PicAlfa** на станцията, базиран на стандарта IEC-61499;
- в средата на **FBDK** е изпълнена симулация на блока за верификация на разработения модел.

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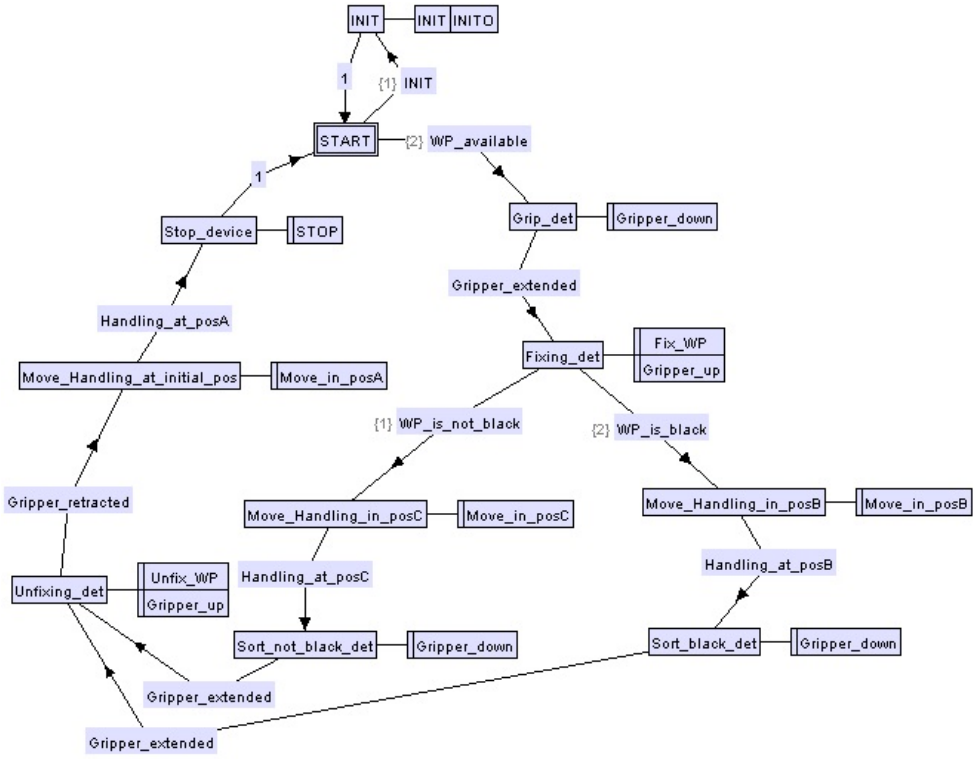

Фиг. 5: *Граф за изпълнение на управлението на ФБ „PicAlfa_ctrl"*

ONTOLOGY BASED DATA AND INFORMATION INTEGRATION IN BIOMEDICAL DOMAIN

Assist. Prof. Dr. Gocheva D. G., Assist. Eng. Eminova H. M., Prof. Dr. Batchkova I. A.
Dept. of Industrial Automation, University of Chemical Technology and Metallurgy
Bul. Kl. Ohridski 8, Sofia, Bulgaria

dani@uctm.edu, h_eminova@uctm.edu, idilia@uctm.edu

Abstract: *One of the main problems of biomedical informatics in the effort to increase its contribution in knowledge retrieval and decision making is the integration of ever-increasing amounts of information and data from multiple heterogeneous sources and domains - clinical, medical, biological etc. The paper proposes an ontology based approach for integration of biomedical data and information using the Linked Open Data vocabularies and a D2RQ-mapped database. A simple example of semantic integration of heterogeneous biomedical and health data sources is given.*

Keywords*:* BIOMEDICAL DOMAIN, ONTOLOGY, DATA, INFORMATION, INTEGRATION, LINKED OPEN DATA, OWL, RDF

1. Introduction

The biomedical domain is distinguished by rapidly and versatile implementation of the achievements of ICT. Significant and with continuous rates increases the amount of accumulated and used information which increasingly is stored in a different size, complexity, levels of abstraction, perspectives and areas of application databases and lexical glossaries, directories and ontologies. Particularly strong growth marks represention of biomedical entities, their terms and relations in form of vocabularies, terminologies and ontologies. Some of them contain overlapping information and some application may require a domain ontology which spans several ontologies. "Ontology integration" consists in establishing relations between concepts belonging to different ontologies. The effective use of this information stored on different sources, in different forms and formats is essential.

Biomedical ontologies provide essential domain knowledge to drive data integration, information retrieval, data annotation, natural-language processing and decision support. The main aim of the proposed paper is to suggest an ontology based approach supporting the data and information integration in the biomedical domain based on the concept of Linked Open Data supported by Linked Open Vocabularies (LOV) [http://lov.okfn.org/dataset/lov] and the OWL version of schema.org namespace [https://schema.org/docs/documentation/html], enhanced with the D2RQ platform for RDB2RDF transformation.

The paper is organized in 5 parts. After the introduction, in part 2 a short overview of existing biomedical ontologies, classified in four basic categories, is given. The third part of the paper discusses the approaches and problems by data and information integration. In Part 4 the suggested approach for ontology based data and information integration is described. Applicability of the suggested approach is illustrated with a case study in part 4. Finally some conclusions are made.

2. Short overview of biomedical ontologies

Too many research efforts have been made in the biomedical domain for creation and use of different in type and size ontologies. Most of current biomedical ontologies are principally taxonomic hierarchies with sparse relationships. Four basic categories of ontologies are in use in the biomedical domain, as shown in Fig.1: top-level ontologies or upper-level, upper-level domain ontologies, domain ontologies and application ontologies.

The top-level ontologies are one of the main pillars used as a formal foundation for building domain ontologies. The primary purpose of top-level ontologies is to describe the general concepts through a framework of axioms and definitions or categories such as continuant, process and boundary and relationships such as "is_a" (for subtype) and "part_of" [1, 2]. The most popular top-level ontologies, useful for the biomedical domain are DOLCE (Descriptional Ontology for Linguistic and Cognitive Engineering) [3] and BFO (Basic Formal Ontology) [4]. DOLCE is a high-level, domain-independent conceptual framework for representing meaning. BFO is a foundational ontology that aims to adopt the structural vocabulary introduced for the characterization of DOLCE as it concerns universals, without fussing about the modal interpretation [3, 1]. The next category includes ontologies, which contain core concepts of a given domain and is working as an interface between the top-level and different domain categories. Some of the most popular representatives of this category are UMLS (Unified Medical Language System) [5] and GALEN (General Architecture for Languages, Enclopedias and Nomenclatures in Medicine) [6]. UMLS support the development of computer systems in biomedical domain, based on the UMLS Knowledge Sources, composed of Metathesaurus, containing information about biomedical and health-related concepts, their various names, and the relationships among them; Semantic Network, providing consistent categorization of all concepts represented in the Metathesaurus and the SPECIALIST Lexicon including many biomedical terms in English. GALEN is one of the first attempts for representing coded patient information and uses common reference model for representing medical concepts.

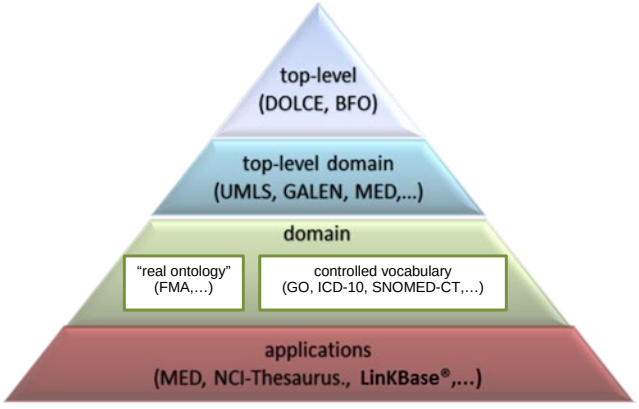

Fig.1*: Biomedical ontologies classification*

The largest category of ontologies in biomedical domain is this of domain ontologies, which represent knowledge about particular part of the world in a way that is independent from specific objectives, through a theory of the domains [1]. In reality, the number of real ontologies is not large. Therefore, they are considered two subgroups: real ontologies and controlled vocabularies. Representative of the first subgroup is the Foundational Model of Anatomy (FMA) [7, 8] that represents

declarative knowledge about structural organization of the human body with the intent of expanding the anatomical content of UMLS. The next subgroup includes the so called "controlled vocabularies" which are purpose-oriented and designed to meet particular needs, such as annotating biological databases (Gene Ontology (GO) [9, http://www.geneontology.org] and other OBO (Open Biological and Biomedical ontologies) ontologies [http://www.obofoundry.org/]) or medical records (ICD-10 [http://www.who.int/classifications/icd/en/], SNOMED CT [http://www.ihtsdo.org/snomed-ct]). OBO are set of orthogonal interoperable reference ontologies for biomedical domain built in the frame of OBO Foundry based on BFO, such as GO. GO as a part of OBO provides structured, controlled biological terminology that describes gene products in terms of their associated biological processes, cellular components and molecular functions in a species-independent manner. Medical records are presented by ICD-10 that is the 10th release of International classification of diseases, disorders, injuries and other related health conditions, and is used in clinical care, research, health care and globally for statistics and trends. The ICD-10 defines the universe of diseases, disorders, injuries and other related health conditions. One of the most comprehensive, semantically accurate, multilingual clinical healthcare terminologies in the world is represented in SNOMED CT, developed by IHTSDO (International Health Terminology Standards Development Organisation) and is used across all health systems, services and products in the world. The ontology concepts represent terms and processes that capture the meanings associated with healthcare related observations, procedures, functions and therapies. The NCI (National Cancer Institute) Thesaurus [http://bioportal.bioontology.org/ontologies/NCIT] is a description of logic-based terminology for clinical care, translational and basic research, public information and administrative activities, and is available on the NCI Term Browser [https://nciterms.nci.nih.gov/ncitbrowser/pages/].

The application ontologies, describes the semantic of a single information resource and are useful for terminology – oriented applications. For example the Medical Entities Dictionary (MED) [http://med.dmi.columbia.edu/] is a concept-oriented metadata dictionary in use at New York Presbyterian Hospital (NYPH) and is a repository of medical terms arranged in a semantic network. The concepts contained in MED include those from ICD-9CM, UMLS and LOINC. Another application ontology, designed to integrate terminologies and databases with applications in natural language processing and information retrieval, is LinKBase® [10].

3. Ontology based data and information integration

As discussed in the above part of the paper, there exist a lot of different specialized biomedical ontologies, databases, information systems, applications, semantic nets that combine data from several sources, each of which is accessed through an API specific to the data provider. The existence of a specialized API for each data set creates a landscape where significant effort is required to integrate each novel data set. Consequently, data returned from Web APIs typically exists as isolated fragments, lacking reliable onward links signposting the way to related data [11]. The applied approaches for data and information integration based on reference models and semantic nets fail to achieve a high degree of integration.

Linking biomedical data distributed in different models and representations requires a standard mechanism for specifying the existence and meaning of connections between items described in this data. The concept Linked Data is introduced by Tim Berners-Lee as unique identification and links between heterogeneous web resources to detect and retrieve information. Linked Data Platform 1.0 (W3C Recommendation since 26 February 2015) defines a set of rules for HTTP operations on web resources to provide an architecture for read-write Linked Data on the web. Linked Data Platform combines a common data model, a standard mechanism to access the data using the HTTP protocol, HTML hyperlinks and approved shared domain vocabularies. The success of Linked Open Vocabularies (LOV) as a central information point about vocabularies is symptomatic of a need for an authoritative reference point to aid the encoding and publication of data. The definitions of terms (classes, properties, or instances) provided by the LOV vocabularies bring clear semantics to descriptions and links thanks to the formal language they use, providing the semantic glue enabling data to become meaningful data. Vocabulary terms are identified by public URIs and can be linked inside a vocabulary and across vocabularies. The latest version of the Ontology for Biomedical Investigations (OBO) in LOV is from 01.08.2015. The large and growing set of terms in the schema.org namespace includes (and references) many established terms. Health and medical types in the schema.org ("MedicalEntity" and subtypes) are useful for content publishers that wish to mark up health and medical content on the web.

A key factor in the reusability of data is the extent to which it is well structured. Ontologies are succeeding to a large degree as a knowledge representation and data integration. Ontology matching is a solution to the semantic heterogeneity problem. It finds correspondences between semantically related entities of ontologies. In [12] ontology matching is formalized based on a unified account over a lot of previous works. The matching operation determines an alignment A′ for a pair of ontologies O_1 and O_2 as shown in Fig.2.

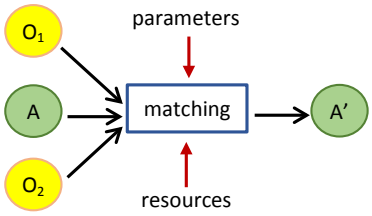

Fig.2: *Ontology matching*

An alignment is a set of correspondences between entities belonging to the matched ontologies. Alignments can be of various cardinalities: 1:1 (one-to-one), 1:m (one-to-many), n:1 (many-to-one) or n:m (many-to-many). Given two ontologies, a correspondence is a 4-uple <id, e_1, e_2, r>, such that: id is an identifier for the given correspondence; e1 and e_2 are entities, e.g., classes and properties of the first and the second ontology, respectively; r is a relation, e.g., equivalence (=), more general (⊒), disjointness (⊥), holding between e1 and e_2. The correspondence <id, e_1, e_2, r> asserts that the relation r holds between the ontology entities e1 and e_2. Correspondences have some associated metadata, such as the correspondence author name. A frequently used metadata element is a confidence in the correspondence (typically in the [0, 1] range).

4. Description of the suggested approach for data and information integration

The approach suggested in this paper in order to represent and integrate different biomedical data in RDF employing the standardized and widely used vocabularies as well as the publishing term definitions via the Linked Data principles.

4.1. Linked Open Data

The Linked Data approach offers significant advantages over current practices for creating and delivering biomedical data. Linked Data and especially Linked Open Data is sharable, extensible, and easily re-usable [13]. It supports multilingual functionality for data and user services, such as the labeling of concepts identified by language-agnostic URIs. Linked Data is expressed using standards such as RDFS, SKOS, and OWL, which specifies relationships, integrate information from multiple sources and are able to infer new information from a set of asserted facts. Quite often, the RDF/OWL ontologies might be automatically generated from legacy data sources such as spreadsheets, XML files and databases.

4.2. D2RQ open source software platform

The approach does not exclude the legacy databases and traditional Web content, because RDF serializations can be generated on-the-fly and present data from multiple datasets as if it were within a single database.

The D2RQ [http://d2rq.org/] is open source software platform for accessing relational databases as virtual, read-only RDF graphs. It offers RDF-based access to the content of relational databases without having to replicate it into an RDF store. D2RQ platform consists of:

- D2RQ Mapping Language - declarative XML-based language for describing the mapping between the relational schema and OWL / RDFS ontologies;
- D2RQ Engine - plug-in in Jena Framework (Java environment, providing software tools and libraries for the Semantic Web and Linked Data), which uses D2RQ Mapping Language to rewrite queries in SQL to the database;
- D2R Server - HTTP server that allows HTML links to data and SPARQL endpoint to query the data.

D2RQ Mapping Language creates a mapping file, analyzing the database scheme as each table is transformed into a new RDF class with the same name and each field is transformed into property data type. D2RQ Mapping Language also creates Uniform Resource Identifiers (URIs) of the database data. D2RQ platform can be used for: (i) query a non-RDF database using SPARQL, (ii) access the content of the database as Linked Data over the Web, (iii) create custom dumps of the database in RDF formats for loading into an RDF store, (iv) access information in a non-RDF database using the Apache Jena API.

4.3. OWL ontology of schema.org

The scope of medical terms in schema.org is broad, and is intended to cover both consumer- and professionally-targeted health and medical web content; as a result, any particular piece of content is likely to use only a subset of the schema. “MedicalEntity” in schema.org is not intended to define or codify a new controlled medical vocabulary, but instead to complement existing vocabularies and ontologies. As a schema, its focus is on surfacing the existence of and relationships between entities described in content. The schema does provide a way to annotate entities with codes that refer to existing controlled medical vocabularies (such as MeSH, SNOMED, ICD, RxNorm, UMLS, etc).

The class “MedicalEntity”, the most generic type of entity related to health and the practice of medicine is presented in Fig.3. The owl version of “MedicalEntity” class consists of 17 subclases:

- “AnatomicalStructure” - consists of subclasses defined for parts of the human body as components of an anatomical system: organs, tissues, and cells;
- “AnatomicalSystem” – is used to describe groups of anatomical structures that work together to perform a certain task such as organ systems: circulatory, digestive, endocrine, integumentary, immune, lymphatic, muscular, nervous and other systems;
- “MedicalCause” - includes cardiovascular, chemical, dermatologic, endocrine, environmental or gastroenterological causes, etc.;
- “MedicalCondition” - includes diseases, injuries, disabilities, disorders, syndromes, etc.;
- “MedicalContraindication” - is a condition or factor that serves as a reason to withhold a certain medical therapy;
- MedicalDevice” - is "Any object used in a medical capacity, such as to diagnose or treat a patient";
- “MedicalGuideline” - are recommendations made by a standard society (e.g. ACC/AHA) or consensus statement that denotes how to diagnose and treat a particular condition;
- “MedicalIndication” is a condition or factor that indicates use of a medical therapy, including signs, symptoms, risk factors, anatomical states, etc.;
- “MedicalIntangible” - is a utility class that serves as the umbrella for a number of 'intangible' things in the medical space;
- “MedicalProcedure” - is a process of care used in either a diagnostic, therapeutic, or palliative capacity that relies on invasive (surgical), non-invasive, or percutaneous techniques;
- “MedicalRiskEstimator” - is defined as "Any rule set or interactive tool for estimating the risk of developing a complication or condition";
- “MedicalRiskFactor” - is anything that increases a person's likelihood of developing or contracting a disease, medical condition, or complication;
- “MedicalSignOrSymptom” - is any indication of the existence of a medical condition or disease;
- “MedicalStudy” - is an umbrella type covering all kinds of research studies relating to human medicine or health, including observational studies and interventional trials and registries, randomized, controlled or not;
- “MedicalTest” - is any test, typically performed for diagnostic purposes;
- “MedicalTherapy” - is defined as medical intervention designed to prevent, treat, and cure human diseases and medical conditions, including both curative and palliative therapies;
- “SuperficialAnatomy” - consists of anatomical features that can be observed by sight (without dissection), including the form and proportions of the human body as well as surface landmarks that correspond to deeper subcutaneous structures.
- “MedicineSystem“ - is an enumeration class for systems of medical practice: “Western conventional”, Homeopathic, Osteopathic “Traditional Chinese”, etc. The property “MedicalCode” for the “MedicalEntity” can be taken from a controlled vocabulary or ontology such as ICD-9, DiseasesDB, MeSH, SNOMED-CT, RxNorm, etc.

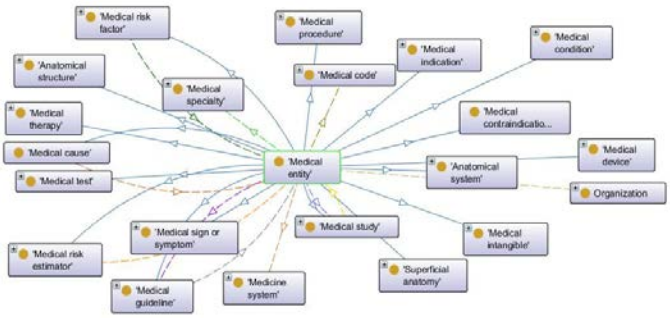

Fig.3: *The OWL version of “MedicalEntity”*

The techniques and platform described above are combined as illustrated in Fig.4 in order to organize a semantic virtual warehouse, allowing the integration and sharing of different data and information from various resources in biomedical domain.

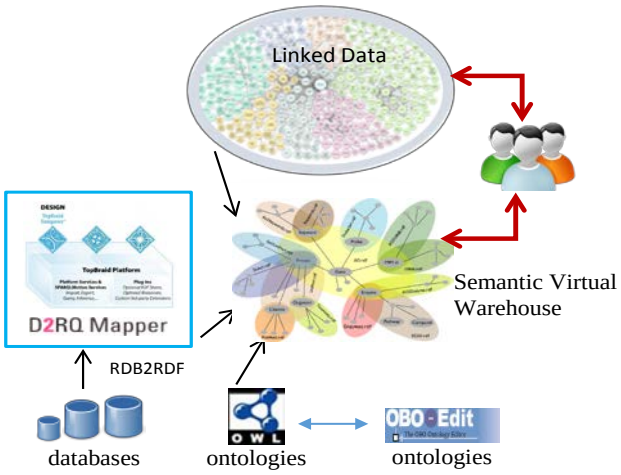

Fig.4: *Illustration of the suggested approach*

4. Applicability of the suggested approach

The proposed approach will be illustrated through the integration of ontology based system for managing clinical data to the owl version of schema.org (updated 2015-08-25). D2RQ platform is used for database to ontology mapping. The database "patient.sql" downloaded from http://sourceforge.net/ is used by "OpenPatientOS" - an information system for managing patient records. The system manages patient personal, medical, and billing records through an easy to use Swing user interface. The "OpenPatientOS" offers personal data entry and management, patient medical records management, patient billing management system, reports creation and user's management system. The system is intended to be used by administrators and physicians; we aim to extend it to patients so that the patients are able to look for their own medical records. The ER model of database and the corresponding ontology model derived with D2RQ mapping language are presented on Fig.5 and Fig.6, respectively.

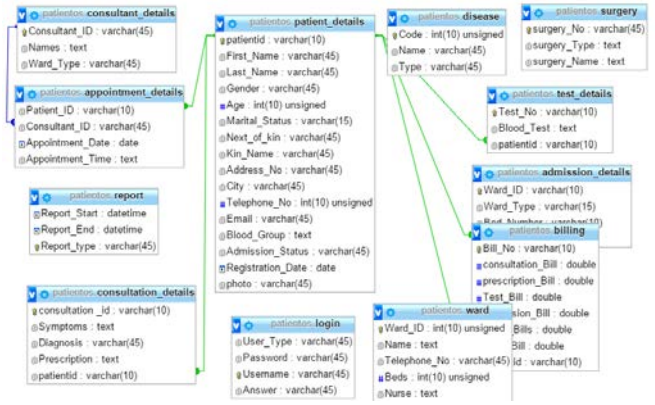

Fig.5: *ER data model of "patient.sql"*

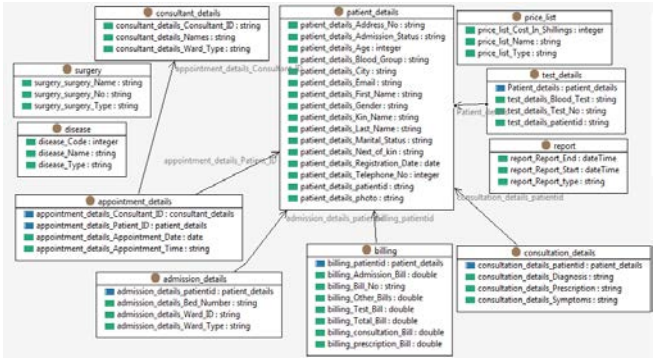

Fig.6: Ontology model corresponding to "patient.sql"

The patient ontology is integrated with the owl version of schema.org ontology in IDE Topbraid Composer [http://www.topquadrant.com/tools/IDE-topbraid-composer-maestro-edition/]. The class "patient:test_details" is declared as a subclass of the class "schema:BloodTest" from the schema.org ontology (Fig.7). As a result of the ontology matching <id31, schema:BloodTest, patient:test_details, ⊂ >, the individuals of class "patient:test_details" inherit 16 additional properties from the schema.org ontology. While the database properties for the class "test_details" are olny "patient:Blood_Test", "patient:Test_No", and "patient:test_detais_patienid", the additional properties: "schema:affectedBy", "schema:signDetected", "schema:usedDevice", "schema:medicineSystem" and "schema:usedToDiagnose" extend the information for a particular patient. A trail SPARQL query for Information retrieval from the integrated model is shown on Fig.8.

5. Conclusions

Based on the analysis of the current state of development of ontologies in biomedical applications and the approaches for data and information integration, discussed in part 2 and part 3 of the paper that most of the data and information resources do not conformed to the formal principle of ontology design and therefore cannot be reused for other purposes and applications and does not support automatic reasoning. The approaches, used to integrate heterogeneous data and information, as reference models and biomedical semantic nets fail to achieve a high degree of integration. The suggested approach allows integration of different heterogeneous data and information resources: Linked Open Data vocabularies, ontologies and relational databases.

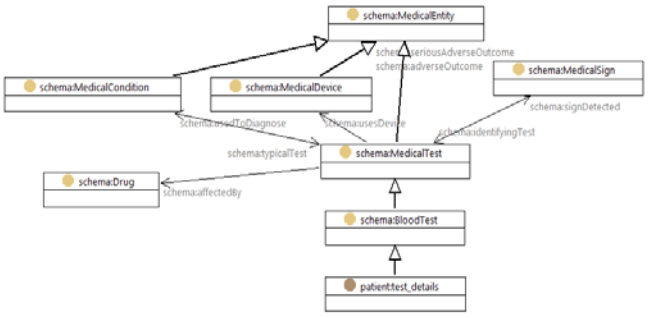

Fig.7: *Integration results*

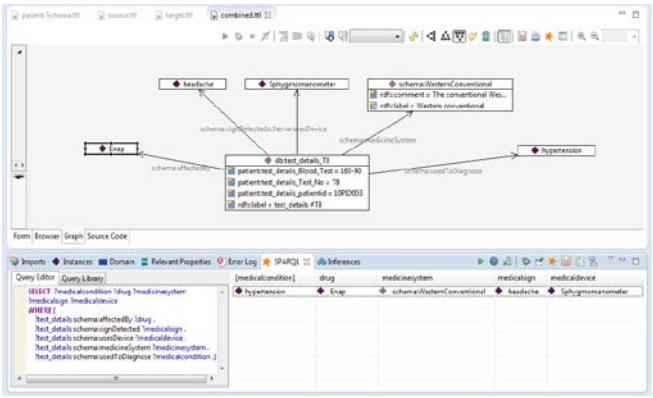

Fig.8*: Information retrieval from the integrated model*

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COMPARATIVE ANALYSIS OF CONTEMPORARY CASE BASED REASONING SOFTWARE FRAMEWORKS

Assoc. Prof. Atanassov A.
Department of Computer Science – University of Chemical Technology and Metallurgy, Bulgaria
naso@uctm.edu

Abstract *The paper presents the comparison of two Case-Based Reasoning (CBR) oriented software frameworks myCBR3 Workbench and CBR-Works ver. 4.3.0 for the development of predictive diagnosis and maintenance systems. Those frameworks were selected after detailed preliminary comparisons of previous versions of myCBR presented in [3], as well of the investigations of the capabilities of other popular CBR software systems [2]. The evaluation of myCBR and CBR-Works includes the capacity to support the: R^4 CBR circle; clusterization of cases, variety of used similarity functions, etc. Specific abilities to provide GUI, database support, required knowledge to work with the systems were also considered.*

Keywords: CASE-BASED REASONING, PREDICTIVE DIAGNOSIS, SOFTWARE COMPARATIVE ANALYSIS

1. Introduction

The methodology of Case-Based Reasoning (CBR) for solving problems or tasks, based on already known past decisions of same problems, is predicated on the hypothesis that similar problems have similar solutions [1]. CBR is a part of artificial intelligence, connected to automation of reasoning based on cases, current problem formulation, searching of one or more solved in the past similar cases and adaptation of old solutions to the current problem.

In this paper a deep comparative analysis of software frameworks myCBR 3 and CBR Works is made. The main purpose of this analysis is to determine whether these software frameworks are applicable for the development of CBR applications in the area of predictive diagnostics and maintenance.

The frameworks myCBR 3 and CBR Works are chosen on base of detailed previous research, published in [2,3] of most distributed and used in practice commercial and non-commercial software tools for CBR, such as CBR Works [6,8], myCBR [7], COLIBRI Studio [11], FreeCBR, CAT-CBR [5] etc.

1.1 Description of CBR reasoning mechanism

The stages of reasoning in CBR systems, based on cases, are known as classical R4 cycle. Cases are the main objects in CBR systems. Each case represents expert knowledge of a solved problem in a specific domain. The case can be represented either as a free text, containing a list of question and answers, or as a structural type when the case is represented as a record or object in the reasoning data base (Case Base).

All structural cases are described as a pair of problem-solution [1]. The problem $\mathbf{p_i = (a_i, v_i)}$ is organized as a structure of attributes and values, described by the attribute vector $\mathbf{a_i = (a_{i1},a_{i2},\ldots,a_{ir})}$ and the value vector $\mathbf{v_i = (v_{i1},v_{i2},\ldots,v_{ir})}$

The solution $\mathbf{s_i}$ can be represented in the same way by number of solution attributes and their values. In some cases the solution can be presented as vectors, defined by the specific tasks. For example in multidimensional supervised control tasks, the decision includes two vectors $\mathbf{s_i = (sp_i, p_{ri})}$, where the first vector $\mathbf{sp_i = (sp_{i1}, sp_{i2},\ldots,sp_{iq})}$ consists of controllers sets on first hierarchical level, and the second $\mathbf{pr_i}$ = ($pr_{i1},pr_{i2},\ldots,pr_{im}$)– values of the target parameters, corresponding to the sets.

For solving an actual problem, the following 4 main tasks of CBR R4 cycle are iteratively performed (Fig. 1) [1, 2, 3]:

Retrieve – process of extraction of one (nearest neighbor) or a group of cases (k-nearest neighbors) having closest definition to the current problem. The global similarity between the problems of these cases (the new $\mathbf{p_{new}}$ and the one in the case base $\mathbf{p_j}$) is presented by following expression:

$$\mathrm{sim}(p_{new}, p_j) = \sum_{i=1}^{n} w_i \mathrm{sim}_i(p_{new\,i}, p_{ji}), \text{ and } \sum_{i=1}^{n} w_i = 1$$

Where $\mathbf{w_i}$ is the weight of i-th attribute $0 \le w_i \le 1$ and $\mathrm{sim}(p_{newi}, p_{ji})$ is the local similarity between i-th attributes of the cases.

For global similarity measure the following metrics are most used: weighted Euclidian distance, Manhattan's metric, Humming's metric, Tversky's metric, Tchebishev's metric, and minimum or maximum metrics etc.

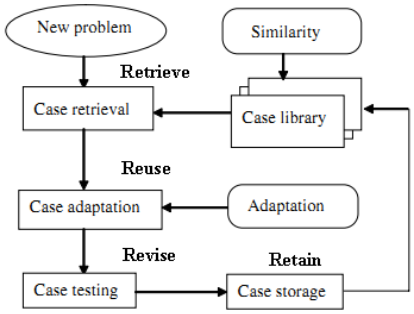


Fig.1 *Classical Case-Based Reasoning R4 circle*

Reuse – reuse of the solutions of chosen in the first step one or k-nearest neighbors.

- When only one nearest case is chosen, the solution of the new problem $\mathbf{s_{new}}$ will be the solution of the chosen case $\mathbf{s_{NN}}$.
- When k-nearest neighbors are chosen, the solution of the new case is calculated on the base of adaptation of k-nearest neighbors' solutions or a part of them.

Revise – validate new solution made on the Reuse stage. This validation and test is mostly done by an expert or it is made based on simulation researches if there is a mathematical model available.

Retain – saving (retaining) the new solution (learned case) in the Case Base for future use, if it is successful

2. Comparative analysis of myCBR 3 Workbench and CBR Works platforms

The analysis of mentioned software frameworks is aimed to compare their capabilities for implementation of real-time and diagnostic CBR systems and takes into account following features:

- Type and level and availability of software documentation;
- Required knowledge to use the software;
- Software support, updates and new versions;
- Presence of graphical User Interface (GUI);
- Internal description of the cases (problems and solutions);
- Type of similarity functions (SF);
- Support of all parts of R4 of the CBR circle;
- Support of different case-base DB (data bases);
- Clusterization and indexation of the cases;
- Visualization of the cases;
- Application of software in specific scientific areas
- Support of interfaces to diagnostic or real-time systems;
- Support of fat and thin clients

MyCBR 3 Workbench [7] is one of the most popular CBR software applications. It is an open source platform written in Java, accessible to all users as SDK. MyCBR 3 Workbench is a

standalone application with certain capabilities and limitations. It is a successor of myCBR 2.6.6 plug-in of open source ontology editor Protégé [9]. MyCBR 3 is developed by the German Research Center for Artificial Intelligence DFKI [7]. Using SDK (Software Development Kit) to support thin (Web-based) or fat (standalone) CBR applications. Its programming code is well documented. The purpose of myCBR 3 is to minimize the efforts to create CBR applications. For its normal use, without modifying the source code, no programming skills are required, but expertise in a specific CBR-domain. Work with the platform and its features are described in the tutorial, available at [7]. At present time (May 2015) new versions 3.1 and 3 of myCBR are available for most popular operating systems.

The framework myCBR 3 supports description of cases with various attributes: numeric, symbol and string, logical, taxonomy type, etc. The templates of the cases are generated as concepts with number of attributes (Fig. 2.). It is possible one attribute itself to be a new concept with its own attributes. This way an object-oriented structure of the case can be implemented.

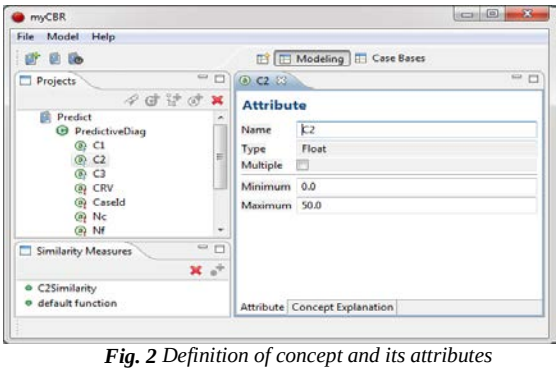


***Fig. 2** Definition of concept and its attributes*

In my CBR 3 the concept is a part of the CBR model which contains case attributes, global and local similarity functions and a textual concept description. It contains as well the weight of each attribute and information whether it is discriminant or not (part of the problem or part of the solution). The weight determines the significance of the attribute in relation to others. Attributes with a weight of zero (0) or discriminant value of false are not considered when searching the case-base DB.

The CBR cases are objects of the concept-class described by its attributes' values.

In myCBR 3 are given the opportunities to select the similarity functions (SF) on concept level (global SF) and to edit it on attribute level (local SF). At the concept level the SF are: Weighted sum, Euclidean difference, Maximum or Minimum distance. On attribute level the SF can be modified through the GUI, as shown below in the middle of Fig. 3 and they can be symmetrical, asymmetrical, step-type or smooth step-type, linear or polynomial. Special symbol (Fig 4) and symbol taxonomy (Fig 5) SF are available for attributes of non-numeric types.

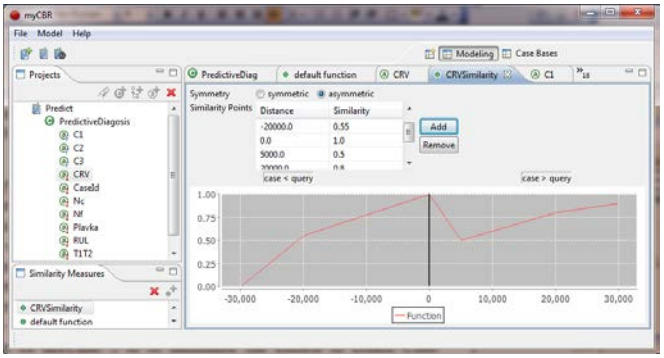


***Fig.3.** Editing the local similarity function via GUI*

In myCBR 3 the cases and their attributes can be created manually or automatically. The automatic generation of attributes is done during the import procedure from the Comma Separated Value /CSV/ file. Then to each column name from the CSV file is assigned an attribute with the same name (See Table 1). For each row of the CSV file a new object (instance of the concept) is created in the Case-Base DB. Unfortunately, when cases are imported from CSV file the maximum-minimum range of variance of each attribute is calculated automatically on the basis of the maximum and minimum values for this attribute in all available cases, so the retrieval of solution for a new case with attribute out of this range is impossible. In this case manual modifications of mentioned ranges are required.

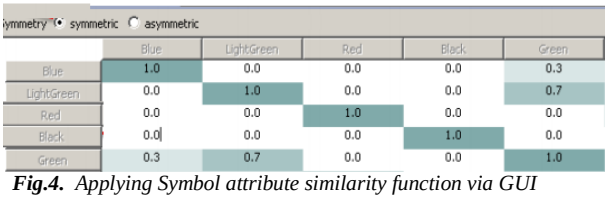


***Fig.4.** Applying Symbol attribute similarity function via GUI*

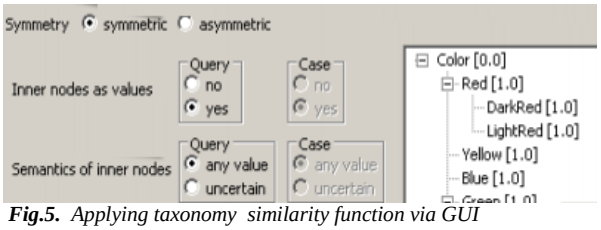
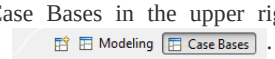


***Fig.5.** Applying taxonomy similarity function via GUI*

When the instance of the case is created manually several steps have to be undertaken. First a Case Base have to be created by selection of the tab Case Bases in the upper right part of the myCBR 3 application 

. Then to select Case Base 

tab on the bottom left window; to press icon Add Case Base  and to provide name of Case Base DB for case-instances. Next step is to add (create) an instance by selecting tab Instances and pressing icon (a little bit confusing) Add Case Base. A new instance with name corresponding to the concept is created in left bottom window. With left mouse click on the created instance a form for adding case values is opened. In contrast to the forms in myCBR 2.6.6., here the attributes are sorted alphabetically which makes problems, if you have to take them, for example, from excel table.

With regard to maintenance of CBR 4R cycle phases, myCBR 3 supports only Retrieve and Retain. During the Retrieve phase all cases are extracted. They are presented sorted by degree of similarity based on the chosen global SF. The Query to the case-base DB could be done on the basis of all or part of the attributes, describing the new case.

Again, in contrast to myCBR 2.6.6 here on Retain phase it is impossible to save the Query as a new case or to use an old case as a basis for new Query.

MyCBR 3 does not work with external DB. It stores the cases in project file with unknown format. Authors of myCBR 3 claim that the concept template with attributes and local SF can be exported to other CBR platforms (COLIBRI Studio) but information how to do that is not available in the tutorial slides. MyCBR 3 can not support the case indexation and clusterization. The cases can not be graphically presented in the GUI. No interfaces to external systems and DB are available in myCBR3. It is valid regarding the interfaces to real-time or diagnostic systems.

CBR-Works 4.3.0 [12] is a standalone application - shell intended to various CBR applications. There is no information about the programming language used for its development, but because it is using a kind of virtual machine it can be concluded that it is mostly Java-based. It is a product of Empolis Knowledge Management GmbH., Kaiserslautern, Germany, supported by ESPRIT project INRECA and Humboldt and Kaiserslautern Universities. The framework is built to support the full R4 CBR cycle and all related, processes as modeling the cases, attributes, SF and rules related to case attributes; support of its own Case Base, as well ODBC connections to databases from which it can import collected knowledge (cases from DB-tables); retrieval and filtering

the cases; providing server capabilities to thin Web-based client, etc. CBR-Works is GUI based application providing four managers to support all CBR knowledge modeling activities-Concept Manager, Type Manager, Case Explorer and Case Navigator.

The Concept Manager can be used to create concept model of the cases. It supports standard attributes (right part of Fig. 6) and object-oriented structures as hierarchical sub-concept trees (left part of Fig. 6). Each concept has its own description and annotation provided by tab Properties, global similarity (Average, Max, Min, Euclidian or Custom defined) and related rules (Fig. 7 - used for adaptation of the case in revised and reuse stages), as well questions regarding every attribute.

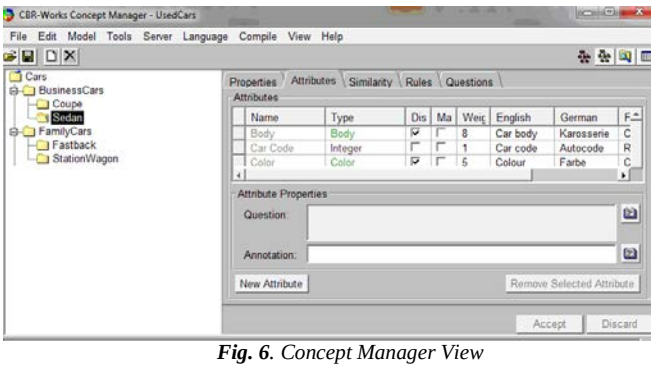


***Fig. 6**. Concept Manager View*

Each concept attribute is described by name, type, weight discriminat and mandatory fields, as well its annotation and questions related to it. The mandatory checkbox is used to define whether the attribute can be used in confirmed cases. In CBR-Works each case can be in one of the four states: - unconfirmed (new case - not used for retrieval before testing); confirmed (used for retrieval); protected (its attributes cannot be modified) and obsolete (old case- not used for retrieval).

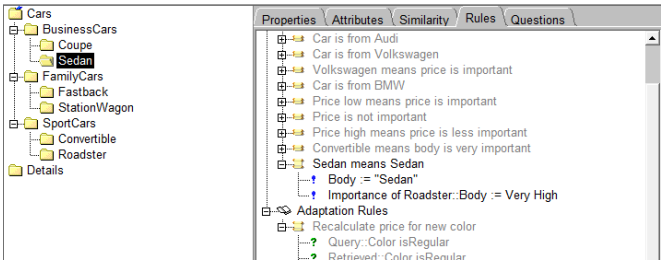


***Fig. 7**. Rules specified for attributes of concept Business Car and Sedan*

The Type Manager is responsible to define the types of the user-defined attributes' and their similarities. Standard numerical and symbol and string types are supported, together with used defined interval or subset types. User defined taxonomy types, ranges and SF are easily edited via Type manager (Fig 8).

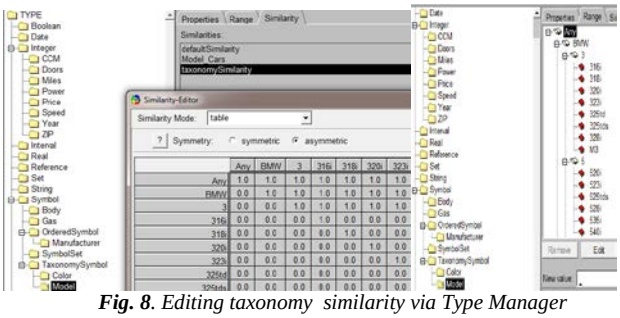


***Fig. 8**. Editing taxonomy similarity via Type Manager*

The Explorer Manager can be used to create instances (Fig. 9) of the cases and to add them to the case base or to edit by attribute value edit or. From this manager the state of the cases can be modified or some case to be selected as a query case for retrieval.

The Case Navigator can be used for retrieval either using some available in the case base case or using retrieval wizard and typing some or all attributes' values. The results are sorted by highest similarity. Some results are presented in the next chapter on Fig 15.

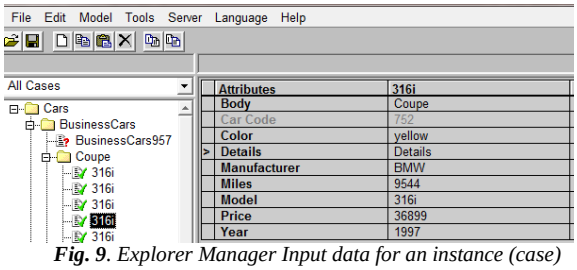


***Fig. 9**. Explorer Manager Input data for an instance (case)*

As it is mentioned above the CBR-Works supports full R4 CBR circle. It provides completion and adaptation rules. The completion rule can be used to complete an existing case attributes or a query. The adaptation one is applied to derive a new result case from the query and retrieved cases (Fig. 10). Both rules are based on precondition ad conclusion part related to the IF-THEN clause in the programming languages. The rules are related to specific attribute and how its value can be set in when certain condition or conditions are fulfilled or not. For consistent rules definition a specific Knowledge Engineer experience is required in the domain of CBR application. Except that no special programming skills are needed to model and develop a CBR system.

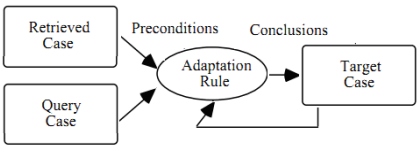


***Fig. 10** Adaptation of the cases based on rules*

CBR-Works does not support clusterization and indexation of the cases in the Case Base but it supports import via ODBC from extern databases, as well export to XML files of concept model, Case Base and the Rules. The product can be configured as server that can be accessed via Web-based thin clients. It means that third party diagnostics or real-time control systems can be connected to CBR-Works via provided interface.

After last version 4.3.0 CBR-Works is no longer supported or further developed but new CBR solutions and knowledge management systems are available on the company site. Nevertheless the product is well documented and some example CBR applications for training purposes are provided together with the product files. Free license code of the product can be obtained after registration on Empolis site.

3. Example with results

There are two CBR applications developed with myCBR and CBR Works for solving the problems related to the diagnostic of a Pierce-Smith converter. It is used for copper converting in metallurgy. The converter, periodically, (after 300-400 melts) can be repair. Decision to stop it for repairing, depends on the uneven thinning of its fireproof walls, number of working tuyeres and other factors. All data is processed using the methodology described in [10]. All cases concerned to the converter are given in table 1. Column A is a case Id, columns from B to J describe the problem attributes of the cases and column K–the decision attribute RUL is-Remaining Useful Life or after how many melts to stop the converter.

Table 1 Case-base data set

Predictive.xls

	A	B	C	D	E	F	G	H	I	J	K
1	CaseId	Plavka	Nf	C1	C2	C3	DeltaC	T1T2	CRV	Nc	RUL
2	1	270	8	17,58	21,22	24,25	6,67	330	3780	299	29
3	2	250	10	14,00	19,4	26,70	12,70	321	10206	268	18
4	3	280	9	12,91	17,55	24,50	11,59	305	10206	286	6
5	4	300	12	24,84	27,88	30,83	5,99	265	7560	317	17
6	5	260	13	21,50	23,78	27,67	6,17	332	7560	301	41

First application is implemented on myCBR. On Fig. 11 the Predictive Diagnosis concept (on left upper part) and its attributes are presented, as well the definition of global (upper right part - Euclidian) and local similarity of these attributes (right most column SMF). The discriminant and weight columns describe whether certain attribute can be used in the retrieval (true) or not (false) and its importance of query (weight).

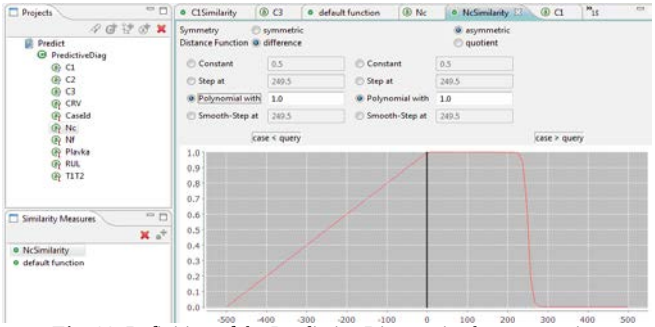


Fig. 11 *Definition of the Predictive Diagnostic class properties*

Figure 12 shows the results of the query to the case-base DB when we have a new case-problem. Upper left part on the figure contains the query values of some attributes describing a new problem. Upper right part contains all cases in the case base database sorted on the base of their proximity to the queried case.. In the estimations of the proximity the local and global SF are taken into account. Bottom part presents first four cases with highest proximity.

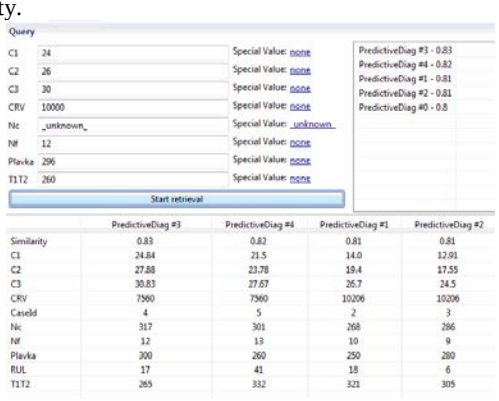


Fig.12 *The results after the query to the case base DB*

Figure 13 shows attribute definition in analogical CBR application, made with CBR Works.

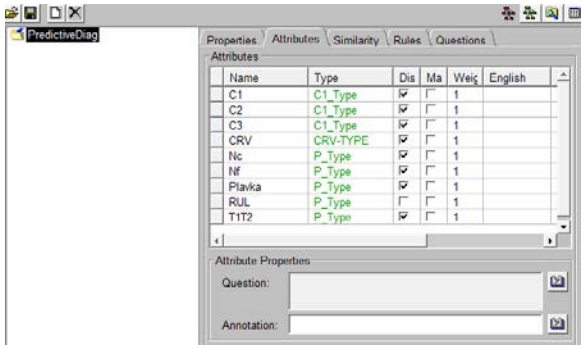


Fig.13 *Definition of the attributes in CBR Works*

On Fig. 14 setting the local similarity is presented and on Fig 15 the retrieval of results of similar query as shown on fig. 12.

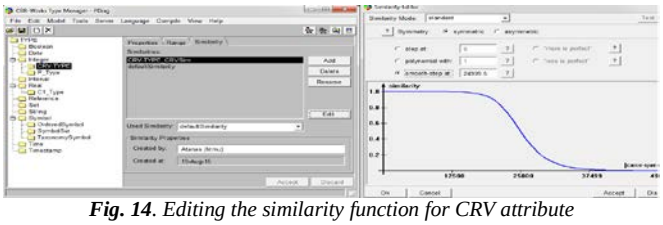


Fig. 14. *Editing the similarity function for CRV attribute*

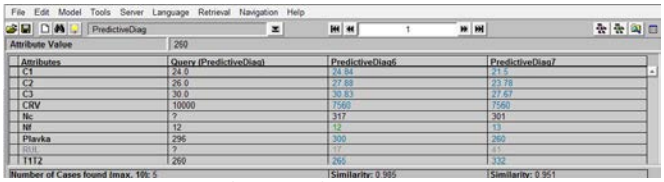


Fig. 15. *Retrieval of results after the query to the case base DB*

4. Conclusions

MyCBR 3 platform can be used for non-complex CBR applications development with partial CBR R4 cycle and with small number of cases. For development of CBR application with myCBR 3 no programming skills are required, only expert knowledge in the professional or scientific domain in which the CBR system is intended. Some design knowledge for case modeling is also desirable. MyCBR is not suitable for application with many attributes, as well with solution attributes containing large amount of text, especially when they must be visually presented in one window. Usage the GUI of myCBR 3, especially for Case Base modeling and case-instance generation is confusing in contras with previous myCBR versions. The retrieval procedure does not work correctly with partial number of problem attributes if Special Value of the attributes whose value is not set explicitly. In this case Special Value must be set to _undefined but not to _unknown (which is default). In myCBR 3 is not possible to update the Case Base with the current query (new case) automatically. It must be done manually. The same is valid if you need to use old case for retrieval.

CBR-Works 4.3.0I can be applied for development for both non-complex CBR applications and complex supporting the full CBR R4 cycle. Development of complex applications however requires Knowledge Engineer experience, especially for synthesis of adaptation rules and their usage. The GUI of CBR-Works provides larger and better functionality for concept (case) and Case base structure modeling and retrieval, than this one in MyCBR. Filtering, query wizard, using a case from Case Base as a query and navigation over retrieved cases is also better than in myCBR. The product support work with external databases, as well import or export of the case base, concept and rules models data. As myCBR the CBR-Works also is not suitable for case modeling with attributes containing large text fields.

Based on the examples, given above, it is obvious that CBR-Works GUI and the support of external interfaces overmatches myCBR 3 and gives more options for weights and SF type modification of attributes and cases. This is of great importance for query adjustment and refining the case base. An advantage of myCBR is that is an open-source SDK and its code can be easily modified to the specific customer needs, but last one requires good programming skills. However, both frameworks can be used for development of CBR systems intended to diagnostics.

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METAMODELS BASED ONTOLOGY DEVELOPMENT TO ACHIEVE STANDARD-COMPLIANT PROJECT MANAGEMENT

M.Sc. Stoyanova.T.

Dept. of Industrial Automation, University of Chemical Technology and Metallurgy, Sofia, Bulgaria,
tonya.stoyanova@gmail.com

Abstract: *The present paper illustrates the current state of affairs for most organizations involved in the sphere of Information technologies that run or strive to run projects in accordance with applicable ISO standards and CMMI. This paper presents the target state of affairs and its design with used technologies. Reaching the goal state is summarized by serialization of metamodels in XML, mapping/parsing of metamodels (in XML) to OWL2 DL (RL profile) ontologies (written/exchangeable in RDF/XML), storages of these semantic metamodels and models (ontologies/semantic data) in advanced RDBMSs with support of ontologies, R2RML mapping of existing project-related relational data to semantic data and storage of semantic data in semantic stores hosted in existing RDBMSs or migration to such ones, extraction of non-relational project-related data and mapping of these logical models to a physical (relational) model and integration in RDBMSs to centralize all project-related data all governed by the defined vocabularies (ontologies of CMMI for Development and ISO 15504/ 12207). Achieving the goal state enables stakeholders to query and infer from project-related semantic data to manage, analyze and assess projects against underlaying standards. Through commonly-accepted adapters, semantic data, metamodels and models are exposed to external applications.*

Keywords: SOFTWARE, PROJECT MANAGEMENT, SPEM 2.0 MODELS, UML, ONTOLOGY, CMMI,

1. Introduction

Various data representation formats that are defined by Semantic Web Group of the W3C consortium are widely considered and accepted by the community as the next step in the data management. A significant challenge in the data management is sharing and analysing data stored in various and independent from one another applications. Advanced business applications for management of semantic data, represented in RDF/S [1, 2] and/or OWL 2 [3] ontologies rely on the latest-generation database systems (Oracle Spatial and Graph (Oracle 11g/12c) [4], IBM DB2/ Graph Stores) for management of relational and non-relational data to solve highly complex problems of national security and intelligence, natural sciences and geolocation/ geopositioning.

This publication presents an analogous complex solution in information technologies, more precesily defines and implements a new model in the software project management in order to ensure the compliance of these projects with international standards and de-facto standards ISO 15504 [5], ISO 12207 [5] and CMMI (Capability Maturity Model Integration) for Development [6].

The analysis of the current state of affaires in companies that manage their projects in compliance with above standards reveals that: the information is not centralised stored; data related to projects, processes and standards are not centralised stored and managed; real on-the-job application of processes and standards is not transparent and is rather difficult to track and monitor.

This paper is focused on reaching the target state of a company that has already integrated and implemented the above mentioned standards at a "machine" level – this stage comes after the formal certification of the organisation.

Reaching the target state is summarised in the following points: XML serialisation of the developed metamodels of the standards; subsequent parsing/transformation of the generated XML metamodels into OWL2 DL (Ontology Web Language 2 Description Logic) (RL profile) [7] ontologies (written in RDF/XML [8]. RDF/XML syntax and semantics are widely accepted as the container for exchange of OWL2 DL ontologies); storage of semantic metamodels and models, i.e. the semantic data, in advanced semantic-relational database management systems that are capable of managing semantic data and of drawing inference from semantic data; R2RML (RDB (Relational Database) to RDF (Resource Description Framework) Mapping Language) [9] mapping of the existing relational models of project-related data and the semantic metamodels and models; transformation of relational data into their equivalent semantic data using R2RML and subsequent storage in the semantic data store [4]; extraction of non-relational project and process-related data (if such data exist in the organisation and are distributed in various formats outside RDBMSs) and transformation of their logical models into relational models and integration of resulting models and data into RDBMSs (Oracle Spacial and Graph, IBM DB2 NoSQL Graph Store). Implementing the described steps will reach the goal of centralising project and process-related data and subjecting them to the unified ontologies describing CMMI for Development [6] and ISO 15504/ 12207 [5]). When the target state of the organisation is achieved, stakeholders will be able to query project and process-related semantic data and draw inference from semantic data in order to manage, analyse and assess projects against undelaying standards. Moreover, centralised semantic data can be accessible to external (or third party) applications through adapters [10, 11].

2. Transformation of metamodels and project models into ontologies and semantic enrichment

2.1. Transformation of standards meta model and project models into ontologies

Another paper ("Development of Software Process Metamodels using SPEM 2.0"), by the same author, presented the skeleton of the SPEM 2.0 [12] metamodel of CMMI for Development ver. 1.3 [6], based on which a hybrid metamodel was developed that meets the requirements of both standards [6, 5] in order to achieve *Capability Level 3 Defined & Maturity Level 3 Defined* acc. to [6] and *Level 3 Established* acc. to [5]. The paper analysed the restrictions blocking the machine execution of metamodels and models developed with tools for business modelling that have a semi-formal architecture. Solutions for overcoming these restrictions were prosposed and are focused on enriching the semantics of the metamodels and building their behavioural semantics. Solutions for validation of metamodels – in terms of completeness, accuracy and execution – were also proposed, i.e. validation using ontologies. The technical implementation (the integration of their ontologies) into the practice was also discussed. The present publication discusses the solutions at a much deeper level, introduces the technologies and the products that are used to build the solutions. SPEM 2.0 is based on the Model-Driven Architecture (MDA) standard that is used for defining the processes of the development of IT and software products and systems and their components. The construction of ontologies of SPEM 2.0 metamodels relies on the fact that both OWL [3, 13] and SPEM 2.0 are serialisable to XML. Constructing an OWL2 DL ontology of the defined SPEM metamodels and models would guarantee the completeness of metamodels and models and the time-bound computation of the inference from data and decisions. The OWL 2 RL profile is chosen with a view to the

current technical realisation [4] and the interoperability. The OWL2 RL profile is aimed at applications that require scalable reasoning without sacrificing too much expressive power. It is designed to accommodate OWL 2 applications that can trade the full expressivity of the language for efficiency, as well as RDF(S) applications that need some added expressivity. The ontology consistency, class expression satisfiability, class expression subsumption, instance checking, and conjunctive query answering problems can be solved in time that is polynomial with respect to the size of the ontology. On the other hand, every OWL 2 ontology, which is an instance of the OWL2 DL structure, and, according to [14], can be translated (transformed) into RDF (Resource Description Framework) graphs (RDF graphs are the most widely used format for representation and storage of semantic data and most advanced RDBMSs use RDF graphs to store semantic data [4, 11, 15]) using bi-directional OWL 2 - RDF mapping [14]. Two formats for translation into OWL 2 DL ontologies are considered: OWL 2 XML [13] serialisation and RDF/XML, the latter is the generally accepted syntax for exchange of OWL 2 ontologies. The OWL XML serialisation is an alternative concrete syntax for OWL 2 ontologies and their exchange, while RDF/XML is the only normative concrete syntax for exchange of OWL 2 ontologies. The OWL XML serialisation accurately reflects the normative structural specification of OWL 2 and is defined in an XML schema that is used for the translation. The XML schema for the serialisation covers the structural specification of OWL 2 in its integrity, which also includes the OWL 2 language profiles. Alternatively, RDF/XML defines the XML syntax for representation of RDF graphs. The translation of OWL 2 ontologies into RDF graphs is done by constructing RDF-Triples. Every RDF graph consists of nodes and labeled directed arcs that connect pairs of nodes which are actually the set of RDF triples. Each RDF triple, at its turn, consists of a subject node, a predicate and an object node. Nodes in graphs are either IRIs (Internationalized Resource Identifiers), literals or blank nodes. Predicates are IRIs and are interpreted either as links between nodes or as an object node of a specified subject node. To encode RDF graphs to XML, nodes and predicates must be represented using the XML syntax and semantics, i.e. using element names, attribute names, element contents, and attribute values. RDF/XML substitutes IRIs for XML Qualified Names. The mapping of the serialised XML metamodels and models and the schema of the OWL XML serialisation and/or RDF/XML uses XSLT (XSL Transformations) [16] templates and applies them to source XML trees in order to generate resulting trees in the desired XML format. XSLT transformations define rules for generating the resulting tree from the source tree. Transformations are in fact associations of source code patterns and templates of transformations. Source code patterns are matched against elements of the source tree until templates are instantiated to generate the desired part of the resulting tree. Source and output trees are completely independent of one another. The structure of the resulting tree is independent of the one of the source tree; the resulting structure can be re-ordered, i.e. already transformed source elements can be re-ordered to fit in the desired structure of the resulting tree. Source XML trees of metamodels and models that were translated into RDF/XML, as it is the case, or to the XML schema of the serialisation of OWL 2 DL using XSLT are further loaded into the working environment [http://protegewiki.stanford.edu/wiki/WebProtegeAdminGuide, http://protegewiki.stanford.edu/wiki/WebProtegeUsersGuide] that supports RDF/S / OWL 2 DL ontologies. Resulting RDF/XML metamodels and models are translated into OWL 2 RL using the mapping in order to enrich the semantics of the ontologies (to elaborate the ontology at length using the expressive power of the semantics of [10, 12]). The OWL 2 RL ontologies are serialised back to RDF graphs (RDF/XML notation) using the mapping [14] to enable to be loaded into the semantic store [4].

2.2. Enriching the semantics of ontologies

Models must be complete and executable but first their semantics must be enrinched to support the needed concepts and meet the following constraints: each task/activity must start at a (pre) defined point in time; all tasks/activities must be time-bound and finish at a (pre) defined point in time; all suspended tasks/activities must be resumed and completed at (pre) defined point in time; task/activities cannot start and finish unless they meet defined constraints on the sequence of tasks and activities; each task/activity must be completed within the (pre) defined time interval; the process cannot be completed unless all its constituent tasks and activities are completed within the specified time interval allotted to each constituent. Semantics and constraints analogous to the described above must be defined for work products as well. Described states must be defined and present in the behavioural model of the metamodel. The definition of a task/activity must include its possible states, i.e. *not started*, *started*, *suspended* and *completed*. For example, these states can be modelled by introducing a new datatype and a data range constraint in the OWL2 ontology: (Declaration (Datatype (a:State)) DatatypeDefinition (a:State DatatypeRestriction (xsd:string xsd:enumeration "notStarted" ^^ "Started" ^^ "Suspended" ^^ "Completed")) DataPropertyRange (a:hasState a:State)); a data property link is defined that connects individuals with the literal. As a consequence of having introduced states, the ontology must be enriched with temporal semantics to model the concept of time and timers associated with each task/activity. This is the prerequisite for defining rules of transitions from one state to another. The solution proposes the integration of the freely available OWL ontology that models the notion of *time* [17, 18]. In OWL-Time [18], the time ontology based upon the Web Ontology Language (OWL), *Instant* and *Interval* are basic mereological individuals, serving as foundational temporal entities. The OWL-Time ontology provides the vocabulary to encode topological relationships between time points and time intervals and expresses *duration* and *datetime*. However, the introduction of the concept *time* complicates RDF graphs, the search in semantic data and the inference.

The *time* ontology is expressed in OWL DL, which is a First Order Logic restriction, based on *SHOIN* DL (Description Logic) [19]. This description logic is decidable thanks to well defined semantics and proven reasoning algorithms which makes the *time* ontology an excellent candidate to use for the operations of the interval algebra [17, 20, 21]. The operations and the axioms of the interval algebra are used to express the *time* characteristics and their evolution. At the core of this algebra is the relationship between time intervals [17, 20]. Having two time intervals *TimeInt1* and *TimeInt2*, a time point *t* and a proposition, one might ask a variety of questions over the time domain and infer if the proposition holds [17, 20]:

- Mereological or "part-of" questions – for example: Is the time interval *TimeInt1* a sub-interval of *TimeInt2*?; Does *t* occur within time interval *TimeInt1* or within *TimeInt2*?; Is the time interval *TimeInt1* equal to the time interval *TimeInt2*?;
- Topological or "connects" questions – for example: Does the time interval *TimeInt1* happen before or after the time interval *TimeInt2*?, Do time intervals *TimeInt1* and *TimeInt2* meet?; Do these time intervals start and/or end at the same moment?;
- Logical or "rule-based" questions – for example: Does tht proposition hold within *TimeInt1*?; If the proposition holds during *TimeInt1*, does it hold during *TimeInt2* too?.

These interval relations can be formally defined in terms of *before* relations among their beginning and end points [22].[1] Source metamodels and models and their ontologies respectively may now be considered complete compared with the initial state and discussed shortcomings.

[1, 26] A sample definition of a relation for overlapping time intervals:
intOverlaps(TimeInt1,TimeInt2)≡[ProperInterval(TimeInt1)
^ProperInterval(TimeInt2)]
^(∃ t2, t3)[ends(t2, TimeInt1) ^begins(t3, TimeInt2) ^before(t3, t2)
^(∨ t1)[begins(t1, TimeInt1) ==>before(t1, t3)]
^(∨ t4)[ends(t4, TimeInt2) ==>before(t2, t4)]]]]

3. Integration and implementation of semantic layer

The ontologies of metamodels and models that are integrated in the semantic-relational database system [4] are, in fact, the layer that envelops relational data and renders them highly normalised (compared with other approaches, commonly referred to as NoSQL approaches, that render relational data denormalised). After having integrated the ontologies, relational data and their semnatic equivalents coexist, are extremely normalised and dependent on the ontologies.

3.1. Translation of relational data into semantic data

Existing relational data in RDBMSs are reused and the fundamental principles of Atomicity, Consistency, Isolation, and Durability (ACID) are preserved, which still ensure the security of data, the backup and recovery of data, the data compression, and the serial and parallel execution of processes. Existing process and project-related relational data are translated into their semantic equivalents acc. to the target vocabulary (the ontology) using R2RML (Relational to RDF Mapping Language). There is a straightforward approach to this mapping that does not use R2RML, however it is considered static and inflexible because of the structure of the resulting RDF graph; the structure of the latter strictly follows the structure of the database. The resulting RDF vocabulary copies the names of the elements from the database schema; the database schema and the output vocabulary cannot be changed. This approach being straightforward and static is inappropriate to be applied considering the complexity, the scale and the purposes of the described solution. Defining a mapping based on R2RML allows for the definition of highly customised views over relational data. Every R2RML mapping is tailored to a specific database schema and a target vocabulary. The R2RML mapping refers to logical tables to retrieve data from the input database. A logical table can be a base table, a view or a valid SQL statement, which is aslo referred to as an R2RML view since it emulates an SQL view without modifying the underlaying database. Output RDF graphs that are generated based on the R2RML mapping use the predicates and the datatypes of the targer vocabulary (the ontology). The semantic-relational data store [11, 4] can store a set of RDF graphs and record information for each graph to allow for the search for information spread in many graphs and the inference from many graphs as well. Logical tables are mapped to RDF using triple maps. Triple maps are the rules that map each row in a logical table to a number of RDF triples. The output sematic equivalents (RDF triples) of the existing relational data can be placed into named graphs (by default all output RDF triples belong to the default graph) using predefined graph maps which are also part of the triple maps (by definition, triple maps consist of optional graph maps, subject maps and predicate-object maps). The R2RML mapping itself consists of RDF in RDF/XML or Turtle (another concrete syntax for writing RDF/S ontologies). The transformation of the existing relational data into RDF graphs is carried out using the R2RML parser [23 (freely available: https://github.com/nkons/r2rml-parser)], which supports a number of RDBMSs (Oracle, MySQL, PostgreSQL) as sources of relational data. The parser implements the R2RML standard and can generate output RDF graphs in Turtle, N-Triple [24], RDF/XML notations using the input R2RML mapping files. The coexistence of relational and semantic data in the same place brings the question of the consistency of the both types of data. Considering the huge amount of data, full re-parsing of all exisiting relational data upon constant changes in operational data is totally inappropriate. The consistency of both types of data can be ensured by incremental parsing of changed relational data based on transaction logs.

3.2. Loading semantic data into the semantic data store

The insertion of semantic data into the store may vary acc. to the format of semantic data [11, 4]:

- Bulk insertion of semantic data into the store using staging tables, where each row in the intermediary staging table contains components of an RDF triple - its subject, predicate and object, and optionally a named graph to which the RDF triple belongs (the SQL loader utility is used to parse and load semantic data in N-Triple format into staing tables while semantic data in N-Quad [25] format are loaded into staging tables using external tables created with the SEM_APIS.CREATE_SOURCE_EXTERNAL_TABLE procedure; in both cases the SEM_APIS.BULK_LOAD_FROM_STAGING_TABLE procedure is called to populate staging tables with semantic data from external tables mapped to an N-Triple or N-Quad format input file);
- Batch insertion of semantic data using the RDF semantic graph support for Apache Jena; semantic data can be in RDF/XML, N-Triple and N-Quad format [https://jena.apache.org/index.html, 24, 25];
- Straight forward insertion of RDF-Triple semantic data into operational model tables using the SQL INSERT statement and the SDO_RDF_TRIPLE_S constructor that creates an RDF triple and assigns it to the model-graph to which it belongs.

3.3. Creating ontologies and loading them with semantic data

Semantic technology models (ontologies) [11, 4] are created with the SEM_APIS.CREATE_SEM_MODEL procedure and after that are loaded with semantic data using the INSERT statement. As far as the internal organisation and representation of models (ontologies) are concerned, the invocation of the SEM_APIS.CREATE_SEM_MODEL creates a model (ontology) identified by its unique name, a table (this table has already been created) that holds references to semantic technology data for this model, the name of the column of type SDO_RDF_TRIPLE_S in this table (this column holds references to semantic data created with the SDO_RDF_TRIPLE_S constructor), and a table namespace associated with the model (the dedicated table namespace has already been created). The creation and manipulation of models (ontologies) entail the creation and/or update of system views with metadata for models (the essential views are the MDSYS.SEM_MODEL$ (a common view for all models) view and the MDSYS.SEMM_*model-name* (per model) view). An MDSYS.SEMM_*model-name* view with metadata (for the triples associated with the model) is created for each model (ontology). This view stores the following information for each triple: the identifier of the text value of the predicate of the triple, the identifier of the text value of the subject of the triple, the identifier of the text value of the canonical form of the object of the triple, the identifier of the text value of the object of the triple, the identifier of the model (ontology) to which the triple belongs, and the identifier of the text value of the graph name for the triple (*null* for the default graph).

3.4. Inference and rulebases

The selected semantic store [11, 4] can contain unlimited number of models (ontologies), rulebases and semantic data generated by the inference; the semantic store also allows the use of many rulebases, including the combination of the native inference and custom-defined rulebases, to draw inference from semantic data. The database [11, 4] inherently supports the following OWL vocabulary subsets (as they are described in the respective standards by the World Wide Web Consortium): RDFS, RDF (as a vocabulary subset of RDFS), OWLSIF, RDFS++, OWLPrime, and OWL2RL; each supported vocabulary has a corresponding rulebase, however these rulebases do not need to be populated because the underlaying entailment rules of these vocabularies are inherently implemented. The native support of the OWL2RL language profile has motivated the choice of the semantic store and as discussed above this OWL2 vocabulary subset, which satisfies the requirements of the complex metamodels and models, is the selected syntax for the description of the metamodels and models. The domain-specific knowledge (i.e. the knowledge of how processes and projects are analysed and assessed acc. to standards [6, 5]) is transcribed into rules in custom-defined rulebases to provide the needed specialised inference capabilities. Custom-defined rulebases are created with the SEM_APIS.CREATE_RULEBASE procedure (for each rulebase, a system table is created to hold rules in the rulebase, along with a

system view MDSYS.SEMR_*rulebase-name* that is used to insert, delete and modify rules in the rulebase and (the view) has the following structure: the name of the rule, IF side pattern for the antecedents, filter condition that further restricts the subgraphs matched by the IF pattern, THEN side patterns for the consequents, and ALIASES that are one or more namespaces to be used, in addition to the default namespace, for expansion of qualified names in the query pattern). The SEM_MATCH table function is used to query semantic data; it requires the creation of entailment objects first (an entailment is an object containing precomputed triples that can be inferred from by applying a set of rulebases to a set of models; an entailment must be created for each rulebase-model combination in the query). The SEM_MATCH table function is able to query and draw inference from virtual models, which are virtualy any combination of models, graphs and entailments. SEM_MATCH queries can also be written in the SPARQL [11, 16] SELECT format, which the semantic store inherently supports.

3.5. Validating ontologies, entailments and semantic data

OWL ontologies may contain errors, such as unsatisfiable classes, instances belonging to unsatisfiable classes, individuals asserted to be the same or different at the same time. Such inconsistencies in models (ontologies) and entailments can be detected and eliminated using the SEM_APIS.VALIDATE_MODEL and SEM_APIS.VALIDATE_ENTAILMENT validation procedures to ensure the trustworthiness of the models (ontologies), semantic data and inferred decisions.

3.6. Ontology-assisted search in relational data

The expressiveness of the search in relational data and the relevance of returned results are considerably increased with the modified ontology-assisted search which is not exclusively based on the lexical match of attribute names and data. The database [11, 4] implements ontology-assisted queries with the SEM_RELATED and SEM_DISTANCE operators. These semantic operators query relational data based on the semantic relationship between the data in a table column and terms in an ontology. The SEM_RELATED operator retrieves rows based on semantic relatedness, while the SEM_DISTANCE operator returnes the distance measures for the semantic relatedness so that the output returned by the SEM_RELATED operator can be ordered by the relevance of data acc. to distance measures.

3.7. Access to the semantic store using adapters

RDF semantic graph (the database) [11, 24] provides support for Apache Jena and OpenRDF Sesame, which both extend the semantic data management capabilities of the database and provide for building open semantic applications, however Apache Jena is of more interest for the present solution. RDF semantic graph [11, 24] support for Apache Jena provides a Java-based interface to Oracle Spatial and Graph RDF Semantic Graph by implementing Jena Graph, Model, and DatasetGraph APIs, which are used for the management of named graph data (quads). RDF semantic graph support for Apache also provides a array of network analytical functions on top of semantic data ([15] in general functions for manipulating nodes and leaf-level nodes in graphs, functions for search for paths in graphs and their costs, in-depth multi-aspect analysis of semantic data). Apache Jena supports SPARQL [25] and applications using the APIs of Apache Jena to access the semantic store are integrated with it though the Joseki HTTP server (which also supports SPARQL queries). Apache Jena, with the capabilities and extensions it provides, is selected for a future development of a semantic application for project management as a wrapper of the core solution presented here in order to make the core solution available to a larger audience of business users and project managers.

4. Conclusions

The present publication presented a fully fledged solution and its architecture for the native (machine) integration and application of the standards being discussed throughout the publication [6, 5]. The core solution provides for the analysis and assessment of processes and projects based on inference from process and project-related semantic data and models (the ontologies of the standards). The architecture of the solution is open and implements standards and recommendations of the World Wide Web Consortium and other (referenced) open technologies and tools and eliminates the need of vague proprietary middleware solutions for the translation of metamodels and models. Oracle Database 11g/12c [4] with support for semnatic technologies, which is still freely available for non-commercial and research purposes, was selected as the best available product which can suit the chosen technologies, the complexity and the scale of the solution. Two paths for future development of the present core solution are considered: development of a Java-based semantic application which will wrap and extend the core solution in order to make it available to a wider business and managerial audience and translation of production rules in the custom-defined rulebases, which store the domain-specific knowledge, into a concrete RIF (Rule Interchange Format) dialect [26, 27], which will make the solution entirely portable between organisations.

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DETERMINATION OF THE OPTICAL PROPERTIES OF BULGARIAN HONEY AND THEIR APPLICATION TO HONEY DISCRIMINATION

Prof. Dr. Tsankova[1] D. D., Ass. Prof. Dr. Nikolova[1] K., Prof. Dr. Evtimov[2] T., Assist. Prof. Dr. Lekova S. D.
[1]Dept. of Industrial Automation, University of Food Technologies – Plovdiv, 26 Maritsa Blvd, 4000 Plovdiv, Bulgaria
[2]Plovdiv University "Paisii Hilendarski", Plovdiv, Bulgaria
[3] Dept. of Industrial Automation, University of Chemical Technology and Metallurgy, 8 St. Kliment Ohridski Blvd, Sofia

kr.nikolova@abv.bg, dtsankova@yahoo.com, teftimov@abv.bg, sv_lekova@abv.bg

Abstract: *The aim of the article is to investigate the optical properties of Bulgarian honey in regard to the potential of honey discrimination on the base of its botanical origin. Samples from three types of honey (acacia, linden, and honeydew) are measured by a fluorescence spectrometer recording emission from 350 to 800 nm with excitation at 370, 395 and 405 nm. A combination of fluorescence emission spectra with some colorimetric parameters (CIELab) is used as input data of three types of honey classifiers: the first two are based on linear and quadratic discriminant analysis, and the third one uses an artificial neural network. The neural classifier is realized as a multilayered perceptron with backpropagation learning algorithm. Principal components analysis (PCA) is used for reducing the number of inputs and for a proper visualization of the experimental results. The comparative analysis of the three classifiers is based on leave-one-out-cross validation test carried out in MATLAB environment.*

Keywords*:* Fluorescence spectroscopy, colorimetry, honey discrimination, PCA, LDA, QDA, artificial neural network

1. Introduction

Honey is a natural product and nothing should be extracted or added to it. But for obtaining more profit, it is often subject to counterfeiting by adding sugar and other impurities. The botanical and geographical declaration of the origin seems to be one of the fundamental aspects of the honey quality that affects its commercial value [1, 2]. So in order to prevent fraud in the labeling, it should be developed a means of distinguishing between different types of honey. At the current stage of knowledge, a reliable authentication of floral origin of honey can be achieved by a global interpretation of sensory, pollen and physicochemical analyses carried out by an expert [3, 4, 5]. The content of different phenolic compounds is recognized to well reflect the type of honey and its quality, because phenolic acids and flavonoids are inherent chemical markers of the floral origin [6, 2]. Unfortunately, the most of these methods are generally too time-consuming, complex, and labour intensive for quality control application or require very specialized personnel to interpret the results.

In addition, most of the analytical techniques involve some kind of sample pre-treatment. The advantages of the technique of spectroscopy (visible, near and middle infrared, fluorescent) with respect to other methods are the non-invasive approach, the relatively easy and quick data acquisition. The principal advantages of fluorescence spectroscopy, pointed out by almost all authors, are its rapidity and sensitivity [7] (100–1000 times more sensitive than other spectrophotometric techniques [4, 5]). Food contains many different fluorophores, whose signals overlap and make it impossible to measure the concentration of a single compound. Nevertheless, the shape of normalized fluorescence spectra in combination with multivariate statistics can be used to characterize and identify different food [4, 5], including different types of honey.

Among traditional classifiers, Discriminant Analysis (DA) is probably the most known method [8] and can be considered the first multivariate classification technique. Some authors [9, 10, 11, 12] have implemented linear discriminant analysis (LDA) for classification of the floral origin of honey, on the basis of its chemical and physical properties, including the mineral composition of honey. But due to the data correlation, the discriminant analysis encounters some computational difficulties such as 'badly scaled or close to singular matrix'. Therefore, usually it is used in a combination with the principal components analysis (PCA) as a correlation reduction method. Artificial neural networks can overcome these problems at processing raw data and can be used for multivariate analysis to create more accurate classifiers [13].

The purpose of this study is to investigate the optical properties of Bulgarian honey and the possibility of recognizing its botanical origin using fluorescence spectroscopy in a combination with CIELab colorimetry. Spectroscopic data obtained undergo subsequent statistical processing including PCA, which is used for reducing the input space dimension and visualizing the clusters formed by different types of honey. Three types of honey classifiers are proposed: the first two are based on linear and quadratic discriminant analysis, and the third one uses an artificial neural network (NN) realized as a multilayered perceptron with backpropagation (BP) learning algorithm. The comparative analysis of the three classifiers is based on leave-one-out-cross validation test carried out in MATLAB environment.

2. Materials and methods

Honey Spectrum Acquisition. Thirty-two samples of three different types of Bulgarian honey (acacia – 8 samples; linden – 10 samples; and honeydew – 14 samples) were purchased from supermarkets (Lexie, Kaufland, Piccadilly) and from private producers. Before spectral measurement, the honey samples were placed in a water container at 50^0C until the soluble substances fully dissolved. Then the samples were annealed at room temperature (25-26^0C).

The fluorescence spectral characteristics of the honey were taken with a fiber optic spectrometer (AvaSpec-2038, Avantes) with sensitivity in the (200-1100) nm range. The sources used to measure the fluorescence spectra are 370 nm, 395 nm, 405 nm light emitting diodes (LEDs). The resolution of the spectrometer is about 8 nm for a 200 μm input slit. An optical fiber with a diameter of 200 μm is used to bring light to the probe and to measure the scattered and fluorescent light. A collimator with a lens of an aperture D = 5 mm is used to gather more light and send it to the receiver. Generally, with classical right-angle fluorescence spectroscopy, the measurements are carried out in dilute solutions where the absorbance is below 0.1 [4, 5]. At a higher absorbance rate, the fluorescence intensity decreases due to the inner filter effect. In that case the front-face fluorescence spectroscopy is more suitable for use. In the presented study, in order to measure the fluorescence spectra of honey (especially dark honeydew honey) without dilution, the cuvette holder was modified as follows. The first probe (optical fiber) was placed between two glass slides, which were fixed by a threshold, consistent with the diameter of the probe. The second probe (LEDs) was fixed on the upper glass, 90^0–angle to the first and the minimum distance between them. Honey was located between the two slides. The resulting three emission spectra with

excitation at 370 nm, 395 nm, 405 nm were normalized by dividing with the maximum intensity value of the respective excitation signal.

Colour Measuring. The measurements were determined according to the methods of the European Honey Commission [14]. All measurements were performed at room temperature. Colorimetric study of honey was made using a software package VISIONlite ColorCalc for spectrophotometer Helios Omega. It was used mode 'Advanced', i.e. calculations were performed in the range of 380 nm -780 nm (instead of 'Basic' mode: 400 nm – 700 nm). The honey samples were placed in a cuvette 10 mm x 10 mm (Recommendations on uniform color spaces, 1971) and the color parameters in CIELab colorimetric system were measured.

Principal Components Analysis [15, 16]. The aim of the method is to reduce the dimensionality of multivariate data (e.g., wavelengths) whilst preserving as much of the relevant information as possible. PCA is a linear transformation, that transforms the data (observations of possibly correlated variables) to a new coordinate system such that the new set of variables, the principal components (PCs), are linear functions of the original variables. Principal components are uncorrelated, and the greatest variance by any projection of the data comes to lie on the first coordinate, the second greatest variance on the second coordinate, and so on. All the principal components are orthogonal to each other. The full set of principal components is as large as the original set of variables. Usually the sum of the variances of the first few principal components exceeds 80% of the total variance of the original data [17]. In this study, the first two PCs are used as input variables of the LDA and QDA based discrimination models, and all the PCs – for training the NN based classifier.

Linear and Quadratic Discriminant Analysis. Linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) are two classic classifiers, with, as their names suggest, a linear and a quadratic decision surface, respectively. The basic idea of LDA is to find a linear transformation, such that the ratio of the between-class scatter and the within-class scatter is maximized. Samples are projected to a new space with smallest within-class distance and largest inter-class distance [18]. Although LDA usually gives a good discrimination performance, it suffers from some deficiencies if variables are highly correlated or class boundaries are complex or nonlinear [12]. To avoid such deficiencies, in the former case, variables are often transformed by correlation-reducing methods such as PCA, and in the latter case, LDA could be replaced by QDA. Unlike LDA, in QDA there is no assumption that the covariance of each of the classes is identical. To estimate the parameters required in quadratic discrimination more computation and data is required than in the case of linear discrimination.

Artificial Neural Network Based Classifier. It is well known that artificial neural networks, with a feedforward multilayered structure, are universal function approximators [19, 20]. One classification task can be easily reduced to a task for approximation. Let the classifier of honey be implemented as a neural network with a feedforward structure and Backpropagation learning algorithm. The neural network consists of $n + 3$ inputs (n is the number of wavelengths included in the emission spectrum characteristics of the honey), 3 outputs and 2 hidden layers. The three additional inputs are designed for the 3 colorimetric indicators (parameters L, a and b) of the CIELab system. The proposed combination of fluorescent emission spectra with the three colorimetric parameters of CIELab system aims to increase the accuracy of predicting the floral origin of honey. The three outputs of the network correspond to the three classes of honey: acacia, linden and honeydew honey. The two hidden layers contain neurons with 'tansigmoid' activation function (hyperbolic tangent), and the activation function of the three output neurons is 'logsigmoid' [21]. The input training samples include the intensity of the emission spectra and the three colorimetric parameters: L, a and b. The supervisor supplies the network's output with the following three combinations: '1 0 0', '0 1 0' or '0 0 1', depending on whether the input receives the data for the classes 'acacia', 'linden' or 'honeydew', respectively. BP is gradient-based learning algorithm that minimizes the sum squared error between the real and required input of the NN. The leave-one-out-cross-validation test is used to validate the NN-based honey classifier. The neural network training and testing are realized in MATLAB environment [21].

The description of systematic use of software abstractions or models as primary artefacts during a software engineering process is a task of MDD. The main idea of MDD is that using of models and their transformation is a better foundation for the development and maintenance of systems than programming. The portability, interoperability and reusability through architectural separation of concerns are primary goals of MDD.

3. Results and discussion

Fluorescence Spectra and Colour of Honey. The normalized fluorescence spectra of a random sample from the three types of honey (acacia, linden, and honeydew) with wavelengths ranging in visible domain under excitation at 370 nm, 395 nm, and 405 nm are shown in Figure 1. The first maxima (with magnitude 1) correspond to the excitation signals, and the second maxima – to the emission spectra's significant values. The averaged fluorescence spectra of the three types of honey - acacia, linden and honeydew are shown in Figure 2, cases (a), (b) and (c), respectively. In Figure 2 the filled contour plots present the averaged normalized intensity of the fluorescence emission spectra as a function of the excitation wavelengths (ordinate) and the emission wavelengths (abscissa). In the experiments only three excitation wavelengths (370 nm, 395 nm and 405 nm) were used, and in Figure 2 the other values between them are obtained by means of the cubic interpolation. For each type of honey the emission with the highest intensity was obtained at the excitation wavelength of 370 nm. Also the honeydew honey had the highest intensity of emission in respect to other types of honey. Table 1 shows the mean values and standard deviations of the CIELab colour parameters related to the different types (classes) of honey.

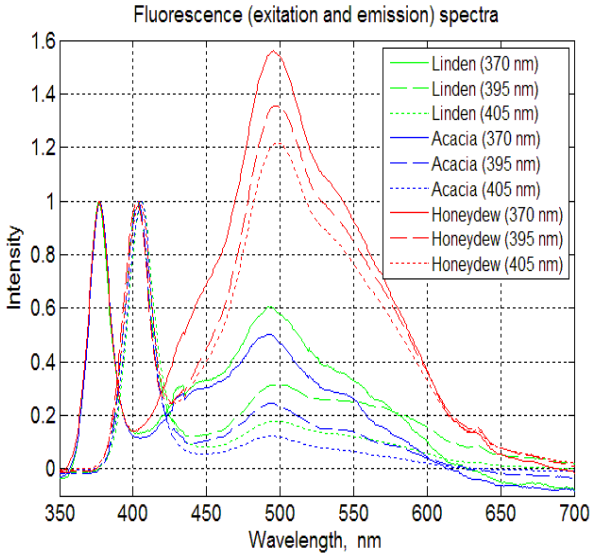

Figure 1. *The normalized fluorescence spectra.*

PC-LDA, PC-QDA and PC-NN Based Models for Honey Discrimination: Since the intensity of emission spectra of the three types of honey is greatest at excitation 370 nm (Figure 2), only the fluorescence spectral characteristics at this excitation were used for the synthesis of the honey's classifiers. PCA was carried out in order to visualize data from different honey samples and to identify their similarities and differences. The spectral dimensionality was reduced to a small number (two) of principal components using PCA. The scores scatter plot of the 1st and 2nd PCs is shown in Figure 3a. It is evident that the samples form three clusters (acacia,

linden and honeydew), which are overlapped. Here, determining the type of honey is based solely on the inscription on the label by the manufacturer, i.e. trusting the manufacturer. The two PCs suitably visualize the honey's spectra, but the information contained in them is not enough to properly distinguish different types of honey. Therefore PCA was applied to a combination of fluorescence spectra characteristics and the three indicators (*L*, *a*, *b*) of the colorimetric system CIELab. In this case the first two PCs explained as high as 94.27 % of variance of the combined data (76.21 % for PC-1 and 18.06 % for PC-2). The result (Figure 3b) shows a better distinguishing between different types of honey, with the exception of a few overlapping samples of classes 'acacia' and 'linden'.

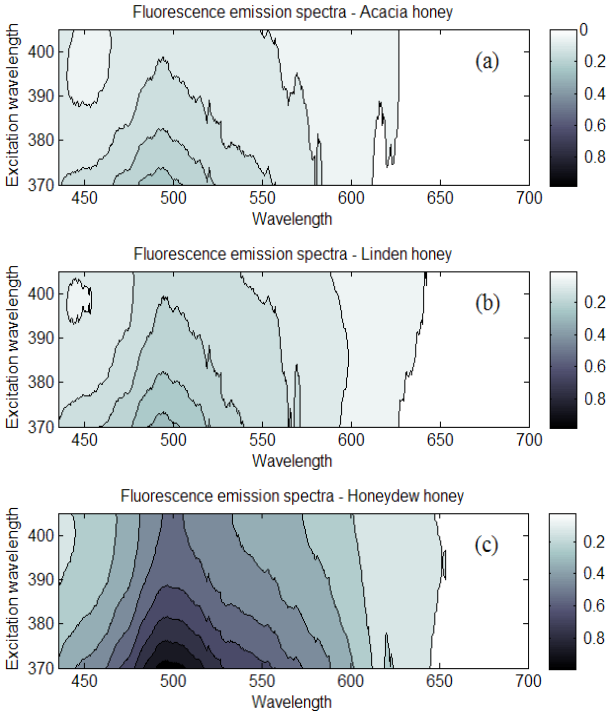

Figure 2. *Contour plots of the averaged fluorescence emission spectra: (a) acacia, (b) linden, and (c) honeydew honey.*

Table 1. *Colour Parameters of Honey*

CIE-Lab Values (Ill.D65/10 deg Observer / 380-780 nm)	**Acacia honey**	**Linden honey**	**Honeydew honey**
	Average value ± Standard deviation		
L	92.45 ± 5.46	85.35 ± 6.63	51.27 ± 12.80
a	0.29 ± 1.78	3.05 ± 4.78	27.94 ± 5.83
b	32.01 ± 15.00	57.65 ± 16.72	74.54 ± 11.63

The two PCs (obtained from the enriched data - spectral characteristics + colour parameters) were chosen to develop PC-LDA and PC-QDA models. Leave-one-out-cross-validation test was used to check the performance of the classifiers. The prediction results of the honey's botanical origin made by the proposed classifiers, PC-LDA and PC-QDA, are shown in Figure 4a / Table 2 and Figure 4b / Table 3, respectively. The performance of the PC-QDA based model was a little better (81.25 % accuracy) than the PC-LDA based one (78.12 %) for honey discrimination.

The neural classifier was trained with all PCs (obtained from the same spectral characteristics and colour parameters mentioned above). The number of neurons in the first and second hidden layers of the neural network was selected heuristically - 500 and 250, respectively. The result from validation test is shown in Figure 5 and Table 4. As evident in Table 4, 2 samples from observed class 'acacia' and 1 sample from observed class 'honeydew' were predicted wrong as 'linden', while 2 samples from class 'linden' were predicted wrong as 'acacia'. The model predicted 27 out of 32 samples correctly. 84.4% prediction accuracy (75% class 'acacia', 80% class 'linden', and 92.9% class 'honeydew') was achieved.

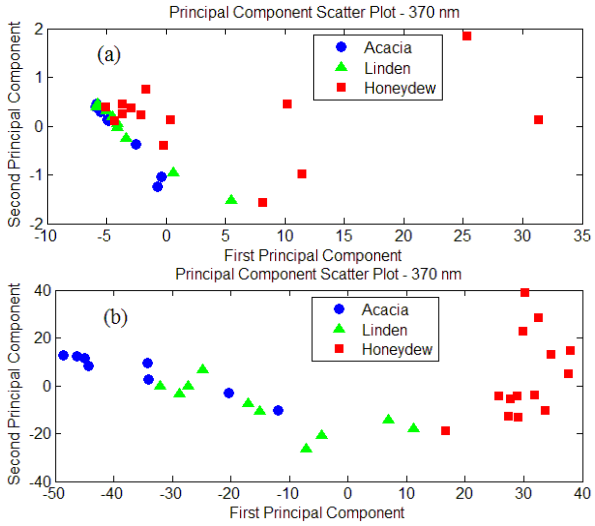

Figure 3. PCA of: (a) the fluorescent spectra, (b) the fluorescent spectra combined with CIELab's parameters

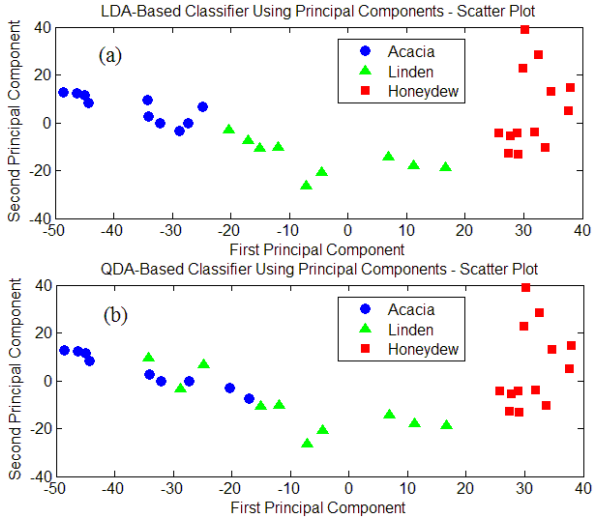

Figure 4. *Honey discrimination by means of: (a) PC-LDA based model, (b) PC-QDA based model.*

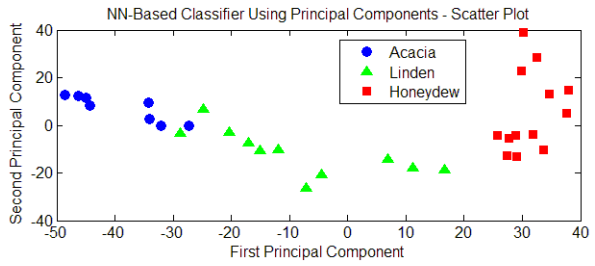

Figure 5. *Honey discrimination by PC-NN based model.*

Table 2: *Discrimination accuracy of PC-LDA based model*

Success: 78.12 %		Predicted Class by PC-LDA			
		Acacia	Linden	Honeydew	
Observed Class	Acacia	6	2	0	8
	Linden	4	6	0	10
	Honeydew	0	1	13	14
		10	9	13	

Table 3: *Discrimination accuracy of PC-QDA based model*

Success: 81.25 %		Predicted Class by PC-QDA			
		Acacia	Linden	Honeydew	
Observed Class	Acacia	6	2	0	8
	Linden	3	7	0	10
	Honeydew	0	1	13	14
		9	10	13	

Table 4. *Discrimination accuracy of PC-NN based model*

Success: 84.38 %		Predicted Class by PC-NN			
		Acacia	Linden	Honeydew	
Observed Class	Acacia	6	2	0	8
	Linden	2	8	0	10
	Honeydew	0	1	13	14
		8	11	13	

4. Conclusions

In this article the optical properties of Bulgarian honey were investigated in regard to the potential of honey discrimination on the base of its botanical origin. The fluorescence spectra combined with the colorimetric parameters of CIELab were used for training the PC-LDA, PC-QDA and PC-NN based classifiers and the following prediction accuracies were obtained: 78.12 %, 81.25 % and 84.38 %, respectively. The future work will include the use of fluorescence spectra, with excitation and emission in UV region.

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MODEL DRIVEN DEVELOPMENT OF AGENT BASED AMBIENT INTELLIGENCE PLACES WITH SERVICE ORIENTED ARCHITECTURE

Assist. Prof. Dr. Antonova I. D., Prof. Dr. Batchkova I. A., Eng. Ivanova Tz.,
Dept. of Industrial Automation, University of Chemical Technology and Metallurgy
Bul. Kl. Ohridski 8, Sofia, Bulgaria

i.antonova@uctm.edu, idilia@uctm.edu

Abstract: *In recent years the use of computer technique and information technology in the domain of Ambient Intelligence (AmI) has been increasing significantly. For successful and efficient development of ambient intelligence systems and their components a new approach is needed. The Model Driven Development (MDD) is an innovative approach for development of different software applications using models at different levels of abstraction and applying model transformation to code generation. In order to satisfy the basic requirements to the developed AmI, in the proposed approach, the MDD, based on Model Driven Architecture (MDA), is directed to combine the use of agents as basic elements of the system and to model the internal and external communications in the system, based on the concept of Service Oriented Architecture (SOA). Such a way, the paper proposes a layered modeling framework for model driven development of agent based AmI systems with service oriented architecture. The deployment of the software on hardware resources is also part of the software process model. Finally some conclusions are made.*

Keywords*:* AMBIENT INTELLIGENCE, MODEL DRIVEN DEVELOPMENT, MULTIAGENT SYSTEMS, SERVICE ORIENTED ARCHITECTURE, UML

1. Introduction

Market penetration of more and more diverse embedded and mobile devices set the agenda for solving the problem of ubiquitous computers dealing with that will make possible the successful implementation of diverse and heterogeneous applications in the area of Ambient Intelligence (AmI). The upcoming trends in the development of the software system in the domain of AmI are connected with the development and implementation of distributed information and control systems, consisting of multiplicity of nonhierarchical modules linked together via different types of communication systems. In order to control the complexity of such distributed real-time systems the following main requirements have to be fulfilled: reliable concept for decomposition and modularity, openness for extensions in the cases of new functionality services and devices, general architecture model of the system has to be producer independent, use of encapsulated, reusable components.

The response to these new challenges is to use new advanced methods in their development life cycle, such as the Model Driven Development (MDD) in order to meet the requirements for reusability, interoperability and cost efficiency. The second aspect is the architecture of the developed system. One very important task is to achieve modularity of the developed system and organizational interoperability between the different components based on Service Oriented Architecture (SOA). The third very important aspect in the system development is to achieve a reactive and proactive behavior of the system components through their modeling and implementation as agents, based on the fusion between SOA and Multi Agent Systems (MAS). The main aim of the proposed paper is to suggest an approach for development of distributed information and control systems for the domain of AmI, based on the combined use of above mentioned advanced approaches of software engineering.

The paper is organized in 5 parts. After the introduction, in part 2 a short analysis of research requirements for AmI is proposed. Part 3 discusses the main features of model driven development, multi-agent systems and service oriented architectures. In Part 4 of the paper the suggested approach is described. Finally some conclusions are made.

2. Short analysis of research requirements for achieving Ambient Intelligence space

Ambient Intelligence (AmI) is a vision of Information Society and Technology Advisory Group (ISTAG) [1] for building of smart environments that are reactive and proactive to people and make their actions safer, more efficient, more informed, more comfortable or simply more enticing. This means that the focus is moved from the individuals that has to adapted, towards of the technologies which need to be adapted to the individuals. As shown in Fig.1, AmI spaces are combinations of two kinds of components; components of operational technologies such as smart materials, I/O devices such as sensors an actuators, ubiquitous communications, adaptive software etc., and AI components including media management and handling, natural interaction, computational intelligence, context awareness, and emotional computing.

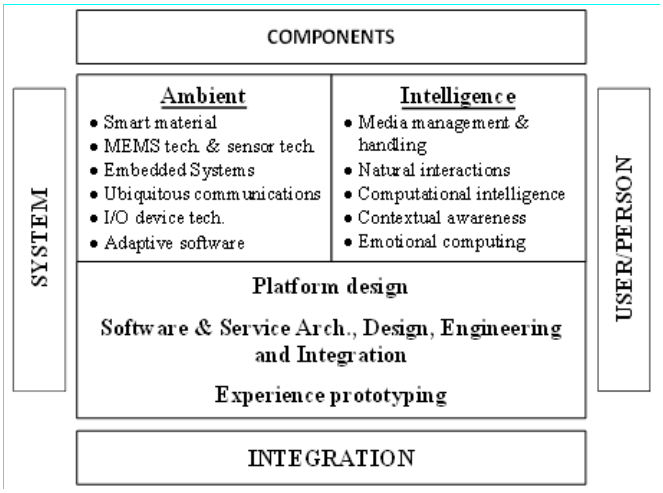

Fig.1: *Main research domain supporting AmI according [1]*

The five main features that an AmI system should fulfill with respect to its relation with users can be determined as [2]:

- Non-obtrusive: the system should not interfere with the user's life style through invisible, embedded and distributed devices.
- Context aware: the system should be able to recognize and anticipate the context the user is evolving in and use this context to react to his needs and requirements.
- Personalized: users' profiles and environments are heterogeneous. The system should be customizable in order to fit in different environments and to be used by different users.
- Adaptive: the system's behavior can change in response to the actions and the needs of a person. New services and functionalities can be added with respect to the user needs.
- Anticipatory: it anticipates the person's desires and environment status; it is context predictive and proactively enabler.

These properties of AmI systems cannot be achieved without the use of new methods, technologies and tools, among which stand out the buzzwords pervasive, ubiquitous, context-aware, profiling etc. Another important factor in achieving the desired properties of the AmI system is the choice of suitable architecture and software infrastructure that enable easy integration, interoperability and extensibility. Considering these aspects, in this paper an infrastructure to support an efficient approach for development of AmI systems, combining the approaches of MDD, SOA and MAS, is presented. In the next part a short overview and comparison of these approaches is given.

3. Short review of the applied techniques

3.1. Model driven development (MDD)

Model Driven Engineering (MDE) and Model Driven Development (MDD) [3] are some of the most promising and challenging approaches for development and maintenance of highly distributed real time information and control systems such as the AmI systems. Here the systems are presented as models that conform to meta-models, and the model transformations are used to manipulate the various representations. The main difference from other development methods based on models is that MDD uses Models as inputs to parameterized implementation generators, i.e. implementation is (semi)automatically generated from the models.

Model Driven Architecture (MDA) [4] is a remarkable MDD initiative of Object Management Group (OMG), providing a powerful conceptual framework for development and transformation of three interconnected types of models - Computation Independent Model (CIM), Platform Independent Model (PIM) and Platform Specific Model (PSM) towards executable applications as shown in Fig.2. The main features of the models are:

- CIM – is also known as business or domain model that uses vocabulary to present the basic expectation from the system and to bridge the gap between domain experts and developers. This abstraction hides all specifications connected to the system implementation.
- PIM – is a view of the system without any details about implementation. Basic tasks of the PIM model are to model logical data, to establish dependencies and defining workflows and processes. Furthermore, PIM models must be sufficiently complete and accurate to ensure a higher degree of automated implementation of the models in the next layer (PSM).
- PSM – combine the PIM specifications with concrete platform information needed for enabling system execution, i.e. the basic role of this model is to ease the code generation using PIM and selected execution platform.

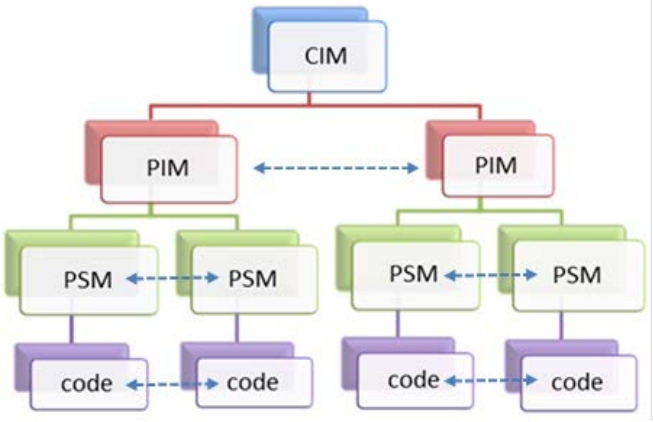

Fig.2: *MDA conceptual framework*

Traditional MDA infrastructure consists of a 4 layer hierarchy of models. The bottom layer is referred as M0 and holds the "user data", i.e., the actual data objects the software is designed to manipulate. The next level is M1 and holds a "model" of the M0 user data. This is the level at which user models reside. Level M2 holds a "model" of the information at M1. Since it is a model of a (user) model, it is often referred to as a meta-model. Finally, level M3 is a mode of the information at M2, and is characterized as the meta-meta-model. For historical reasons it is also referred to as the MOF. Very important aspect of the MDA approach is the transformation between the different viewpoint models. Model transformation relies on a set of mapping rules between models that inform the transformer tool about the patterns it needs to follow to output the target model [5]. The MDA approach is supported by the OMG techniques like Unified Modeling Language (UML), Query View Transformation Specification (QVT) and Meta Object facility (MOF) [6]. In the core of MDA are the open standards, UML, MOF, XMI, etc. UML [7] provide an integrated modeling framework, covering structural, functional and behavior descriptions. The UML notations support the development of various diagrams that reflect different aspects of the system in order to capture the full complexity in the phases of detailed analysis and system design.

MDD and MDA are suitable for use in the development of AmI systems and its combination with SOA or MAS, because of the opportunities they create through the applied meta-models and model transformations for providing reusability, verification and validation of models, integration and interoperability. There are some successfully developed agent meta-model and transformation means for development of MAS, such as for example: SODA, MACMAS, DMLS4MAS, PIM4Agent, Pineapple, Sol, etc. A review of these tools and applications is presented in [8].

3.2. Service Oriented Architectures (SOA)

Service Oriented Architecture (SOA) is a software model in which the concept of a 'service' is an abstraction of a function used by an application and provides an architectural approach that brings the flexibility and agility required by today's global business environment [9]. The model of Service Oriented Architecture (SOA) includes three main applications: application for providing a service, application for requiring a service and application for registration of service (Fig.3). The interactions between applications involve three basic operations: publish, find and bind. They are performed with the objects of web service model, which are: service and service description. Service requestor is a client application requesting data or functionality. To request data, the application must call the web service. Service provider contains the web service that can be used by any other application. Service registry contains a description of all services that the user creates. When request a web service, the service registry is looking for requested service and sends the search result to the service requestor.

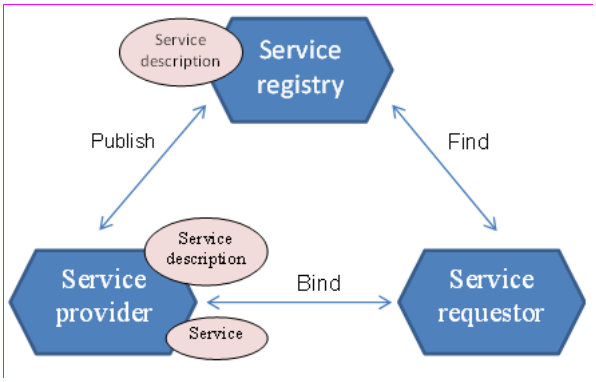

Fig.3: *Model of SOA*

Different environments for development of Service oriented architectures and models are known. Some of the most popular and used are: W3C Web Service Architecture, OASIS SOA Reference model, ebXML, Semantic Web Services, JINI, OSGi etc. [10]. All these initiatives are collections of best practice principles and patterns in service-oriented design. The W3C Web Services Architecture as one of the most promising architectures identifies

the functional components of Web Service architecture and defines the relationships among those components in order to affect the desired properties of the overall architecture [11]. Web Services generally use either SOAP or XML-RPC as communication method for services, UDDI for service discovery and WSDL for service description. Web services are process driven and use process model to describe process orchestration. Orchestration is a composition of business objects in process flows through defining the interactions between them including business logic and execution order. Choreographies on the other hand define collaborations between interaction parties.

MDD methodology may be used as a starting point for development of SOA based applications. For example, Rational Software has provided an extension to Rational Unified Process (RUP) called RUP-SOMA, built by IBM for service-oriented analysis and design and used for identification, specification, and realization of services, service components, and flows [12]. Another contribution towards the integration of MDD and SOA is the UML profile for modeling services and SOA named SoaML profile (http://www.SoaML.org, http://www.omg.org/spec/SoaML/), which is proposed by OMG, and allows expanding the capabilities of UML tools in the direction of modeling the basic elements and constructs of SOA. The joint use of SOA and MDA ("ModelPro" engine for Eclipse) reduces the development time of SOA applications, facilitating their maintenance and prolongs their lifespan.

3.3. Multi Agent Systems (MAS)

Multi Agent Systems (MAS) can be defined as "a loosely coupled network of problem solvers (agents) that work together to solve problems that are beyond the individual capabilities or knowledge of each problem solver" [13]. Jennings and Wooldridge [14] have defined an agent as "a computer system situated in some environment and capable of autonomous action in this environment, in order to meet its design objectives". Agents have the following main properties and characteristics [15]:

- autonomy: agents encapsulate some state (that is not accessible to other agents), and make decisions about what to do, based on this state, without the direct intervention of humans or others;
- socialability (interactivity): agents interact with other agents (and possibly humans) via some kind of agent-communication language, and typically have the ability to engage in social activities (such as cooperative problem solving or negotiation) in order to achieve their goals;
- reactivity: agents are situated in an environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the INTERNET, or perhaps many of these combined), are able to perceive this environment (through the use of potentially imperfect sensors), and are able to respond in a timely fashion to changes that occur in it;
- pro-activeness: agents do not simply act in response to their environment, they are able to exhibit goal-directed behaviour by taking the initiative;
- mobility: agents can transport themself across different systems architectures and platforms.

The agent community has considerable interest in developing methods and techniques for specifying, modelling, implementing and verifying of MAS for distributed information and control systems, as are the AmI systems, but so far no standardized design methodology has been recognized. Several object-oriented methodologies have been suggested for agent-oriented analysis and design, based on UML. Important drawbacks of using UML to model MAS are the modelling of agent communications as method invocations and the absence of references to the mental state of the agents. To overcome these drawbacks, the UML notations are extended to reflect the characteristic properties of the agents. Successfully extensions of UML are achieved in AUML, GAIA, MESSAGE/UML, AgentUML, Prometheus, etc. Some of them are based on FIPA standard (http://www.fipa.org) suggesting an agent reference model for creation, registration, location, communication, migration and retirement of agents. Recently are also available some specialized tools for lightweight devices, some of them suitable for the domain of AmI, such as DSML4MAS (http://dsml4mas.sourceforge.net/), FIPA-OS, ASEME (for Eclipse), Tropos (http://www.troposproject.org/), INGENIAS (http://sourceforge.net/projects/ingenias/), Jade-Leap, etc. However, there are limitations and drawbacks, associated with the variety of devices and communication protocols, specific for AmI. As well there are some agent-based development environments especially for the AmI domain, as for example: THOMAS, MaRV, ALZ-MAS, CodeBlu, etc.

The discussion around the fusion of MAS and SOA is connected with enhancing some basic features of developed distributed system, such as adaptability, flexibility, interoperability and modularity. Moreover AmI systems must be improved in respect to service discovery, self-organization, rich knowledge representations and context-awareness. The combination of MAS and SoA can be performed in different ways, as for example [16]:

- Through gateways between agent and services, translating semantics.
- Using the concept of "agent-based services", resulting in encapsulation of single agents as services and direct access to other services.
- Using the concept of "service-oriented agents", resulting in that they not only share services, but also complement their own goals with external provided services, i.e. enabling agents in existing systems to request, provide or manage web services.

The presented approach for MDD development of AmI systems is based on the concept of "service-oriented agents" and is shortly discussed in the next part of the paper.

4. Description of the suggested approach

In order to fulfill the basic requirements to the AmI systems, the software infrastructure of the system is necessary to be distributed, enabling self-organization of devices and their software components. AmI systems are much more complicated than traditional computing systems. Hence, characteristics such as adaptability, flexibility, interoperability and modularity are more important. Furthermore, these systems must provide common improvements such as service discovery, self-organization, rich knowledge representations and context-awareness.

The suggested model driven approach supporting the fulfillment of above mentioned requirements uses MDA and comprises the whole development life cycle of software development, starting with CIM meta-model to the deployment. The approach is illustrated in Fig.4 using 4 layers: one CIM layer, two PIM layers and one PSM layer. Four principles as architecture cornerstones are chosen:

- Model-driven principle using MDA of OMG, supporting the platform independent and model based domain engineering;
- Service-oriented architecture using PIM4SOA meta-model (http://pim4soa.sourceforge.net/):
- Web services meta-model for description of loosely coupled, reusable, composable components;
- PIM4Agents meta-model [17] - platform-independent model that specifies multiagent systems in a technology independent manner.

With the proposed approach it is possible to design an agent-based AmI system with service oriented architecture specifying high level concepts in a platform-independent agent model (focusing on the domain model), and later automatically transform it for diferent implementation models, bridging the gap between design and implementation. The use of two layers of PIM models enables for horizontal transformation between the models of the second layer and the use of "foreign" environments for performance.

The platform-independent model for service-oriented architectures (PIM4SOA) covers four important aspects:

information, services, processes and quality of service. For example the services aspect include the services, which are represented as collaborations specifying pattern of interactions between participating roles, as shown in Fig.5.

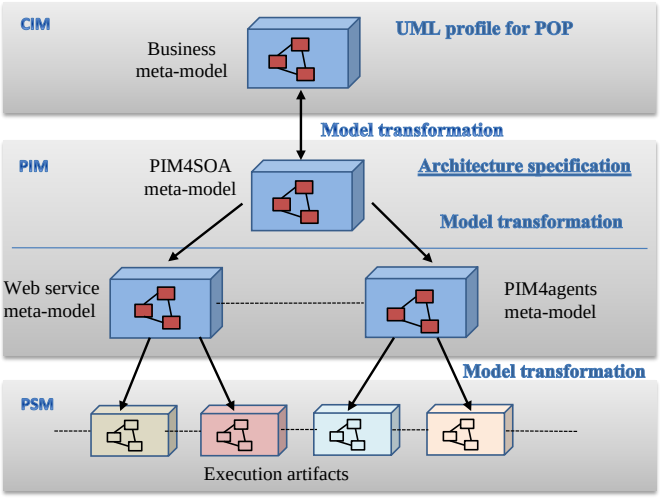

Fig.4: *Illustration of the suggested approach*

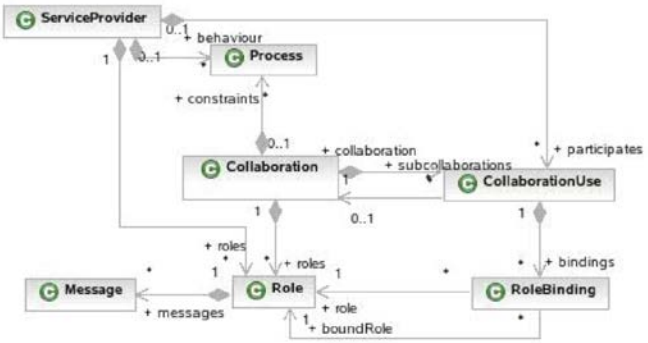

Fig.5: *Subset of PIM4SOA for service aspect*

PIM4Agents meta-model represents an integrated view on agents in which different components can be deployed on different execution platforms. The PIM4Agents meta-model defines modeling concepts that can be used to model different aspects or views of an agent system, such as: Agent, Organization, Role, Interaction, Behavioral, Environment etc., as is shown in Fig.6.

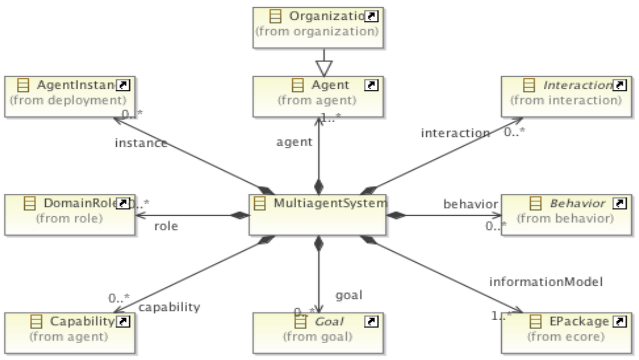

Fig.6: *Basic Views of PIM4Agents meta-model*

5. Conclusions

The suggested approach uses the MDA to address the modeling of MAS and SOA in order to facilitate software development through abstractions avoiding the specific implementation details. The proposed meta-models are implemented in EMF of Eclipse and are presented in ECORE format. The transformation PIM and PSM may be done by using ATLAS transformation language (ATL). The main idea is to achieve a layer based design that enables the division of system elements into levels, reducing the coupling between modules, facilitating abstraction as well as the distribution of responsibilities. Combining SOA with MAS will improve the characteristics of the system being developed in the direction of meeting the requirements of anticipatory and adaptability. The choice of PIM meta-models is essential to achieve the requirement for context awareness of AmI systems.

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ОЦЕНКА НА ЕРГОНОМИЧНОСТТА НА СРЕДАТА В ОФИС ПОМЕЩЕНИЕ ПРИ ДЕКОРАЦИЯ СЪС СВЕТЕЩИ СКУЛПТУРИ

ASSESSMENT OF THE ERGONOMY IN AN OFFICE DECORATED WITH ILLUMINATED SCULPTURES

Ас. Станева Галина, Доц. д-р Мурзова Ц., Доц. д-р, инж. Василев Р., ас. д-р, инж. Гюров
Технически университет - Варна

Ass. Prof. Staneva G., Assoc. Prof. Dr. Murzova C., Assoc. Prof. Dr. Eng. Vasilev R., Ass. Prof. Dr. Eng. Gjurov V.
Technical University - Varna, Bulgaria
artist.galina@gmail.com, cenamurzova@abv.bg, rsnvasilev@abv.bg, vgiurov@yahoo.com

Abstract: *This report presents the opportunities of using high-tech spectral adjustable illuminated sculptures and their impact on the visual ergonomics of the environment aiming to optimize the system "man - environment" with main focus on the psycho-physiological effects of the pieces of art and the light emitted by them. The evaluation is based on a survey on the subjective perception of the business climate under the effect of different lighting scenarios which is focused on achieving certain psycho-physiological effects.*

Keywords: ILLUMINATED SCULPTURES, OFFICE LIGHTING, VISUAL ERGONOMIC, PSICHO-PHYSIOLOGICAL EFFECT

1. Въведение

Малките и големи фирми в България все повече обръщат внимание на подобряването на условията на труд с цел повишаване трудоспособността. В офисите се създават кътове за хранене, почивка и спорт. Помещенията за работа, в които хората прекарват голяма част от деня си, трябва да отговарят на техните изисквания и потребности. Ергономичната визуална среда е важен фактор за постигането на определен физиологичен и емоционален комфорт. Обзавеждането, осветлението, цветовете на интериора трябва да са съобразени с естеството на дейностите, които се извършват в дадената работна среда. Създаването на възможност за различни видове цветово-светлинни въздействия, чрез използването на декоративни осветителни тела, може да подобри визуалната ергономичност на вътрешното пространство, а оттам и да повиши работоспособността на потенциалните потребители. [1:156] За целта е създаден прототип на софтуерно управляема, спектрално регулируема композиция от декоративни светещи форми.

Целта на проведените експерименти е да доведат до предложение за подобряване ергономичните параметри на работната среда и увеличаване на комфорта и работоспособността на работниците в малък до средно голям офис.

2. Предпоставки и начини за разрешаване на проблема

Визуалната ергономичност на средата се определя от зрителните, физиологични, психически и социални изисквания и предпочитания на хората, които я обитават.

Още през 1911г. румънският лекар Ф. Стефанеску-Гоанг установява, че светлината с различен спектрален състав променя физиологичните показатели на човека. При пурпурна, червена, оранжева и жълта светлина се ускоряват и задълбочават дишането и пулса, а при зелена, синя и виолетова светлина пулсът и дишането се забавят. Изследванията на Ф. И. Комаров, Л. В. Захаров, В. А. Лисовский през 80-те години на XX в., доказват влиянието на интензивността и спектралния състав на светлината върху дейността на сърдечно-съдовата, ендокринната, централната и периферната нервна система [2:50]. Френският невропатолог Ш. Фере доказва пряка зависимост между цветовото въздействие и мускулната работоспособност. При кратковременна работа червеният цвят повишава работоспособността, оранжевият, жълтият и зеленият имат действието на дневната светлина, а синият и виолетовият намаляват производителността. Той открива и факта, че кратковременното прекъсване на цветовото въздействие и почивката от него благоприятства повишаването на производителността. [3:75] Руският офталмолог проф. Рабкин определя цветовете от централната част на спектъра – жълт и зелен, като оптимални за физиологичния комфорт на човек по време на продължителна работа. [4:75]

3. Резултати дискусия

На базата на данните от споменатите изследвания са подготвени различни светлинни сценарии за интериорни пространства, обзаведени със специално проектирани за целите на настоящото изследване четири софтуерно управляеми и спектрално регулируеми декоративни светещи форми. Тези сценарии са съобразени със спецификата и интензивността на работата, която се извършва в дадената среда, като са предвидени и прекъсвания, които благоприятстват визуалния и общ комфорт на потенциалните потребители.

Проведена е анкета, на базата на демонстрация в реална среда за определяне оптималните цветове за зрителния комфорт на човека, работещ в офис. Взети са под внимание характеристиката на разнообразието на дейността и нейната продължителност.

В експеримента хората са изложени на въздействието на светлина в 20 цветови нюанса, за определен период от време: пет минути, половин час и 1 час. Установени са цветовете, които най-добре влияят на зрителния процес при различни видове дейност, като четене на книга, работа на компютър, чертане, обсъждане на служебна информация и др. Те са подбрани с помощта на програмата Color Play 3. Според палитрата, цветните тонове H (hue) са обозначени в градуси, които показват ъгъла в спектралния кръг. В диапазона от 50 – 260 градуса могат да се използват за най-дълъг период от време (над половин час) без да причинят дразнения в зрителният орган. Останалите цветове от 0 до 50 градуса и от 260 до 359 градуса, трябва да се използват ограничено – не повече от 5 минути.

Продължителността, с която може да се използва цвета зависи от неговата наситеност S (Saturation) – степента на смесване с белия цвят на светлината и яркостта V/B (Value/Brightness). Колкото повече намалява числото на S и на V/B толкова по-дълго окото може да бъде изложено на

конкретния цвят. Например оранжевият цвят с параметри H: 39, R: 255, G: 111, B: 0 е подходящ за осветление не повече от 5 мин., но когато числото на S намалява от 255 към 0, което го доближава до белия цвят, продължителността може да нарастне до половин час. Нюансите стават по светли и следователно по–поносими за очите при наблюдение. При намаляване числото на V/B от 255 към 0 цветът потъмнява и вдействието също се омекотява.

Фиг. 1 *Декоративни осветителни тела светещи в червен цвят – R: 255; G: 0; B: 0 и H: 0º.*

Таблица 1: *Граници на ергономично оптимално време на въздействие при различните цветове светлина при работа в офис среда.*

Цвят	R:G:B:	Hº	5 мин	½ час	1 час
червен	255;0;0	0	+	-	-
оранжев	255;111;0	26	+	-	-
жълто-оранжев	255;166;0	39	+	+	-
жълт	255;221;0	52	+	+	+
лимон	234;255;0	65	+	+	+
жълто-зелен	179;255;0	78	+	+	+
светлозелен	123;255;0	91	+	+	+
зелен	13;255;0	117	+	+	+
синьо-зелен 1	0;255;98	143	+	+	+
синьо-зелен 2	0;255;153	156	+	+	+
светлосин	0;247;255	182	+	+	+
син	0;191;255	195	+	+	-
тъмно син	0;136;255	208	+	+	-
син	0;26;255	234	+	+	-
син-виолет	85;0;255	260	+	+	-
виолет 1	140;0;255	273	+	-	-
виолет 2	195;0;255	286	+	-	-
розов	251;0;255	299	+	-	-
розово-червен	255;0;149	325	+	-	-
бял	255;255;255	0	+	+	+

Ергономичното въздействие на даден цвят светлина може да бъде подобрено, ако тя се комбинира с друг, като се сменят последователно (през определен период от време), преливат един в друг или въздействат едновременно.

Като най-подходящи за зрението по време на работа са съчетанията на два съседни цвята: жълт – оранж, син – зелен и т.н. и съчетанията със зелен, жълт и бял цвят. Те намаляват дразнението на очите, което се чувства при самостоятелното действие на червения и виолетовия цвят. Ярките тонове са необходими, за да нарушават монотонността, която при по-голяма продължителност изморява очите. Те трябва да се използват за кратко и през големи интервали от време.

Фиг. 2 *Декоративни осветителни тела светещи в комбинация от зелен и оранжев цвят светлина – R: 0; G: 255; B: 0 – R: 255; G: 166; B: 0.*

Таблица 2: *Граници на ергономично оптимално време на въздействие при различните цветови комбинации с два цвята светлина, при работа в офис*

Цветова комбинация	**R: G: B: - R: G: B: (I цвят) - (II цвят)**	**Време на въздействие заедно**
зелен - червен	0;255;0 – 255;0;0	10 минути
жълт - виолет	255;255;0 – 140;0;255	10 минути
оранж - син	255; 166;0 – 0;136;250	½ час
жълт - червен	255;255;0 – 255;0;0	10 минути
жълт - син	255;255;0 – 0;136;250	1 час
син - червен	0;136;250 - 255;0;0	10 минути
зелен - оранж	0;255;0 – 255;166;0	1 час
зелен - виолет	0;255;0 – 140;0;255	½ час
виолет - оранж	255;166;0 – 140;0;255	10 минути
жълт - оранж	255;0;0 – 255;166;0	1 час
оранж - червен	255;166;0 – 255;0;0	10 минути
червен -виолет	255; 0;0 – 140;0;250	5 минути
виолет - син	140;0;255 – 0;136;250	½ час
син - зелен	0;136;250 – 0;255;0	1 час
зелен - жълт	0;255;0 - 255;255;0	1 час

4. Заключение

На базата на оценката за ергономичността на работната среда, проведена в реални условия са достигнати търсените резултати, при въздействието на спектрално регулируемите лампи, предназначени за офис. Информацията извлечена след експериментите с тях и провеждането на анкета, може да бъде приложена при създаването на по-сложни светлинни сценарии, с участието на повече от два цвята. Времетраенето и нюансите могат да бъдат регулирани според продължителността на работния ден и според естественото и изкуственото осветление в офиса. Могат да се създадат програми, които да бъдат прилагани при различни видове дейност и да бъдат осигурени необходимите прекъсвания, за да бъдат осигурени зрителен комфорт и оптимална цветова и светлинна среда по време на работа.

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КУКЛАТА БАРБИ КАТО БЕЛЕГ НА НАШЕТО СЪВРЕМИЕ. ДИЗАЙН И ТРАДИЦИИ ВЪВ ФИГУРИ ОТ ФИЛЦ.

THE BARBIE DOLL AS A SIGN OF OUR TIMES DESIGN AND TRADITION IN FELT FIGURES

ас. Гаджева М. Г. Технически университет – София, България mihaelagadjeva@abv.bg
as. Gadjeva M. G. TU – Sofia Bulgaria

Abstract: *"Any significant cultural object appears, as a rule, in two roles: in its immediate function, determining the social needs in certain specific areas, and also in a 'metaphorical' one, when its properties are transferred onto a broad range of factors, whose model this object becomes." J. Lotman*
The frequent use of human image, widespread through the so-called object-doll and having various intentions and motives, suggests the question whether the doll can be considered as the first and natural child toy; whether it does not appear later on as an imitation of the human image; and, finally, whether the purpose of this activity is not really very serious.
Authorial dolls – felt and textile figures - will be presented in contradistinction to the contemporary doll-idols.
Key words*: DOLL, DESIGN, MATERIALS AND PROPORTIONS, TOY AND GAME, MACHINES AND TECHNOLOGIES – PROGRESS OR DECAY, ETC.*

1. Увод

Куклата, е нещото пряко свързано с човека – датира заедно с него, по образ и по форма го копира и в този смисъл, тя е неотменен негов спътник. Ролята и вида на този предмет през различното време от развитието на човечеството, съвсем съвпада с нивото на неговото развитие във всеки един смисъл-вярвания, сръчности и умения, умствено, душевно и духовно,... В този смисъл, куклата се явява един безценен исторически, културен и социален артефакт. Тя е живото свидетелство за развитието, порастването и паденията на цивилизациите в един глобален мащаб. Доказателство за всичко това са преките свидетелства на кукли артефакти от различните периоди на човешкото съществуване. В началото куклите са се изработвали, като много бегло напомнящи човека и най вече неговият образ. Липсата на всички човешки атрибути като крайници и части от лицето, свидетелства за едно преклонение пред човешкото изображение и страх, че дори и съвсем малко да го наподобим , ни грози опасност от „оживяване чрез вселяването на зли духове", или „наказание от Бога". Намираме куклата във всевъзможни форма и изображения, за да го замести или представи . Тя го съпътства при раждането му, при смъртта му, при болест и радост, като пазителка в образа на „ Зерневушка" и отменителка при японската „ Ханива", за плодородие и късмет. В днешно време тя може да е символ на държава, населено място, народ и култура...
Честата употреба на човешкото изображение, целящо различни намерения и случаи, ни навежда на въпроса -дали можем да считаме куклата за първата и естествена играчка на детето и не се ли появява по късно като подражание на човешкото изображение и целта на тази дейност не е ли доста сериозна?!
Деликатния подход към човешкото изображение в зората на човешката цивилизация, особено ярко контрастира с по късните изображения и особено тези от нашия век.
Проследявайки поетапно развитието и промяна на куклата във формооразуването, материалите, размерите, начините на изработка, начините и предназначенията за използване, се оформят различни групи, направления, течения, школи, авторски бележити разработки. На базата на това се сформират различни потребители в зависимост от функцията. И колкото повече се задълбочаваме и прецизно анализираме разнообразието от изображения въплътени чрез куклата, се сблъскваме с нещо уникално – „Тя", като нещо което безспорно е вдъхновено от човека, започва да имитира и проиграва, всички възможни прояви, пози, жизнени години, професии, красоти, грозоти и всеки образ който е възможен в процеса на живеенето, достъпно и присъщо на човека.
Куклата е навлязла в ежедневието до степен на сраствне с човека. За това и ролите които се предоставят са значещи и незабележими. Безспорно важни, което им осигурява естественото им приемане и съгласяване с тях.
Както в самото начало на човечеството, когато човекът много не се е отличавал в развитието си от своето дете, без значение от възрастта всички еднакво са се ползвали и са имали нужда от куклата, така и до ден днешен куклата е за всички, особено тези днешните, които са съвсем като жив човек и реално целта им на съществуване не е обърната към детската игра.
Напреднали технологии, нови изумителни материали, с помощта на които се копира човека до болезненост във всяко едно отношение при куклите – Брадс и BJD, където целта е да замени човека да се създаде истински човек – говори за друг вид отношение към образа и личността и живота като цяло. Липсва детската чистота на ранния човек и се изправяме в лице в лице с безпардонния можещ всичко творец където целта оправдава средствата.
Друг ярък пример, който не можем да отминем, продукт на нашата цивилизация и ценностна система е малката фигурката в женки образ – Барби. Тя е тази която владее всяко ниво и професия на съвременната „дама" – консуматорка и капризна женичка. От първообраза си на лека жена Лили, която се подарява като закачка на ергени, Барби се издига до бизнес дама и каквото още се сетим като умело чрез необходимия антураж от вещи и макеаж се превъплащава и завладява сърцата и всичките сетива на подрастващите момиченца, под формата на играчка. Умела манипулация и шеметен маркетинг за всички времена, Барби остава противоречив образ. За нея се говори като за жив човек. Възприятията ни са двойствени, заради съществуването и между два свята- този на детето и на възрастния, които съставят нейното съществуване. А кога куклата е била идол и после играчка, не е ясно всъщност дали едното изобщо е престало да бъде за сметка на другото.?!

2.Предпоставки и начини за решаване на проблема

Линор Горалик е първият автор дръзнал да оповести една явна истина и глобална тема за изследване – Барби – като културен феномен. Дванадесет сантиметровата фигурка става повод да си зададем множество въпроси произтичащи от нейната популярност, масово храносмилане - превъплътена във всичките възможни професии, физически и модно трансформируема и желаеща, говореща и търсеща- какво?

Поставено е началото на нечувана до тогава а и до днес мощна индустрия, която да обслужва този персонаж.

Бележити дизайнери в модата стават и лични дизайнери на Барби, като Пиер Карден, Кристиан Диор и др.
През 1997 г., в целия свят са продадени 1 000 000 000 милиард от този продукт.
Идеята на куклата е да отговаря на всеки период и възможна ситуация и роля в която е възможно да се намира и заема жената. Куклата става модел на поведение и осъществява мечтите на момиченцата за начин на живот и възможности за красота, дрехи, прически, грим, като със същата тази сила, Барби намира своите опоненти в лицето на педагози, изкуствоведи, духовници, политици-жени. Във външният и вид те откриват леката жена. А създадената говореща Барби доказва чрез репликите които практикува, консуматорски търсения и цели, с което се възпитава и такова отношение и търсения от страна на подрастващото момиченце.
Барби е обявена от съдиите за „общо културно явление“ и е поместена в „капсула на времето“, като един от символите на цивилизацията“ и е на почетно място сред восъчните фигури в музея на Мадам Тюсо.
В речника за кукли съществува понятието –базова кукла- означава една базова към която има предназначени аксесоари или дрехи, такава базова е и Барби с всичко останало предназначено за обслужването и преобразуването на тази една и съща базова форма.
Джак Раян – скулптур, прави Лили тинейджерка. Ентани Булон твърди, че той е истинския автор на куклата. Първата е продадена в Япоия, плашеща и порочна открито предлагаща себе си. Тогава японците не знаят за нейния прототип-Лили. През последващите години куклата претърпява изменения, на които няма да се спирам подробно тъй като това не е тема на статията, а повод да се направят някои изводи и да се зададат въпроси, както за формата, рисунъка, орнамента като средство за целенасочено внушение към потребителя.

/Играта се оказва най-загадъчния феномен за определяне и изследване, с който се опитват да се справят педагогически, изкуствоведски, философски теории. Литературните и историческите материали, отделят особено внимание на „играта“, като най-сериозна форма на човешката дейност, в сравнение с политиката, идеологиите и изкуството, морала и собственото човешко съществуване. Битието на играта се разпростира на територията на космическия универсум, като позволява да се говори за нейния онтологически характер. Такъв извод е направен на базата на граничните и екстремални състояния като – мит, сън, любов, смърт/. Апинян/

Технологиите ни предизвикат. Те не оставят нашата сетивност и умения да направим избор като свободни, осъзнати, преценяващи личности. Възможностите които предлагат ни изнудват да се отдадем, пък каквото ще да става. Резултатите са потресаващо успешни. Това същото се внедрява и в детската играчка като целта е една единствена, посредством умалени вещи от ежедневието на възрастните, да подготвя и социализира подрастващия за избора си на начин на живот – желания, вкусове, стремежи, като единственото което му оставя и така прецизно предоставяно от възрастния – просто да си избере от предоставените възможности. С играчките които поставяме в живота и обкръжението на нашето дете, ние го поставяме наравно със всички. То да има като всички и да стане като всички. Така сигурно и прецизно приспиваме сетивата на нашето дете и отрязваме възможностите за творчество – които се оказва се провокират в кратката детска възраст.
С куклата не е нужно да съзерцаваш чужди мисли каквато цел има статуята, а да играеш. За това прекалената натурност, имитираща действителни предмети от живота, подробности и украшателство, по скоро я увреждат. Отменят нейната цел. Известно е че натуро - имитиращите играчки, с повече разказвателност и подробности, радват най вече възрастните и не са така пригодни за игра от страна на детето, за разлика от схематичните самоделки, за чиито детайли е нужно да се напрегни въображението.

3.Решаване на проучения проблем.

В настоящата статия предлагам авторски разработки на форми, кукли които да са в противовес и съвсем различни на съвременните тенденции и възможности. Като се обръщам назад във времето и поглеждам леко в страни за да претворя познатия от древността материал – вълна, предоставям на вниманието на потребителя фигури, които с нищо не разказват за конкретни полови атрибути, крайниците и самото тяло са символични и първични в своето формообразуване, като целта им е да радват, да носят настроение и усмивка, изненада, че не приличат и не напомнят на нищо познато, различно от „истинските кукли“, както ги определи един баща в анкета проведена сред възрасни за определяне въздействието на авторските кукли от филц. Тези кукли имат за цел да провокират детските възприятия, без да имат функцията игра, а само като присъстват в обкръжението на детето или подрастващия, като друг, различен акцент, който предполага различно преживяване, веднъж заради формообразуването – различно от масовото произведени кукли, и друго – заради самия материал и чудния му начин за обработване, в процеса – иглонабиване.


Авторски кукли – вълна, иглонабиване

4.Заключение

От всичко казано произлиза извода : куклата е сигурен източник и свидетел за традициите, вярванията, вкусовете, уменията, търсенията на всеки един народ, култура, общност, семейство. Жалко е наистина, че този безценен източник на история не е така траен иначе в историята не би имало никакви тайни.

Куклата е модел за подражание. Човекът не може да живее без идеали защото е иконно същество. Проблемът на човекът е неговият образ. Той става такъв, в зависимост с кого се съединява и на кого иска да подражава. Трансексуалния – човек без идентичност, безпомощно търсещ със безпомощните си сили да разгадае своята тайна. Колко мощно явление днес се оказват моделите в лицето на Барби. А коя всъщност е тя, и на кого подражават в този смисъл нашите момиченца?! И колко сме отговорни ние като родители когато със задоволство казваме, че всички имат такава!? Психолозите твърдят, че човешката фантазия и особено тази на детето е толкова неуловима и лепкава, без особени усилия податлива, че тези създавия като Барби – наречени играчки, чрез четливо изразени полови белези водят до ясната цел за която са предназначени тези творения.

Днешната играчка е такава, че ни отделя от другия, от споделянето, от общуването, с който акт се отличаваме от целият останал свят, а с това и от самите себе си. Изработването на куклата, играчката, е сериозен дизайнерски и ергономичен проблем, в оромното море от вече съществуващи вещи, се питаме какво има още да се прави! Считам, че проблема за куклата и играчката тепърва трябва да се постави на различен прочит, като глобална тема, която стои в основата на човешкото развитие.

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AN APPROACH FOR COMBINING THE CAPABILITIES OF IMMERSIVE VIRTUAL REALITY AND MODERN CAD-CAM SOFTWARE SYSTEMS TO CREATE VIRTUAL MODELS OF WORKSHOPS FOR MECHANICAL PROCESSING

M.Sc. Slavov, Stoyan D., PhD.
Faculty of Mechanical Engineering of the Technical University of Varna, Bulgaria
sdslavov@tu-varna.bg

Abstract: *The article describes an approach for creation virtual reality scenes of workshops for mechanical processing, using three-dimensional models from CAD/CAM and on the basis of "immersion" of the designer in a virtual environment. Applications software and hardware resources used to achieve the interaction between CAD/CAM models of the machine tools, equipment and human avatars and virtual reality environment are described. Conclusions for the advantages and problems of the proposed approach and guidelines for future work also are given.*

Keywords: IMMERSIVE VIRTUAL REALITY; DESIGN WORKSHOPS FOR MECHANICAL PROCESSING; MACHINE TOOLS LAYOUT; CAD/CAM.

1. Introduction

Contemporary Computer Aided Design (CAD) systems offer large modeling features and functions for development of 3D models of machine parts, assemblies and entire products, which increase the productivity of the new products design [1, 6]. While the geometrical structure of the CAD models is 3D since long time ago, the user interaction within this software still remains unchanged. At present time the most widely used CAD tools has standard - Windows, Icons, Menus, Pointers desktop-based Graphical User Interfaces, and the interaction is made through standard computer keyboard, mouse and LCD display, which are mainly 2D devices.

In the recent years, Virtual Reality (VR) technology became a dynamic field of research that has begun to be used to a certain extent in industrial and educational applications. VR provides new perspectives for user interaction with CAD tools and models. It enhances the immersion feeling and the depth perception of 3D objects, providing information with less perceptive ambiguities. This opportunity is important for example, when using CAD applications for designing of workshops for mechanical processes, where users must have a direct and thus better appreciation of object shapes and dimensions of the environment. Many research activities are currently focused to integrate CAD architecture inside VR-systems in order to enhance the immersion feeling and the user interaction interface.

VR is composed usually of an interactive computer simulation, which senses the user's state and operation and replaces or augments sensory feedback information to one or more senses in a way that the user gets a sense of being immersed in the simulation (virtual environment). There are four basic elements of VR: the virtual environment, virtual presence, sensory feedback (as a response to the user's actions) and interactivity [9].

2. Interaction between CAD/CAM objects and VR environment.

Computer aided design, manufacturing and engineering, called CAD / CAE / CAM (Computer Aided Design / Computer Aided Engineering / Computer Aided Manufacturing) are the best currently existing form of organization of automated design data. CAD systems are mainly designed to solve problems to describe the geometry of parts, components and products in general (ZD-drawings or 3D-models). Over recent years their opportunities widened and extended to other non-geometrical features required for integration with other subsystems (CAE, CAM, etc.). The goal is to avoid the "manual" reformatting data. The result includes geometrical, digital and technological data used for description the designed products (drawings, results of calculations, materials, etc.), production specifications (bill of materials), experimental results (e.g. protocols of measurements), and additional text information (e.g. technical descriptions, instructions for servicing, maintenance and installation). CAM is associated with all tasks concerning the management and control of the manufacture or assembling of the devices. These systems generate data on the direct control of CNC machines, robots, transportation and storage systems. At this stage the problems relating to the general organization of production, the flow of material, the instrumentation, warehouse, etc., are also considered.

The difference between VR technologies and technologies for designing often not understood properly [1]. Many users of CAD software for design still believe that VR technology can be used only for creation of PC games, 3D movies or attractive presentations and they relate CAD systems only with high precision engineering geometrical models. In fact, VR and CAD are complementary technologies. CAD systems are set up to build models and assemblies for VR can be used to display these models by "immersion" the designer in the virtual environment. Some CAD models now can be viewed in VR through use of special viewing helmets or glasses, and software that formats video images to create the impression of depth.

The impression of depth results from seeing two perspective views of a three-dimensional object that correspond to the same views seen by our left and right eyes [4, 5]. There are two general ways to create these views. The approach employed in VR helmets is to use two small video screens, one for each eye, and send each view to the respective screen. A second method, which is more suitable for CAD applications, multiplexes the two images onto the sequential video fields of an ordinary monitor (or projector). The viewer wears an inexpensive set of glasses that contain an infrared receiver and polarized left and right lenses. An infrared transmitter synchronized to the alternating video fields sends signals to the eyewear which cause each lens to shutter on and off at the appropriate time so that each eye sees the corresponding left or right view. To track the view provided by the eyewear in space requires a special view controller consisting of three ultrasound speakers sitting on top of the monitor. They emit signals to microphones incorporated in the eyewear. Signals from both the eyewear and speaker array go to a control unit. The controller detects phase differences in the transmitted and received ultrasound signals, and uses the information to track the user's head position. Software calculates new perspective views from this information.

3. Creation realistic models of mechanical workshops in the VR environment.

Using CAD software intended for design industrial plants

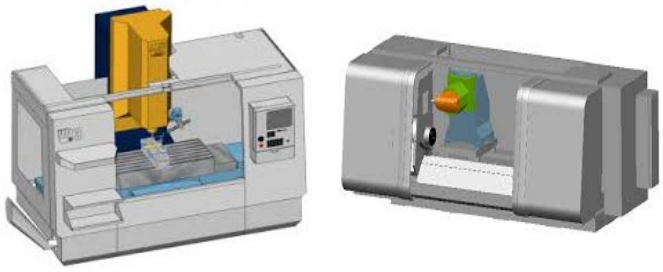
In recent years, many software companies develops specialized in designing of production plants CAD software products, such as 3D Plant Design (Autodesk), Siemens FactoryCAD™, Smap3D Plant Design (CAD Partner GmbH), DELMIA Quest and DELMIA Plant Layout (Dassault Systemes), etc. Even though these software

products are designed to help users design, simulate and analyze the process flow in 3D factory environment, there are still various difficulties to use them as effective tool to creating an immersive VR environment. The more significant of them are: The equipment libraries usually contains limited 3D templates of machine tools and typical processing equipment for mechanical workshops; The user interface often is quite difficult to grasp for the beginners such as students and course participants, and this required extensive help of instructors; Often there are no readily available user tutorials, manuals and examples of their usage; Even though the modeling of plant or workshop layout is entirely carried out in a 3D environment, the user interface remains two-dimensional by using ordinary computer displays; Another limiting factor often is the price at which these high level CAD software products are offered.

For these reasons, the main objective of this work is to develop an approach and methodology for relatively rapid creation of the realistic models of workshops for mechanical processes in the environment of the virtual reality, suitable for students, studying in the majors of mechanical engineering.

Using existing 3D models from CAM software, which represent the real machine tools

For more realistic simulations of the machining processes, some CAD / CAM systems (for example Delcam family: FeatureCAM, PowerMill, but also PEPS, Edgecam, CAMWorks, etc.) enables users to choose some previously defined 3D models of the machine tools (associated with NC postprocessors), or ability to set their own machines kinematics for simulating their specific milling, turning or turn-milling machines in action. By using machine simulation the operator not only catches part gouges or tool collisions in the work piece, they can see the machine components in action and any occurrences of axis over-travels and more. For 4^{th} or 5^{th} axis programmers can see rotary rewinds, perform machined part deviation analysis and even gather the minimum and maximum cutting length data which is helpful for shops in the estimating process. Examples of two real machine tools 3D models are shown on Figure 1 (a, b). Each machine tool is described by its mathematical model, which is referred to as the kinematic model of the machine. These models contains information used by the (Delcam) Postprocessor to transform coordinates received from the CLDATA file (model coordinates) into coordinates of a machine tool.



a) b)

Fig.l: *Realistic 3D models of real CNC machine tools: a) Haas Automation's VF-4 vertical machining centre, included in FeatureCAM (Delcam) and b) Turn-mill machining centre - CTX gamma 2000 TC 4A / linear (DMG MORI), included in PowerMill (Delcam).*

There are more than 100 previously defined 3D models of real existing machine tools and robots, available in FeatureCAM and PowerMill. The machine models are presented in specific formats, called "Machine Design" files with extensions "*.mtd" in PowerMILL and "*.md" in FeatureCAM, but they can be exported into universal 3D vector formats, like: "*.stl" (Stereolithogrphic), ".step" (ISO 10303), "*.x_t" (Parasolid) or "*.iges" (Initial Graphics Exchange Specification) and after that imported for aditional processing into third-party CAD or other type software for 3D modeling, animation, and rendering, like: Autodesk 3ds Max, Maya, Maxon CINEMA 4D, etc. To accomplish the equipment motion, every movable part of the 3D models of machine has to be distinct. Otherwise there will be difficulties in properly rendering the different parts and animating the typical movements of machine parts will not be possible. In addition, the most CAM software's (from medium and high level) usually are equipped with modules, that allows users to create their own models of machine tools (and also additional equipment such as clamps, vises, tool holders, etc.) using standardized CAD methods and techniques, in case they are not included in the libraries of the CAM software. These peculiarities, and the ability to export to universal 3D formats makes this approach preferable in comparison with using specialized in designing of production plants CAD software or creating trimeric models of different types of machines for mechanical workshops from the scratch.

Based on this, below is described an algorithm for creating realistic mechanical workshop (in real dimensions) into VR environment of Vizard (WorldViz), including necessary basic technological and auxiliary equipment, workshop building and staff.

4. Short description of the used computer software.

At the core of the mechanical workshop VR scene creation stays Vizard VR Toolkit (WorldViz) [11]. It is a versatile virtual reality development interface designed for building and rendering virtual worlds with minimum effort. Designed for rapid prototyping, the toolkit gets creating fast and provides the resources to deploy even the most challenging applications. This software supports stereoscopic head-mounted displays, 3D sound and many peripheral input devices, including head trackers and game pads. Distributed, networked environments are also supported. Vizard is guaranteed to support all head-mounted displays, LCD shutter glasses, and several other specialty display technologies such as dome projectors and auto stereoscopes. Most commercially available tracking devices are supported in Vizard. The toolkit also supports numerous other devices such as gloves, haptic displays, force-feedback systems, and simple Microsoft Direct Input TM compatible gamepads and joysticks. There is even built-in support for high-quality 3D sound and multi-user networking. VRML and other 3D formats provide immediate access to large 3D databases. The open-source language Python is free and has an active user community providing a wealth of resources for applications. Built-in human face and body models and an accompanying morph designer offer a powerful tool to almost instantly insert virtual humans into existing environments. For custom bodies, 3DMax Character Studio bipeds can be imported into Vizard. WorldViz also provides a large selection of additional high quality avatars that are available for purchase.

Solidworks (Dassault Systemes), MS Visio (Microsoft) along with SketchUp (Trimble Navigation, Ltd) can be used for creating 2D layouts of mechanical workshop, rendering the 3D models and converting the machine tools files from FeatureCAM in suitable for importing in Vizard VR Toolkit file formats. SketchUp is a 3D modeling computer program for a wide range of drawing applications such as architectural, interior design, civil and mechanical engineering, film, and video game design [10]. The free version of Google Sketchup can export 3D to .dae and Google Earth's .kmz file format. The Pro version extends exporting support to include the .3ds, .dwg, .dxf, .fbx, .obj, .xsi, and .wrl file formats, which are supported in Vizard VR Toolkit. SketchUp also can save elevations or renderings of the model, called "screenshots", as .bmp, .png, .jpg, .tif. 3D Warehouse (formerly Google 3D Warehouse), an accompanying website for SketchUp, is a free cloud service that allows users to search, upload, download and share 3D models, which facilitates further development of virtual workshops and compiling them with additional (auxiliary) equipment.

5. Purposed algorithm for creating VR scenes of the mechanical workshops by using Vizard VR toolkit.

The proposed algorithm for creation VR scenes of workshops for mechanical processing in the virtual reality environment based on existing 3D models of the equipment is illustrated schematically in the left side on Figure 2. On the right side in the same figure,

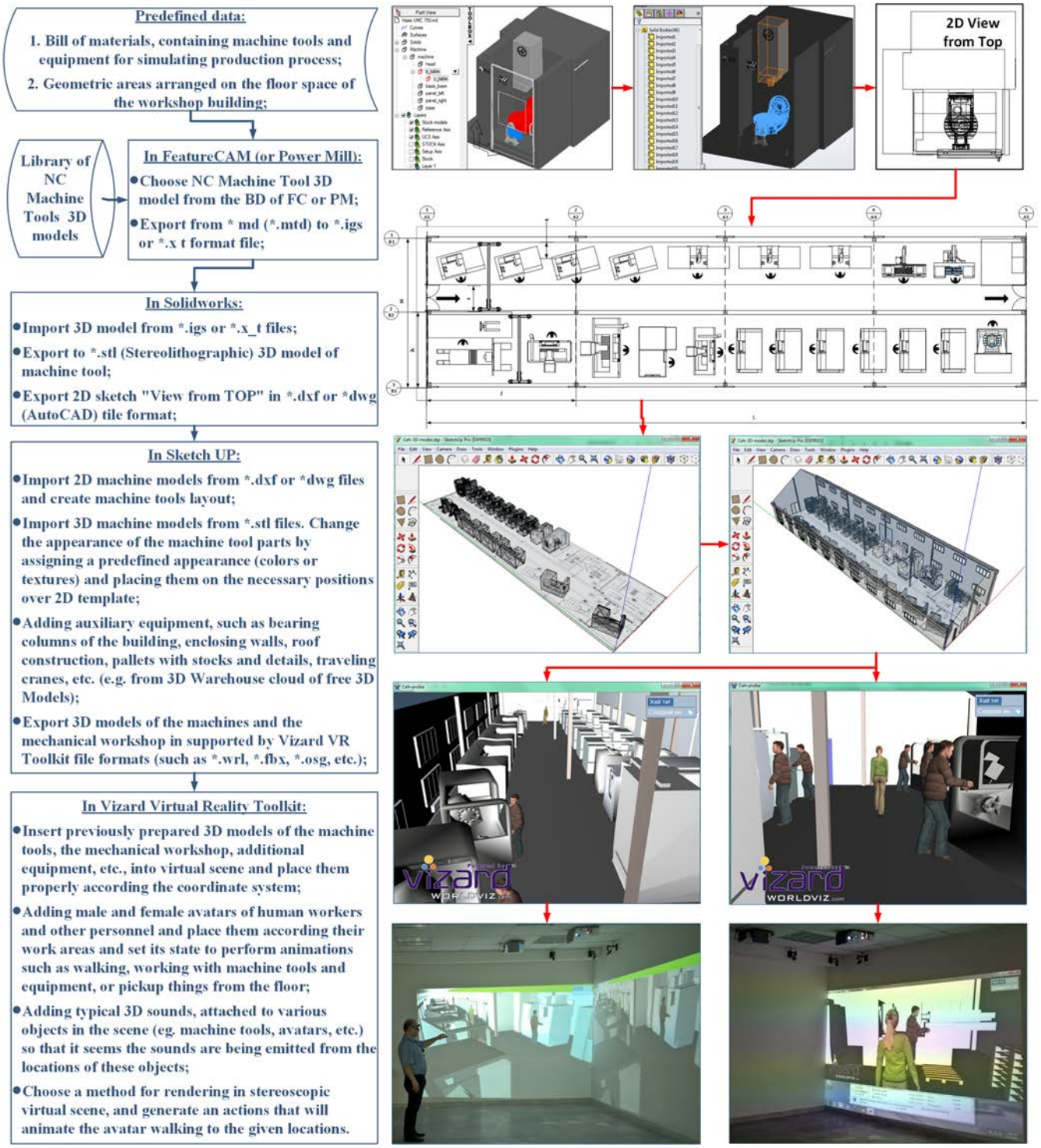


Fig.2: *An algorithm for creating virtual reality scenes of the machining workshop, using realistic 3D models of machines, avatars and auxiliary equipment.*

graphically examples of the main stages of the algorithm, as well as the final outcome of its implementation are also presented.

For brevity it is assumed that the work on determining the types of machines, their number, the pattern of their arrangement within the area of the workshop, and the distances between them, and between them and the walls, supporting columns of the building, and transport routes, have been predefined, using standardized methods [2,7,8]. Therefore, at the beginning of the algorithm as an inputs are used the specification of the technical equipment (Bill of Materials) and the scheme of machines layout in a workshop (or factory building), based upon decisions about the type of manufacturing process.

From the postprocessors and models of real machines library in FeatureCAM (or Power Mill) are exported those, which are included in the specification for further processing. Each exported model of Machine from FeatureCAM, during the next phase is imported into Solidworks, MS Visio or SketchUP in order to obtain 2D template (a top view – see Figure 2) for the two-dimensional layout of the machines in the workshop, and also maximum close to the reality three-dimensional model of the machine for use in VR environment.

Referred software's above are not mandatory, and it is possible other CAD-s (with similar functionality) to be used instead.

The resulting 2D sketches and 3D models of machinery, equipment, buildings, etc., stored in appropriate file formats can be imported, positioned or scaled (if necessary) in the virtual scene of the mechanical workshop in the working environment of Vizard VR Toolkit, using commands from Python open-source language. In

order to make the virtual model as much as possible closer to the reality, in front of machines and workplaces can be added "avatars", representing the workers or the auxiliary staff, and also specific sounds and noises generated of people and equipment in the workshop. The word "avatar" here (a Hindi word for the embodiment of a deity) is commonly used to describe a virtual object that represents a user or real object inside the virtual environment.

As the final step of the algorithm, depending on the existing computer hardware and VR peripheral devices used for "immersion" the user in the virtual scene, it is necessary to choose the method for creating the stereoscopic view of the VR scene. Vizard VR Toolkit provides numerous methods (both passive and active) for rendering in stereo, such as "Parallel displays", "Anaglyphic", "Polarized filters", "Interlacing", "CAVE's" and "Powerwalls", etc.

6. Conclusion and future work

From the initially proposed objective, and considering the obtained approach and algorithm for creating VR scenes of the workshops for mechanical processing by using Vizard VR Toolkit it is possible to conclude:

- The proposed approach in this work allows a relatively rapid creation of realistic virtual reality scenes of mechanical workshops, using 3D models of machines from CAM, auxiliary equipment and basic elements of industrial buildings (from 3D Warehouse cloud of the SketchUP), and animated avatars representing the normal working moves performed the actual workers;
- Suggested for use software resources (such as FeatureCAM, MS Visio, Vizard VR Toolkit, etc.) has intuitive and easy to learn UI, making them easy to use even by not specifically trained users;
- The training methodology based on virtual reality brings numerous benefits for the educational sector compared to the traditional methods, and more specifically for the disciplines of mechanical engineering field, enabling a greater amount of trainings and being a very important option to solve the high cost of training problems.

Along with the above mentioned advantages, the purposed approach has some drawbacks, the most important of which are:

- The Vizard VR Toolkit does not support direct insertion of file formats, which store 3D models of machines in the CAM software. Even considered universal 3D formats, such as Initial Graphics Exchange Specification (IGES), Parasolid, etc., cannot be imported directly into the virtual reality environment. This requires using third party software (such as Solidworks, MS Visio or SketchUP for example) to re-convert from one file format to another, implying risks of the occurrence of errors, such as impaired geometry of the models, incorrectly rendering or complete loss of textures, colors, lights, etc.;
- In the programming environment of the Vizard VR Toolkit, even using intuitive programming language Python for building algorithms for optimization analysis, such as effective location of the machines in the workshop or shortest path of material flows for example, is not that easy as opposed using specialized CAD systems that are embedded parameter modules for such analyzes.

During development, several aspects that could be included in future work to improve the proposed approach and to apply the same concept in other educational fields were identified, these include:

- In order to further increase training opportunities for students it is possible to develop and integrate specific library with different types of realistic 3D models of real machines, equipment and human avatars so that the user can select appropriate models and arranges them in the virtual space of the workshop, when performing trainings.
- Increasing the degree of freedom of the user to manipulate the objects in the virtual environment and to simulate in real time its movement within the workshop by adding new markers or integrating it with appropriate tracker devices, so that interactivity and realism of the designed mechanical workshops may be augmented.
- Add more scenarios with more specific applications in others studied subjects, such as assembly of parts in the mechanical engineering industry or other training applications such as mechanical processing of work pieces, welding, etc.

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МЕТОД ЗА ОЦЕНЯВАНЕ НА СЪТРУДНИЧЕСТВОТО ПРИ УПРАВЛЕНИЕ НА ВИРТУАЛНИ ОРГАНИЗАЦИИ

METHOD FOR EVALUATING COOPERATION IN MANAGEMENT OF VIRTUAL ORGANIZATIONS

Проф. д-р Димков С.В.
Технически университет, Стопански факултет – София, България
sdim@tu-sofia.bg

Abstract: *Today, businesses increasingly harder experiment new organizational models that are more consistent with a high degree of contemporary business environment. The concept of virtual enterprises is a model that successfully respond to changing market conditions. Object of this work are dynamic virtual organizations formed by independent actors. Scope of work is the management of virtual organizations, formed on the principles of collaborative entrepreneurship. The main goal that puts the work is the development of method for assessing the effectiveness of cooperation in the formation of virtual organizations, composed of independent stakeholders.*

Keywords: COLLABORATION, VIRTUAL ORGANIZATIONS, PERFORMANCE ASSESSMENT, BUSINESS NETWORKS

1. Увод

През последните години се забелязва глобализиране на пазарите, породено от напредъка на информационни технологии и най-вече с широкото разпространение на Интернет. Това обстоятелство засилва конкурирането между бизнес организациите и налага нуждата от бързо адаптиране за удовлетворяване на пазарните изисквания. Вследствие на това бизнес организациите се стремят на реализират различни форми на сътрудничество със свои контрагенти с намерението да укрепят слабите си страни. Такива организации, които се кооперират и информационни системи сътрудничат чрез човешкия си капитал посредством информационни технологии са познати като базирани на сътрудничество бизнес мрежи [1].

Според Рийс [2] базираните на сътрудничество предприятия от мрежов тип могат да се групират в две основни категории: т.нар. „Разширени предприятия" и т.нар. „Виртуални предприятия". Молер и кол. [3] определят разширените предприятия като логистични вериги (Supply Chain), а виртуалните предприятия – като виртуални организации (Virtual Organisation).

Прейс [4] дефинира виртуалните организации като съчетание на бизнес обекти при които сътрудници и работни процеси от бизнес обектите интензивно си взаимодействат за извличане на взаимни ползи за всички страни. Рийс [2] счита, че виртуалните предприятия се могат да се определят като общности без лидер, характеризиращи се с допълващи приноси на различните участници, при което един от тях играе ролята на координатор (главен контрактор).

Поради бързото популяризиране на практиките за разширени и виртуални предприятия, ключова важност придобива изграждането на стабилни и надеждни системи за оценяване на организационната резултатност, които позволяват ефикасно и ефективно следене и оперативно управление на резултатността на разширени и виртуални предприятия. Това е и основна цел на настоящата работа.

2. Оценяване на резултатност при бизнес мрежи

Понастоящем само незначителна част от разработваните модели оценяват резултатността при бизнес мрежи от индустриални предприятия. Един от най-релевантните такива модели е моделът разработен от Билингер, Кюнер и Хооф [5], който представлява съчетание на балансирани регистрационни карти и SCOR модел. Показателите в SCOR модела се фокусират върху потоци от материали и продукти чрез оценяване на логистичната резултатност. Основната идея за използване на мрежови регистрационни карти е оперативно да се управляват логистичните мрежи за постигане на набелязаните цели чрез оценяване на управленските резултати [6]. Взети заедно показателите формират цялостно средство за оценяване на резултатността на логистични процеси.

За оценяване на резултатността на бизнес мрежи Лесьор, Шоу и Чапман [7] въвеждат концепция за т.нар. „Мета резултатност". Тя се представя чрез двудименсионен модел, който отчита аспектите „резултатност" и „справедливост" на бизнес мрежата.

3. Прогностично оценяване на резултатност при бизнес мрежи

Тенденциите за развитие при индустриални предприятия се променят понастоящем от дългосрочни партньорства между производители и доставчици към нестандартни форми на кооперране, базирани на специфични нужди на динамични клиентски поръчки [8]. Структурите от такива временни бизнес мрежи са познати като т.нар. „Виртуални организации" [9]. Продължителността на сътрудничеството при виртуални организации, изградени от независими партньори се ограничава от рамките на определени проекти и при следващ проект са налага изграждане на нова мрежа.

Основна характеристика на мрежовото сътрудничество във виртуални екипи спрямо традиционните логистични вериги са кратките периоди за функциониране.

Днес съществен управленски проблем при подготвителната фаза на изграждане на виртуални организации е дефинирането и конфигурирането на оптимално функциониращи колаборативни мрежи, които да са максимално резултатни при изпълнение на определени клиентски поръчки.

Необходимо е да се постигне цялостно оптимизиране на цялата верига от бизнес процеси и ресурси. При устойчивите логистични вериги, базирани на дългосрочно сътрудничество такава оптимизация може да се извършва непрекъснато.

При виртуални организации непрекъснати дългосрочни процеси на оптимизиране, базирани на ретроспективни оценки са невъзможни. Основна причина за това е динамичния характер на виртуалните организации, при които веригата от процеси и сътрудничещите си субекти са специално конфигурирани за определена клиентска поръчка. Възможно най-високата резултатност на една виртуална организация трябва да се осигури още при първата поръчка поради това че сътрудничеството е свързано със строго определена поръчка. Това означава, че изборът на партньори по време на подготвителната фаза от жизнения цикъл на една виртуална

организация определя резултатността по време на оперативната фаза. Това означава, че прогностичното оценяване на резултатността на планирана конфигурация на виртуална организация по време на подготвителната фаза е задача с ключово значение, която има силно въздействие върху възможностите на бъдещия междуорганизационен екип. При подготвителната фаза значим фактор е експертното изучаване на потенциалните партньори в бъдещата виртуална организация, с които да се създаде подходящ за конкретната клиентска поръчка екип и оценяването на способностите им да допринесат за максимално решаване на поставената задача.

За създаването на системи за оценяване на резултатността при виртуални организации липсват подходи, които са способни да оценяват междуорганизационните процеси и които да пресмятат резултатността на бизнес мрежи [8]. Освен това динамичният характер на виртуалните организации не допуска оценяването на минали процеси като средство за стартиране на подобрения поради липсата на устойчивост на бизнес мрежите. При ограничавани във времето сътрудничества с цел изпълнение на определени клиентски поръчки е необходимо постигане на висока резултатност от самото начало. Това означава, че подходите за оценяване на резултатността трябва да са стартирани още във фазата на иницииране на бизнес мрежите за да се гарантира, че в оперативната фаза мрежите ще постигат резултати по най-добър начин. Средата, при която възможните участници в планирани бизнес мрежи са идентифицирани и избирани от набор от възможни партньори (позната като т.нар. „Генеративна среда”) не е развита достатъчно и затова все още се ползва подхода за оценяване на резултатността [9].

Създаването на всеки продукт изисква специфична верига от бизнес процеси, т.е. специфично съчетание от процеси. В рамките на една виртуална организация съществуват множество налични изпълнители на процеси, което е предпоставка за създаване на множество варианти на веригата от бизнес процеси от гледна точка на ангажирани партньори. Основната задача при подготвителната фаза за реализиране на базирана на сътрудничество дейност е определянето на съчетанието и разнообразието от процеси за генериране на стойност, които да доведат до възможно най-висока резултатност.

За гарантиране на най-резултатна бизнес мрежа е необходимо да се предвиди резултатността на планираната бизнес мрежа. Поради временността на мрежата традиционните процеси за непрекъснато усъвършенстване на бизнес процеси не са приложими. Трябва да се гарантира, че замислената виртуална организация представлява най-добрата селекция от генеративната среда. За да се реагира гъвкаво и с най-високо качество на клиентските заявки трябва да се прилагат методи за подпомагане на вземането на решения при инициращата фаза на виртуалната организация.

Понастоящем действащите подходи за оценяване на резултатността не подпомагат извършването на прогностично оценяване на резултатността. При извършване на прогностично оценяване на резултатността на виртуални организации е необходимо създаването на обща за всички участници във виртуална организация методология. Това изисква отчитане на следните аспекти:

- Използване на един и същ модел на процеси при всички партньори във виртуалната организация за осъществяване на моделиране на разпределени процесни вериги.
- Дефиниране на общи набори от ключови показатели за резултатност за гарантиране на съвместимост между партньорите.
- На основния контрактор, който сформира виртуалния екип, трябва да се осигури достъп до данни за резултатността на всички потенциални партньори.
- Разработване на методология за подпомагане на търсенето на оптимален виртуален екип.

4. Модел на система за оценяване на резултатността

Представеният в работата модел за оценяване на резултатността при виртуални предприятия предоставя необходимите методи и техники за оценяване на текущия статус на организациите и механизъм за преход към концепция за виртуално предприятие.

От извършения задълбочен литературен обзор може да се заключи, че днес са необходими методи, системи и процедури, които да регламентират процеса на управление на резултатността в условия на бизнес сътрудничества, като се отчитат и социалните аспекти на партнирането в единен интегриран подход. Предлаганият от автора модел отчита тези характеристики и е развитие на модела на Алфаро и кол. [10], който включва три етапа: дефиниране на стратегически модел; дефиниране на структура от процеси; мониторинг.

В структурата на модела ясно се разграничават две нива: мрежово и бизнес ниво. При формиране на виртуални организации мрежовото ниво се формира от интегриране на няколко предприятия (или бизнес единици), принадлежащи към различни логистични вериги, а бизнес нивото се формира от бизнес процесите във всяко от ангажираните предприятия.

Моделът има две дименсии – вертикална и хоризонтална. Вертикалното измерение дефинира компонентите на системата за оценяване на резултатността: цели, задачи, стратегии, планове, политики, критични фактори за успех и производни ключови показатели за резултатност на двете нива. Хоризонталното измерение обхваща четири различни гледни точки, които следва да се вземат под внимание при дефиниране на компонентите на системата за оценяване на резултатността: организация; ресурси; информация; функционалност.

На мрежово ниво основна задача е описанието на резултати, които замислената виртуална организация цели да постигне в бъдеще. След това трябва да се разработи стратегия, която описва начина за извършване на дейностите и процесите на замислената виртуална организация и управлението на ресурсите на виртуалната организация за достигане на поставените цели. Критичните фактори за успех са онези фактори, които гарантират чрез следене и реализация успеха на виртуалната организация. Те се формират чрез обединяване на измерими цели и стратегии. След дефиниране на целите, стратегиите и критичните фактори за успех се дефинират ключови показатели за резултатност, които са заключителната и оперативна част от системата за оценяване на резултатността.

На бизнес ниво ключовите показатели за резултативност оценяват най-значимите състояния на организациите, които имат намерение да се интегрират във виртуални предприятия. Чрез тях се оценява и управлява оперативно текущото състояние, желаното състояние, траекторията за преход от текущо в желано състояние и качеството на получаваните резултати. Когато се извършва предварително дефиниране на компонентите на системи за оценяване на резултатността, е необходимо да се вземат под внимание следните фактори и гледни точки: функционалност; информация; ресурси; организация.

Целта на разработения модел е да се обхванат всички подлежащи на оценка и анализ аспекти на едно виртуално предприятие от тези четири гледни точки.

В резултат на литературния обзор бе констатирано, че една от основните задачи, свързани със създаване на стабилна и надеждна система за оценяване на резултатността при виртуални предприятия, която да насърчава постигането на състояние на съгласуваност, е равнопоставеността между

партньорите. За да се постигне такава степен на съгласуваност между различните нива (бизнес и мрежово), както и между различните партньори, които формират бизнес мрежата от най-съществено значение, е системата за оценяване на резултатността ясно да отчита връзките между всички свои компоненти. Само тогава ще е възможно недвусмислено следене и оперативно управление на всички компоненти на системата. За решаване на тази задача системата трябва да предоставя методи за ясно проследяване от ключовите показатели за резултатност до висшестоящите цели от които произтичат ключовите показатели за резултатност.

Създаването на предлаганата система за оценяване на резултатността при реализиране на бизнес сътрудничества започва с разработване на стратегически подход за адекватно интерпретиране и реализиране на практика. Стартова точка за създаване на предлаганата система за оценяване на резултатността при реализиране на бизнес сътрудничества е дефинирането на стратегически модел (Етап 1). По-конкретно, разработването на стратегически модел трябва да включва всички елементи на резултатността (концептуално планиране – мисия и визия; изисквания на заинтересовани субекти; тактически цели; стратегии; ключови фактори за успех; ключови показатели за резултатност. Всички тези елементи са дефинирани в четири аспекта на резултатността [11]: финансов; потребителски; процесен; познавателен. Тези гледни точки спомагат за структуриране на процеса за оценяване на резултатността на базата на причинно следствени връзки.

В разработения модел, освен гореспоменатите четири аспекта, е въведен пети аспект - „Управление на взаимоотношенията на сътрудничество", който отчита социалната гледна точка на сътрудничеството. Този аспект допълва другите четири аспекта, тъй като отчита културата на сътрудничество като средство за създаване на атмосфера за проява на четирите основни аспекта. Този аспект включва структура от цели, стратегии, ключови фактори за успех и ключови показатели за резултатност, които са свързани с характеристики като: атрибути на взаимовръзките (доверие, ангажираност, коопериране и др.); комуникационно поведение (процес на обмен на информация); средства за разрешаване на конфликти.

5 Модел на система за прогнозно оценяване на резултатността

Разработеният модел на система за прогнозно оценяване на резултатността се базира на допускането, че процесите на отделните участници в една виртуална организация са относително стабилни. Процесната верига във виртуалната организация е композирана чрез съчетаване и интегриране на такива относително стабилни процеси. Устойчивостта на отделните процеси, които са обекти в процесната верига позволява да се разработи подход за оценяване на резултатността, базиран на централизирана база данни и два основни модула:

- Модул за следене на бизнес процесите на потенциалните участници във виртуалната организация;

- Модул за конфигуриране на варианти на виртуалната организация

Централизираната база данни е Уеб базирана и съхранява данни за резултатността, които се пресмятат от модула за следене на бизнес процесите и ги предоставя на модула за конфигуриране на варианти на виртуалната организация, чрез който се симулират варианти на процесната верига. Модулът за следене на бизнес процесите на потенциалните участници във виртуалната организация подпомага оценяването на процесите на всяка бизнес организация, която потенциално ще участва във виртуалната организация и предоставя нужните данни на модула за конфигуриране на варианти на виртуалната организация. Модулът за конфигуриране на варианти на виртуалната организация включва средство за планиране на процеси, с помощта на което се моделира процесната верига. Чрез проектирането и сравнението на възможни варианти на резултатност модулът за планиране предоставя на виртуалния екип възможност за постигане на възможно най-висока резултатност.

6. Заключение

Съществуващите подходи за оценяване на резултатността се основават на традиционното схващане за логистични вериги и не вземат под внимание нарастващото влияние на виртуалните организации , които изискват междуорганизационен фокус на оценката на резултатността.

Настоящата работа накратко описва наличните в момента модели за оценяване на резултатността на виртуални предприятия. Идентифицирани са разминаванията на тези модели с изискванията на бизнес мрежите. Предложен е модел за преодоляване на тези разминавания и за реализиране на система за оценяване на резултатността на виртуални предприятия. Описани са основните елементи и функционалности на модела и ползите, които може да донесе реализирането му на практика.

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МЕХАНИЗМЫ ТРАНСФОРМАЦИИ ПРИКЛАДНЫХ НАУЧНЫХ ИССЛЕДОВАНИЙ В ПРЕДПРИНИМАТЕЛЬСКИЙ СЕКТОР РЕАЛЬНОЙ ЭКОНОМИКИ

TRANSFORMATION MECHANISMS APPLIED RESEARCH IN THE BUSINESS SECTOR OF THE REAL ECONOMY

Топ-менеджер Ускова И., Менеджер Чекунова-Томашева Н. -
НИТУ МИСиС, Москва, Россия
uskova@fin.misis.ru; alisatom@rambler.ru

Abstract: *The main issues are considered in this topic: the economic form of realization of innovative activity and to facilitate its implementation, the search for innovative solutions, as well as the lever stimulate and regulate this activity*

***KEYWORDS**: INNOVATIVE MECHANISM, THE SYSTEM OF INNOVATIVE MECHANISMS, LIFE CYCLE, TECHNOLOGY TRANSFER*

1. Введение

Инновационный механизм - это организационно – экономическая форма осуществления инновационной деятельности, поиск инновационных решений, а также рычаг стимулирования и регулирования этой деятельности. Инновационные механизмы должны формировать функциональное обеспечение инноваций в его привязке к стадиям их жизненного цикла. Под функциональным обеспечением понимается инновационное, инвестиционное и финансовое обеспечение.

Особое внимание следует уделить совершенствованию существующих и разработке новых механизмов трансформации научных исследований в практическую деятельность корпораций.

2. Результаты и дискуссия

Систему инновационных механизмов можно сформировать и представить ее пятью основными группами :

1. механизмы организации
2. механизмы разработки и внедрения
3. механизмы финансирования и стимулирования
4. механизмы технологического трансферта
5. механизмы интеллектуальной собственности.

***Таблица 1.** Характеристика взаимосвязи элементов функционального обеспечения и стадий развития предпринимательских структур*

Характеристики функционального обеспечения	Этапы развития предпринимательской структуры			
	становление	развитие	зрелость	упадок
инновационная	Поиск научно – технических инновационных решений, защита интеллектуальной собственности	Разработка и развитие научно-технических решений	Разработка псевдо-инноваций – продуктов, инноваций процессов, передача технологий	Поиск научно-технических решений по замене устаревших процессов, приобретение лицензий и патентов
инвестиционная	Определение направлений начального вложения средств, инвестиционные льготы за освоение приоритетных направлений деятельности	Определение направлений производственного инвестирования, формирование благоприятного инвестиционного климата	Долгосрочные инвестиции в участие в капитале других предприятий	Определение направлений и вложение в переориентацию предпринимательской деятельности
финансовая	Стартовое финансирование, получение дотаций через инкубаторные программы	Финансирование на стадии освоения и расширения охвата рынка, выход на финансовые рынки роста	Финансирование развития производственных мощностей, доступ к кредитным ресурсам	Финансирование сворачивания устаревшего производства, дотации и субсидии

Механизм организации направлен на формирование и реорганизацию структур, осуществляющих инновационные процессы.

Создание - это формирование новых предприятий, структурных подразделений или единиц, призванных осуществлять инновационную деятельность. Наиболее существенными элементами новых организационных форм могут быть матричные структуры, научно-технические подразделения, научно-технические организации, осуществляющие деятельность по рыночным принципам, внутренние венчуры.

Процессы создания новых инновационных организаций особенно важны для крупных корпораций, т.к. эти структуры имеют сложную систему управления инновациями и как правило ориентируются на крупные проекты, реализация которых должна за короткий период времени обеспечить получение высоких доходов.

Матричные структуры представляют собой такие организационные формирования, которые создаются на срок разработки и внедрения инноваций, включают в себя специалистов различного профиля, административно подчиняются руководителям соответствующих постоянных подразделений, но временно направленных во временную внедренческую структуру для проведения работ по определенной специализации. Такие временные подразделения позволяют объединить различных специалистов на срок разработки и внедрения инновации. Такой организационный инновационный механизм позволяет, во – первых, обеспечить выполнение работ в короткие сроки, во-вторых, позволяет сконцентрировать под единым руководством специалистов различных профилей, в-третьих, значительно удешевить процесс разработки и внедрения.

Научно – технические подразделения создаются на постоянной основе, они не имеют хозяйственной самостоятельности и их деятельность осуществляется за счет бюджета компании в целом. Эти подразделения могут быть децентрализованными и ориентированными на конкретные производственные единицы, либо – централизованными и подчиняться непосредственно руководителю компании. Их особенность заключается в том, что они пербедают свои разработки в производство напрямую без установления внутренних рыночных механизмов.

Самостоятельные научно-технические организации, напротив, имеют собственный бюджет и продают свои разработки производственным подразделениям компании.

В ряде случаев весьма эффективным организационным механизмом может быть поглощение крупной компанией небольших инновационных фирм, деятельность которых входит в круг интересов компании. Данный механизм предполагает осуществление больших единовременных затрат, но приводит к значительному сокращению сроков выхода новых продуктов на рынок и позволяет достичь синергетического эффекта от объединения инновационных достижений.

Механизмом, дополняющим поглощение, является установление тесных связей крупной компании и малых инновационных фирм, основанных на создании долгосрочных договорных отношений (рыночная инновационная интеграция). В этом случае инновационные фирмы сохраняют свою самостоятельность, но попадают в сферу рыночных производственных связей крупной компании.

Сочетание процессов поглощения и рыночной инновационной интеграции дает основание предположить использование «веерной» организации инновационного процесса. Ее смысл заключается в создании инновационного окружения производственной компании, состоящего из фирм, в отношении которых совершено поглощение (ИФП), а так же рыночно интегрированных фирм (РИФ) [1]. «Веерная» организация инновационного процесса может оказаться в наибольшей степени эффективной для компаний, имеющих наступательную стратегию инновационного развития.

На первом этапе инновационного процесса проводится инжиниринговый анализ результатов фундаментальных исследований (идеи, концепции, закономерности). Финансирование осуществляется в основном из госбюджета на безвозвратной основе.

На втором этапе проводятся исследования прикладного характера. Они финансируются как за счет бюджета, так и за счет средств заказчиков или инвесторов. С этого этапа возникает возможность потери вложенных средств в разработки инновации, что предопределяет рискованный характер бизнеса.

На третьем этапе осуществляются экспериментальные разработки. Источники финансирования те же, что и на втором этапе, а так же собственные средства организаций.

На четвертом этапе осуществляется процесс коммерциализации от запуска в производство и выхода на рынок и далее по основным этапам жизненного цикла продукции.

Процесс коммерциализации и крупномасштабное внедрение инноваций в практическую деятельность корпораций требует создания нового адекватного современным условиям механизма внедрения и финансирования, где субъектами таких отношений является организации вузовской науки как продуценты инноваций, внедренческие организации в виде научно-производственных кластеров, центров трансферта технологий; корпорации заинтересованные во внедрении инноваций, кредитные организации и венчурные фонды, государственные субсидии для инноваций, имеющих федеральное и региональное значение по соответствующим федеральным и региональным бюджетам [2]. Предлагается следующая схема взаимодействия вышеперечисленных структур. (рис. 1)

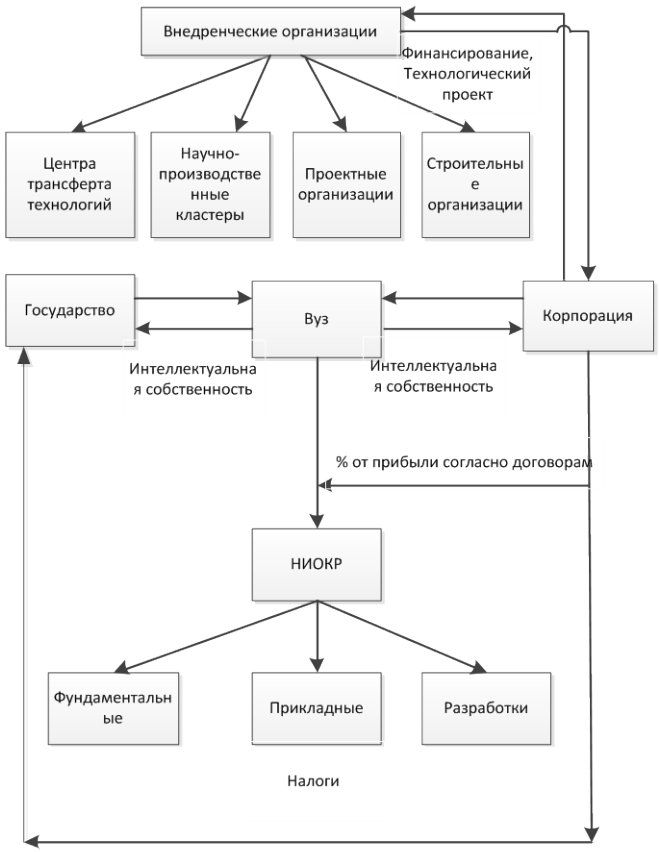

Рис.1. *Механизм внедрения и финансирования инноваций*

3. Решение рассматриваемой проблемы на примере университета

В 2014 году в НИТУ «МИСиС» была продолжена реализация программы по предоставлению государственной поддержки ведущим Университетам Российской Федерации в целях повышения их конкурентоспособности среди ведущих мировых научно-образовательных центров (проект 5-100). Стратегическая цель программы - вхождение и закрепление НИТУ «МИСиС» в числе ведущих мировых университетов, что предполагает получение места в числе ведущих 100 вузов по основным международным рейтингам (THE или QS), за счет фундаментальных и прикладных исследований мирового уровня в материаловедении, металлургии и горном деле, нанотехнологиях, а также в информационных технологиях и

биомедицине. Основные цели, стоящие перед научным комплексов в рамках программы можно сформулировать как обеспечение эффективности и результативности научно-исследовательской деятельности в ключевых областях и позиционирование НИТУ «МИСиС» как коммерчески успешного, признанного в мире инновационного лидера.

Реализация программы построена по проектному принципу, в 2014 году по направлению «Наука» было сформировано два портфеля проектов: «Молодые НПР и стимулирование публикационной активности» и «Привлечение международных ученых и мобильность». В общей сложности было реализовано 12 проектов. Объем финансирования проектов составил около 334 млн. руб.

Активно велась работа по привлечению к работе в составе действующих научных коллективов НИТУ «МИСиС» и руководству научно-исследовательскими проектами ведущих иностранных и российских ученых. Был проведен «Открытый международный конкурс на получение грантов НИТУ «МИСиС» для поддержки научных исследований в области развития научного направления, проводимых под руководством ведущих ученых».

Общий объем финансирования научно-исследовательских и опытно-конструкторских работ составил 2 515,3 млн. рублей, что превышает объем финансирования 2013 г. более чем на 870 млн. рублей, Структура финансирования научно-исследовательских и опытно конструкторских работ в 2014 г. представлена на следующем рисунке:

Рис.2 *Структура финансирования*

Наибольший вклад в общий объём финансирования в 2013 г. приходился на НИР, выполнявшиеся в рамках федеральных целевых программ: «Исследования и разработки по приоритетным направлениям развития научно-технологического комплекса России» на 2007–2013 годы – 25%, «Проекты по созданию и развитию инжиниринговых центров на базе ведущих технических вузов» – 18%, «НИОКР в рамках мероприятий по повышению международной конкурентоспособности вуза среди ведущих мировых научно-образовательных центров» – 13%, а так же прямые договора с хозяйствующими объектами – 12%.

Участие НИТУ МИСиС в программах по государственной поддержке ведущих российских вузов в 2014 году П218 и П220 приведено в следующей таблице:

Мероприятие	**Общий объем привлеченных средств, млн. руб**	**2014 год, млн. руб.**
Гранты Правительства РФ для государственной поддержки научных исследований, проводимых под руководством ведущих ученых в российских вузах (Постановление 220)		
Неорганические нанотрубки и графены	**172,5**	**22,5**
Нанотехнологии и сверхпроводящие материалы	**172,5**	**22,5**
Гибридные наноструктурные материалы	**90,0**	**30,0**
Современная физика материалов: новый инструмент ускоренного проектирования материалов в 3-м тысячелетии	**90,0**	**30,93**
Развитие кооперации российских вузов и производственных предприятий (Постановление 218)		
ОАО "ВНИИХТ" –	**195,0**	**50,0**
ОАО «Уфимское моторостроительноепроизводственное объединение» -	**198,0**	**60,0**
ЗАО "Инжиниринговая компания "АЭМ-технологии" -	**160,0**	**58,0**

Таблица 2 *Участие Университета в программах по господдержке*

4.Заключение.

Задача трансформации прикладных научных исследований в предпринимательский сектор реальной экономики может быть выполнена, в частности, при решении руководства образовательного / научно-исследовательского учреждения и бизнес - структуры о продолжении исследований, в частности более конкретного подхода к внедрению инновационных технологий в деятельность корпораций на основе двухсторонней заинтересованности, перехода от разработки методологических подходов к определению методики определения эффективности M&A, созданию базы данных о слияниях и поглощениях в отрасли.

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ОРГАНИЗАЦИЯ НАУЧНО-МЕТОДИЧЕСКОГО ОБЕСПЕЧЕНИЯ И УПРАВЛЕНИЯ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИМ КОМПЛЕКСОМ

THE ORGANIZATION OF SCIENTIFIC-METHODICAL PROVISION AND MANAGEMENT RESEARCH COMPLEX

Менеджер Чекунова-Томашева Н., Топ-менеджер Ускова И.
НИТУ МИСиС, Москва, Россия
alisatom@rambler.ru; uskova@fin.misis.ru;

Abstract: *The organization of the system of information and legal support of implementation of scientific and technological developments and intellectual property, based on the creation of conditions to the financial interest of the developer in higher technical, economic and commercial impact in terms of research complex*

KEYWORDS: *SCIENTIFIC, TECHNICAL AND FINANCIAL-ECONOMIC ANALYSIS, RESEARCH PROJECTS, RESEARCH WORK*

1. *Введение*

Определяющее требование рынка – выгодность реализации интеллектуального продукта для ключевых субъектов рынка: для производителя – получение наивысшей прибыли; для потребителя – достижение максимального экономического эффекта от внедрения инновации. Представляется необходимым учитывать проблематику синтеза рыночной реализации нового продукта. Идеальная схема – созданный продукт в сравнении с аналогами должен быть более высокого качества с меньшей себестоимостью. В реальности сложность освоения производства нового материала (затраты на научно-исследовательские работы, подготовку производства и т.п.) может привести к повышению цен [1]/

Создание единого сервиса доступа научного персонала университета к информации о научно-исследовательских, опытно-конструкторских, опытно-технологических, технологических работах позволит уделить внимание совершенствованию существующих и разработке новых механизмов трансформации научных исследований в практическую деятельность корпораций.

2. *Сущность проблемы*

Для увеличения объемов выполняемых научно – исследовательских, опытно – конструкторских, опытно – технологических работ необходимо создание определенных условий, в частности создание электронного сервиса по обслуживанию научно-технических проектов организации.

Для решения данной проблемы необходима электронная система управления научно – техническими проектами (далее - ЭС УНТП), и создание офиса управления научно-техническими проектами.

Решаемые проблемы:

1. Обеспечение устойчивого финансирования научно-исследовательского комплекса, включая диверсификацию источников, усиление взаимодействия с бизнесом.
2. Развитие новых компетенций научно-исследовательского комплекса в организации взаимодействия с бизнес - сообществом для научного сопровождения совместных с корпорациями проектов.

Рис.1. *Краткое резюме проекта*

Рис.2. *Цели и задачи проекта*

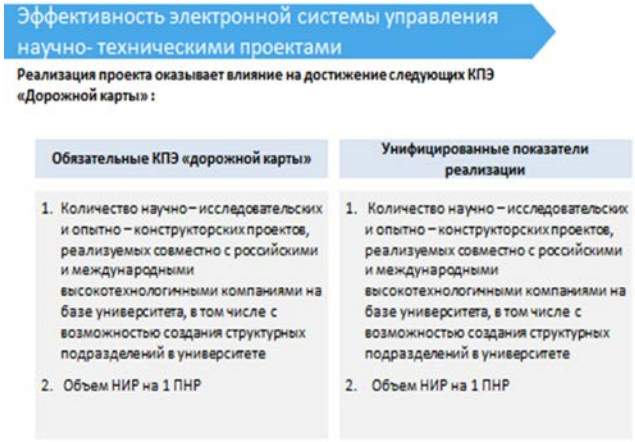

Рис.3. *Эффективность электронной системы*

Электронный сервис существенно увеличит количество научно-исследовательских проектов, реализуемых с перспективными научными организациями и бизнес – сообществом.

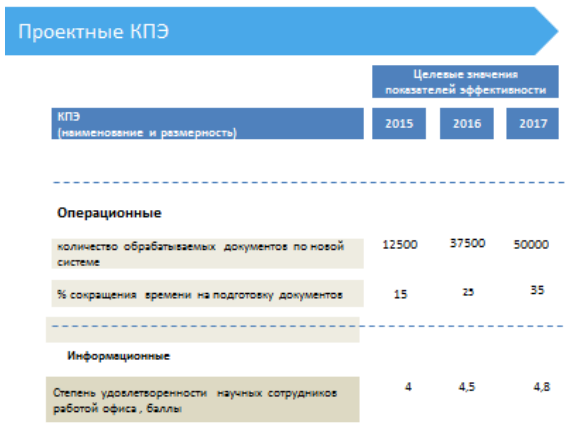

Рис.4. *Проектные коэффициенты полезной эффективности*

Электронная система обслуживания запросов к научно-техническим проектам научной организации - электронный сервис предоставления информации включает:

прием, классификацию, запуск внутренних процедур выполнения, контроль подготовки ответного материала и взаимодействие с запрашивающим лицом для нижеперечисленных запросов:

- оформление заявки на участие в конкурентных способах определения поставщиков (исполнителей, подрядчиков);
- предоставление информации о научно-технических проектах Университета (далее – НТП) из ЭС УНТП;
- предоставление организационно-распорядительных документов, создаваемых в рамках выполнения НТП;
- предоставление бухгалтерской и управленческой документации по факту (по ходу) выполнения работ в рамках НТП;
- оформление документов для заключения субподрядных договоров в рамках НТП;
- оформление заявки на приобретение оборудования;
- осуществление сервисной поддержки в рамках выполнения НТП;
- осуществление выплат в соответствии со служебной запиской на утверждение штатной расстановки в рамках выполнения НТП;
- осуществление выплат стороннему исполнителю в рамках выполнения НТП ;
- регистрацию, обработку, подготовку ответа, контроль подготовки ответа для входящей корреспонденции по НТП Университету (текущим, выполненным);
- автоматический мониторинг публикаций на порталах Университета по выбранным направлениям НТП, подготовка тематических дайджестов (бюллетеней) и их рассылку (регулярно, по запросу);
- формирование статистических отчетов с оценкой востребованности информации о научно-технических проектах научной организации.

4.Заключение.

Организация обеспечения и управления научно-техническими проектами позволяет, во-первых, обеспечить выполнение работ в короткие сроки, во-вторых , позволяет сконцентрировать под единым руководством специалистов различных профилей, в-третьих, значительно удешевить процесс научно-технической деятельности в интересах разработчика, что повышает конкурентоспособность научной организации. Позволяет формировать каталог работ и услуг, выполняемых на базе научно-исследовательской инфраструктуры организации и создать информационный портала для взаимодействия с партнерами организации

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CONTEMPORARY METHODS FOR MANAGEMENT AND ORGANISATION OF MULTIMODAL TRANSPORTATION

Eng. Nakova Kate

Faculty of Management – Technical University of Moscow, Russia

kate_nakova@abv.bg

ABSTRACT:*THE MAJOR OBJECTIVE OF THE TRANSPORTATION PROCESS–SATISFACTION AND BEST INTEREST OF THE CUSTOMERS USING TRANSPORTATION SERVICES. SPECIFICALLY THIS IS MANIFESTED IN THE ORGANISATION OF MULTIMODAL TRANSPORTATION BASED ON ALL PRINCIPLES OF LOGISTIC ACTIVITIES.*

Introduction

Nowadays the observation of contemporary schemes of "door to door" cargo transportation implementing the transportation processes of several modes of transport is considered of high importance. However this is not possible without the clarification of the relevant terminology accepted in the international practice.

We are going to examine the terms combined, intermodal and multimodal cargo transportation. "The terminology of combined transportation" has been developed by the European Economic Commission UN (EEC UN) and the European Committee as well as discussed during the European Conference of the ministers of transport.

1. Key definitions

Multimodal transportation – transportation of cargo (goods) using two or more modes of transport.

Intermodal transportation – involves successive transportation with two or more modes of transport in one and the same cargo (load) unit or road vehicle without any handling of the cargo itself when changing modes of transport.

Combined transportation is a form of intermodal cargo transportation where the major part of the inter-continental route is traveled by railway, inland waterways or sea transport and an arbitrary initial and/or final part of the road - by motor transport which is as short as possible and in this way the term "multimodal transportation" turns out to be common for both intermodal and combined transportation and includes them.

On its turn **intermodal transportation** includes in itself the term combined transportation which has a more narrow meaning and turns out to be a subtype of intermodal transportation. [1] [2]

Multimodal transportation tends to be more universal because it integrates different subsystems of transportation resulting in the emergence of a new legal subject - the multimodal transportation operator (MTO) who signs a "door to door" transportation contract with the owner of the goods or the shipping agent. That contract is the unified transportation tariff which leads to the issuance of an unified transport document – multimodal Bill of Lading FIATA.

2. Technical aspect

The Technical aspect of the interaction is reduced to construction and power unification of all elements and junctions, different modes of transportation participating in the realization of the combined transportation. For that purpose it is necessary:

- to coordinate the admission and processing capacity of the connected lines carrying the combined cargo as well as those of the equipment (machinery) in the individual junctions for example the capacity of the railway roads on the stations and the port docks, the capability of the equipment to unload the cargo from the train and load it into the ship (vessel) or vehicle and visa versa, the power of the unloading and loading equipment, the capacity of the warehouses and the availability of the necessary means for maneuver.
- to coordinate the parameters of the mobile means of the interacting modes of transport. In particular there has to be a compliance between the loading capacity of the vessel and the railway composition (the mass of the train); between the loading capacity of the carriage and the motor car; the special purpose of the vessel and the carriage.
- to plan rationally the transportation junctions, the location of the separate elements and departments inside them, the provision of the parameter and geometrical compliance of the track (road), the mobile means and the loading equipment.
- to create a reliable and comfortable system – telephone, teletype or other connection first of all between the operating staff providing the combined transportation in the transportation junctions. [3]

The technical aspect is complicated enough and is subject to further not only practical but also a theoretical development.

3. Technological aspect

The technological aspect deals with the necessity all the operations for cargo handling to follow (observe) unified rules which are instrumental for the accomplishment of a fast and effective transfer of loads from one mode of transport into another. Today the coordination of the technological processes between the branches is absolutely necessary. This refers to the railway stations, motor vehicle (truck) companies, ports and other units in the junctions. In order to synchronize the work, mutually acceptable "unified technological processes" are traditionally developed in the form of an independent document which has to receive the confirmation of staff representatives of the different modes of transport. We can say that the interaction between the see, rail, river and road transports is organized by the implementation of unified technological processes in many transport junctions. [3]

4. Organization

As far as the organization is concerned the interaction is provided on the one side by the mutual development of a number of specific documents, regulating the comparatively long-term functioning of the different modes of transport and on the other side by accepting a unified system of operative planning of the current work. The contact schedules for the movement of the transport units along the lines connected to the junctions which guarantee coordination of the frequency and regularity of the movement of the units to the junction, could be considered a specific document. The unification of

the system of operative planning in all elements of the junctions can be accomplished by the usage of unified forms of time schedules and work shifts, introduction of unified time of beginning and ending of the work shifts. In Table 1 are given the results for international transportation of goods.

Table 1. *Import-Export for Bulgarian ports for 2012 and 2013*

Months	Export - FOB			Import - CIF		
		EC[2]			EC[2]	
I.2012	2810,3	1733,9	1076,4	3501,3	2130,3	1371,0
II.2012	2862,9	1659,7	1203,2	3603,3	2125,2	1478,1
III.2012	3363,6	2053,3	1310,3	4207,2	2540,7	1666,5
I - III.2012	**9036,8**	**5446,9**	**3589,9**	**11311,8**	**6796,2**	**4515,6**
IV.2012	3171,8	1950,5	1221,3	4277,3	2348,4	1928,9
V.2012	3647,7	2149,9	1497,8	4646,8	2679,1	1967,7
VI.2012	3462,2	2017,5	1444,7	4372,3	2643,4	1728,9
IV - VI.2012	**10281,7**	**6117,9**	**4163,8**	**13296,4**	**7670,9**	**5625,5**
I - VI.2012	**19318,5**	**11564,8**	**7753,7**	**24608,2**	**14467,1**	**10141,1**
VII.2012	3645,9	2251,4	1394,5	4341,6	2657,5	1684,1
VIII.2012	3658,4	1979,5	1678,9	4115,4	2232,0	1883,4
IX.2012	3549,9	2120,9	1429,0	4033,4	2351,8	1681,6
VII - IX.2012	**10854,2**	**6351,8**	**4502,4**	**12490,4**	**7241,3**	**5249,1**
I - IX.2012	**30172,7**	**17916,6**	**12256,1**	**37098,6**	**21708,4**	**15390,2**
X.2012	3637,5	2106,5	1531,0	4537,8	2630,0	1907,8
XI.2012	3802,9	2230,6	1572,3	4340,5	2718,9	1621,6
XII.2012	3009,8	1680,1	1329,7	3816,8	2202,1	1614,7
X - XII.2012	**10450,2**	**6017,2**	**4433,0**	**12695,1**	**7551,0**	**5144,1**
I - XII.2012	**40622,9**	**23933,8**	**16689,1**	**49793,7**	**29259,4**	**20534,3**
I.2013	3482,5	2018,0	1464,5	3724,5	2067,5	1657,0
II.2013	3243,0	1952,2	1290,8	4033,2	2458,5	1574,7
III.2013	3476,6	2172,7	1303,9	3852,9	2333,5	1519,4
I - III.2013	**10202,1**	**6142,9**	**4059,2**	**11610,6**	**6859,5**	**4751,1**
IV.2013	3866,5	2191,7	1674,8	4359,9	2624,7	1735,2
V.2013	3308,9	1879,3	1429,6	4131,5	2374,3	1757,2
VI.2013	3437,8	2041,0	1396,8	4240,2	2549,1	1691,1
IV - VI.2013	**10613,2**	**6112,0**	**4501,2**	**12731,6**	**7548,1**	**5183,5**
I - VI.2013	**20815,3**	**12254,9**	**8560,4**	**24342,2**	**14407,6**	**9934,6**
VII.2013	3992,4	2438,0	1554,4	4670,0	2850,9	1819,1
VIII.2013	3917,0	2384,8	1532,2	3878,3	2191,6	1686,7
IX.2013	3779,0	2448,4	1330,6	4570,1	2794,8	1775,3
VII - IX.2013	**11688,4**	**7271,2**	**4417,2**	**13118,4**	**7837,3**	**5281,1**
I - IX.2013	**32503,7**	**19526,1**	**12977,6**	**37460,6**	**22244,9**	**15215,7**
X.2013	3962,7	2392,2	1570,5	4535,5	2764,9	1770,6
XI.2013	3970,9	2452,6	1518,3	4526,4	2669,2	1857,2
XII.2013	3121,9	1740,2	1381,7	3992,9	2485,7	1507,2
X - XII.2013	**11055,5**	**6585,0**	**4470,5**	**13054,8**	**7919,8**	**5135,0**
I - XII.2013	**43559,2**	**26111,1**	**17448,1**	**50515,4**	**30164,7**	**20350,7**

5. Economical aspect

In the economical aspect the first and most important prerequisite for the provision of the interaction is the creation of identical plans for combined cargo transportation and their submission for execution to all the subdivisions of the corresponding modes of transport. The long-term and especially the annual and operational plans for transportation (quarterly, monthly) should coincide in their capacity, nomenclature, terms, starting points, unloading and destination, names of the companies sending and receiving the cargo. The presence of identical transportation plans for each of the interacting modes of transport makes it possible to foresee on a timely manner the handing over of the load, to prepare the permanent equipment, the means for maneuver and unloading, to provide the process of transferring the load from one mode of transport to the other using the required labour force. For the mutual coordination of the planning of cargo transportation in direct railway-waterway transport a specific system was created which is presented in the corresponding documents and in particular in tariff handbooks where the list of sea and river ports providing such mode of transport is published. However, sometimes the order of planning might be broken resulting in the lack of compliance between the separate positions in the transportation plans. In that case even if the necessary technical equipment is present in the transport junctions, the cargo and the mobile means of transportation might be delayed with all the negative consequences. [1] The complications in the junctions occur if the recommendations and regulations for each mode of transport are not followed. The unification of planning for the different modes of transport including cargo nomenclature, terms of development and confirmation of projects requires to be accomplished as fast as possible. The tariffs are an important economical leverage for the development of effective multimodal transportation. The railway transport as a part of a direct railway-river transportation lowers the transportation price with 30%. In that connection it is necessary to create a system of unified tariffs which would stimulate the clients to use the effective combined transportation. A number of economic questions also arise. In particular it is the way of payment and financial incentive of the workers in different modes of transport for the sake of better interaction as well as the improvement of judicial and legal regulations. The system of management and more precisely the operative management exercises a significant influence on the results of the work in the junctions and in the larger subdivisions of the different modes of transport. The effectiveness depends not only on the observance of the abovementioned terms but also on the personnel selection, their qualification and personal qualities. Practice has proven effective to assign specific experienced people to specific work shifts. The most important field of interaction is the cargo and commercial work and the legal side including development, coordination and control of observance of the mutual obligations of the parties in the transportation contracts, provision of the storage, observance of the insurance obligations, state laws, rules, codes and instructions.

Multimodal transportation is the future of international business.

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ERGONOMICS IN E- LEARNING

ЕРГОНОМИЯ В ЕЛЕКТРОННОТО ОБУЧЕНИЕ

Assist. Prof Karamanska D. Y. PhD.[1], PhD student Todorova, M.V .[2]
University of Chemical Technology and Metallurgy, Bulgaria[1]
d_karamanska@hotmail.com

Abstract. *E-learning, seen in the ergonomic aspect, is a complex and intense human activity that is subject to investigation and analysis in order to optimize it. The quality of education is seen as a trinity of its effectiveness, efficiency and satisfaction - criteria that are defined, studied and assessed using a specially developed, original methodology of the authors. These criteria were used to investigate BA, MA and Ph.D. students in two consecutive years.*

Keywords: *E-LEARNING, ERGONOMIC RESEARCH, EFFECTIVENESS, EFFICIENCY, SATISFACTION.*

Introduction

In today's information society based on knowledge and intellect, education plays a fundamental role in the professional training of each individual. The rapid advent of electronic (information and communication) technology is completely changing the educational context. Traditional learning, implying one-way transfer of knowledge from teacher to student (top-down) is no longer sufficient. Students have to prepare for autonomous life-long learning through cooperation and interaction with the teacher. E-learning has the potential to change the way we teach and learn. It provides new opportunities for customizing the learning process and makes prerequisites to enrich the learning experience and the quality of learning. E-learning can not replace teachers, but in combination with the existing traditional methods, it can enhance the quality and enrich their teaching practice. In a more general sense, blended learning is characterized by the upgrade, incorporation, integration of various information and communication technologies in traditional educational settings. [7, 8]

The advent of e-learning has enormously increased the motivation of learners to participate in the learning process; classes and knowledge are becoming more experimental and attractive. New values, skills, competencies are being cultivated. Creativity is being stimulated, original decisions are being made and communication at all levels is being improved, including the skills to use information and computer technologies. [1, 2]

Training students, like every other human activity, can be optimized, and this requires its permanent monitoring and evaluation. Ergonomics is the scientific direction aimed at continuous improvement of human activities. The ergonomic evaluation of the activity is carried out under the following criteria: achieving excellence in labor (effectiveness) while preserving the health of everyone with minimal psychological, physiological risks, saving time and finances (efficiency) and providing the necessary conditions and facilities so that the Man feels satisfied. [3, 6]

Prerequisites for the solution of the problem

The effects of the introduction of electronic technologies can be evaluated by the help of ergonomic criteria: effectiveness, efficiency and satisfaction. [4]

The effectiveness of e-learning consists of more successful (than traditional training) solving learning tasks such as acquiring knowledge and skills through free and easy access to educational and scientific information, successful preparation and self-preparation for exams, writing course projects, theses as well as participation in research projects and forums.

Efficiency takes into account factors such as: reducing the time to prepare for exams as well as for completing educational and scientific tasks; saving resources material and non-material plan (psychological, medical, social). Briefly, the efficacy of e-learning means to achieve good results coupled with a minimum expenditure of time, mental, financial, etc. resources.

Satisfaction with e-learning is a subjective assessment, which includes demonstrated confidence, activity in school and outside school activities and general contentment with the obtained results.

Solution of the problem

E-learning at UCTM is at the stage of gradual introduction. Its share in the traditional forms of education: lectures, seminars, laboratory work is still relatively small. The software products for self-learning and self-control are also insufficient. On the other hand, there is a strong motivation of students to learn in an electronic environment. [5] Furthermore, in recent years, university management has been investing seriously in refurbishing computers, developing e-learning platforms, making electronic libraries, expanding access to various databases, buying specialized software to assist in designing course and graduation projects.

In view of the above, the investigation of the effectiveness, efficiency and satisfaction of the introduction of electronic technologies in education at UCTM was performed using a specially developed for this purpose Ergonomic card among BA, MA and PhD students in two consecutive years.

In order to evaluate effectiveness, the view of the trainees was sought for, concerning their expectations on the wider introduction of electronic technologies in traditional forms of education: namely in lectures, seminars, laboratory work; to increase the opportunities for self-learning, self-control, and ultimately for final evaluation and test. These are the main directions of electronization that lead to effective improvement of education- its modernization, upgrade and integration with traditional technologies.

In order to evaluate efficiency, the assessment of trainees on existing university facilities was asked for: hardware (sufficient number of computers and multimedia in the halls) database software (free access to Internet, a sufficient number of programs for self-learning, self-control, availability of specialized software for engineering research , projects and theses). Positive evaluations on these matters are important prerequisites for achieving high efficiency of training i.e. achieving good academic results with a minimum expenditure of time, mental, financial, etc. resources.

As far as satisfaction is concerned, the respondents were asked to express their personal opinion about the quality of the computer equipment at the university, the stock of electronic library with academic and scientific information, access to various databases; they were also asked to assess the level of work with electronic technologies of their teachers and finally to assess their competence to work in WEB environment. Satisfaction with the introduction of e-learning is higher if there are material facilities and good psychosocial environment of the required standard.

Results and discussion

The results of the study of the effectiveness, efficiency and satisfaction with regard to the introduction of electronic technology in education are given in tables and graphs. Tables 1-3 and Figures 1-3 show the percentage [%] positive attitudes and evaluations of the three different groups of respondents: BA, MA, Ph.D. students according to the three ergonomic criteria. Tables 4-6 and Figures 4-6 show the percentage [%] positive attitudes and assessments of students in two consecutive years.

Table1. *Assessment of effectiveness by groups of students in varying degrees of training*

Effectiveness	**Bachelor**	**Master**	**Ph.D. student**
Lectures	97	100	100
Seminars	89	82	82
Laboratory Work	53	42	59
Self-education	94	86	94
Self-assessment	100	80	94
Examination	78	82	71

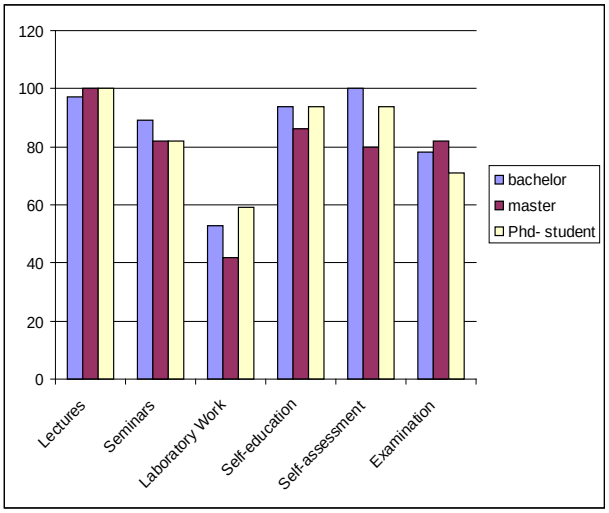

Fig.1. Assessment of effectiveness by groups of students in varying degrees of training

Evaluations of the effectiveness of e-learning show high positive motivation of the three groups of students on most indicators: students at UCTM welcome the introduction of new technologies to lectures, seminars, self-education. The students are reserved regarding their use in laboratory work and final control.

Table 2 *Assessment of efficiency by groups of students in varying degrees of training*

Efficiency	**bachelor**	**master**	**Ph.d. student**
Multimedia	93	92	96
Free Internet	70	87	88
Computers	88	88	88
Software for engineering	61	77	78
Self-education	78	60	67
Self-assessment	70	56	62

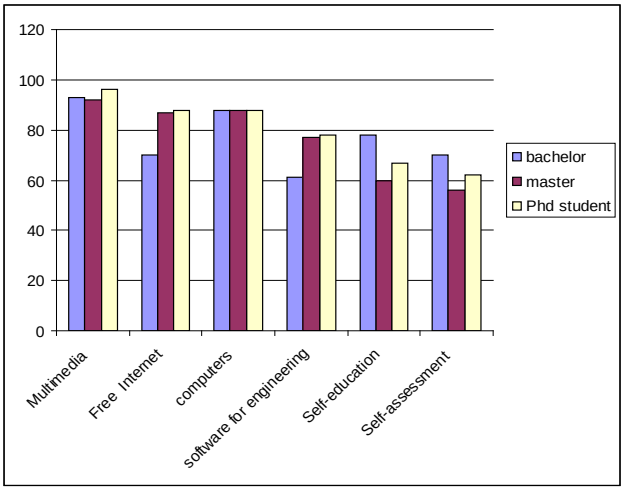

Fig.2. *Assessment of efficiency by groups of students in varying degrees of training*

The efficiency of the introduction of electronic technologies in education is reflected in the high ratings of the respondents for facilities: available computers, multimedia, access to Internet. There is much to be done in the direction of providing specialized software engineering research programs for self-study, self-control, especially for the groups of postgraduates.

Table 3 *Assessment of satisfaction by groups of students in varying degrees of training*

Satisfaction	**Bachelor**	**Master**	**Ph.D. student**
Quality computers	94	88	84
E-libraries	95	91	88
Database	89	90	87
Faculty competence	89	84	89
Students' competence in WEB	100	98	100

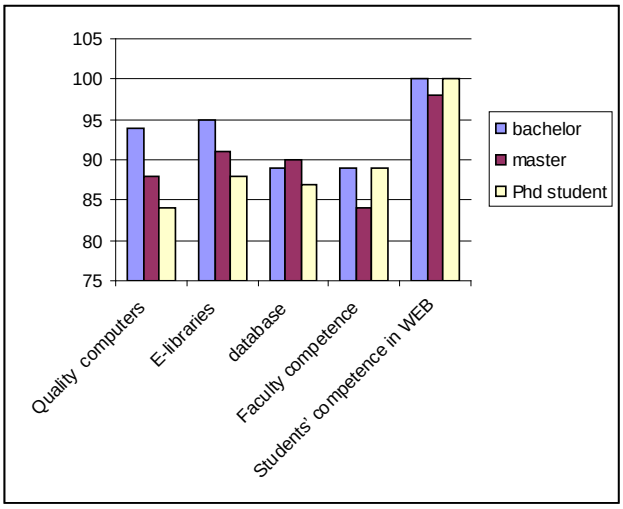

Fig 3.*Assessment of satisfaction by groups of students in varying degrees of training*

Satisfaction with the introduction of e-learning for all the investigated groups was relatively good. As expected, the group of doctoral students (such as people with higher requirements and experience) give relatively low scores concerning quality of available computers, the available educational and scientific information in digital libraries, access to various databases. The high self-esteem of all the three groups concerning their work in WEB environment is very optimistic.

Table 4. *Assessment of the effectiveness by years*

Effectiveness	2014	2015
Lectures	94	97
Seminars	80	89
Laboratory Work	42	53
Self-education	86	94
SELF-ASSESSMENT	82	100
EXAMINATION	76	78

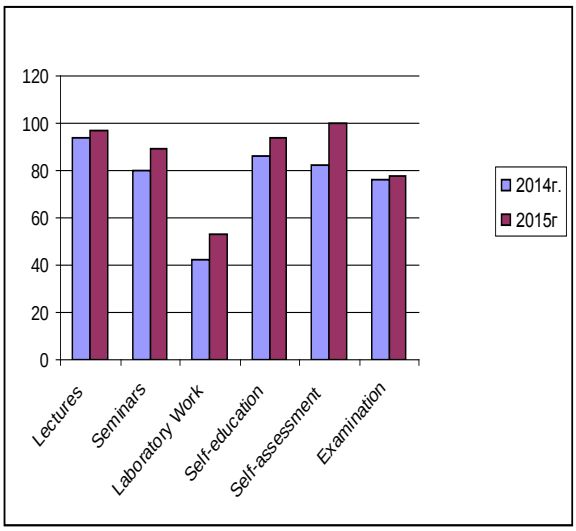

Fig. 4. *Assessment of the effectiveness by years*

Table 5. *Assessment of the efficiency by years*

Efficiency	2014г.	2015г.
Multimedia	91	93
Free Internet	85	70
Computers	89	88
Software for engineering	68	61
Self-education	64	78
Self-assessment	66	70

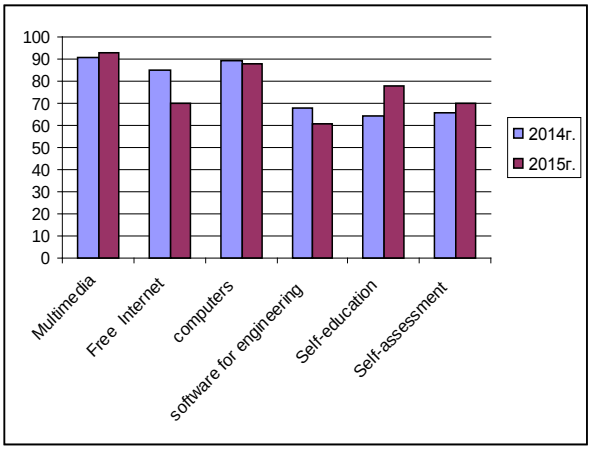

Fig.5. *Assessment of the efficiency by years*

Table6. *Assessment of satisfaction by years*

Satisfaction	2014г.	2015г.
Quality computers	66	94
E-libraries	88	95
Database	83	89
Faculty competence	67	89
Students' competence in WEB	100	100

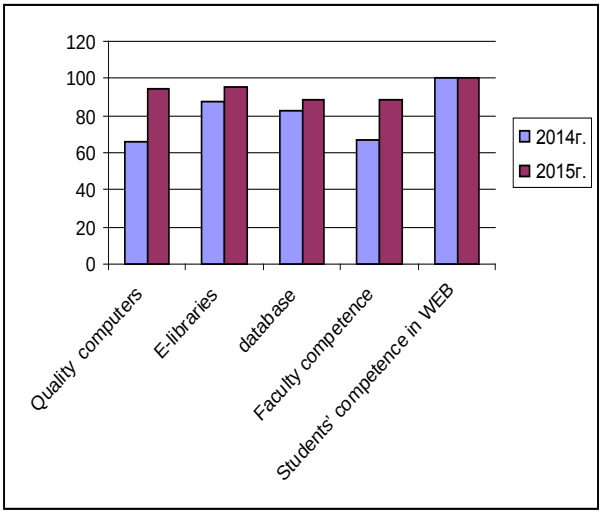

Fig. 6. *Assessment of satisfaction by years*

Findings and conclusion

There is a steady trend, expressed by the majority of students, to increase the share of E-learning, both in traditional forms of education: lectures, seminars, laboratory work, as well as for self-study, self-control, even for the final control.

Amid the growing desire for rapid development of electronic technology in engineering education, the students have more requirements concerning the availability of uninterrupted Internet access at the university, and the need for wider application of specialized software for engineering analysis and projects.

Positive trends in the field of E-learning can be identified according to the assessment given by students:

The share of high-quality computers at the University increases;

The capacity of the electronic library at the University increases;

The access to various databases increases;

The qualifications of the teaching staff are being evaluated more and more positively, amid the pronounced "excellent student training" to work in an electronic environment.

E-learning has been developing in the context of the information society, which "is not only related to the transmission of sound knowledge verified by tradition in successive generations, but it has the heavy task to teach the younger generation to deal with the chaotic and difficult to predict flow of knowledge, where the young must be able to "swim"." E-learning is interactive and it provides great freedom of the learner in terms of means, place, time and rhythm of learning.

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SOME PROJECT MANAGEMENT TECHNIQUES

M.Sc. Ivanova Milka

Faculty of Mechanical Engineering – Technical University of Sofia, Bulgaria

milkachr@tu-sofia.bg

Abstract: *There are many specific techniques involved in each of the four* major sets of activities called POMA (**P**lanning, **O**rganizing, **M**onitoring, **and Adjusting**) *phases. Some require extremely deep technical knowledge and others demand great social skills, in this section, we will focus on four commonly needed project management skills: project effort estimation, work breakdown structure, project status tracking with earned value and* development measuring & *metrics The first two of them are techniques needed in the planning and organizing phases, and the third is needed in the monitoring phase. The fourth is needed for part of planning and for monitor*ing.

In the report they have explained some techniques for estimating software project management

Keywords: SOFTWARE, PROJECT MANAGEMENT, PROJECT MANAGEMENT SKILS - PROJECT EFFORT ESTIMATION, WORK BREAKDOWN STRUCTURE, PROJECT STATUS TRACKING WITH EARNED VALUE AND DEVELOPMENT MEASURING & METRICS

Introduction

There are many specific techniques involved in each of the four major sets of activities called POMA (**P**lanning, **O**rganizing, **M**onitoring, **and Adjusting**) phases. Some require extremely deep technical knowledge and others demand great social skills, in this section, we will focus on four commonly needed project management skills: project effort estimation, work breakdown structure, project status tracking with earned value and development measuring & metrics The first two of them are techniques needed in the planning and organizing phases, and the third is needed in the monitoring phase. The fourth is needed for part of planning and for monitoring.

I. Project Effort Estimation

Estimating the software project effort has been a difficult task. In estimating software project effort there must be some inputs that describe the project requirements. The accuracy and the completeness of these inputs is a significant problem. Because the inputs themselves are mostly estimates, it becomes necessary to convert them into a single numerical number expressed in some unit of measurement such as person-months. After the effort has been expressed in some units, the problem of uniformity must be faced, In other words, one person month may vary dramatically depending on the skill level of assigned person. In spite of these problems, it is still necessary to estimate the project effort and put a plan together. With so much uncertainty, it is not difficult to see why monitoring and adjustment phases are crucial to project management.

In general, the estimation may be viewed as a set of project factors that may he combined in some form to provide the effort estimate. The formula can be used:

$$\text{Unit of effort} = a + b\,(\text{size})^{c} + \text{ACCUM(factors)}$$

The units of effort are often person-months or person-days. The constant ***a*** may be viewed as the base cost of doing business. That is, every project has a minimum cost regardless of the size and the other factors. This cost may include administrative and support costs (such as telephone, office space, and secretarial staff). The variable size is an estimate of the final product size in some units, such as lines of code. The constant ***b*** is a figure that linearly scales the size variable. The constant ***c*** allows the estimated product size to influence the effort estimation in some nonlinear form. The constants ***b*** and ***c*** are derived through experimentation with past projects. The term ***ACCUM(factors)*** is an accumulation of multiple factors that further influence the protect estimation (the function ACCOM may be an arithmetical sum or an arithmetical product of a list of factors, such as technical, personnel, tools, and process factors, and other constraints that influence the project). They will discuss two specific approaches to effort estimation that may be viewed as some derivative of this general formula.

COCOMO Estimation Models The first estimation model they will look at here is the constructive cost model (COCOMO) approach, which originated in [1]. They will utilize the intermediate level here as an illustration and show the overall COCOMO estimation process. The following is a summary of the steps in COCOMO estimation:

- Pick an estimate of what is considered as three possible project modes: organic (simple), semidetached (intermediate), and embedded (difficult). The choice of mode will determine the particular effort estimation ;
- Estimate the size of the project in thousand lines of code (KLOC);
- Review number of factors, known as cost-drivers, and estimate the amount of impact each factor will have on the project: the team's understanding of the project objectives, the team's experience with similar or related projects, the project's need to conform with established requirements, the project's need to conform with established external interfaces, the need to develop the project concurrently with new systems and new operational procedures, the project's need for new innovative technology, architecture or other constrains, the project's need to meet or beat the schedule, project size;
- Determine the effort for the software project by inserting the estimated values into the effort formula for the chosen mode.

The three modes of organic, semidetached, and embedded may be roughly equated to simple, intermediate, and difficult projects, respectively, Most of the projects will have a mix of project characteristics. For example, the parameter "*project size*" may be small but the parameter *"need to meet or beat the schedule"* may be very stringent for the specific software project. Even just considering these two characteristics, it would be difficult deciding whether a project is simple or intermediate. Imagine the difficulty of making a decision on the project mode when a software project has a mixture of eight characteristics. There are estimation formulas for three modes (with effort unit in person-months):

Organic: Effort = $[3.2 \times (\text{size})^{1.05}]$ x PROD (f 's)

Semidetached: Effort = $[3.0 \times (\text{size})^{1.12}]$ x PROD (f 's)

Embedded: Effort = $[2.0 \times (\text{size})^{1.2}]$ x PROD (f 's)

Thus, based on the eight parameters, if we decide that the project is simple (organic), the effort for the organic mode will he estimated with the equation Effort = $3.2 \times (\text{size})^{1.05}$. This estimation equation provides the basic estimation of project effort in person-months, and it is the first level of estimation.

The next level of estimation in COCOMO is considering the additional project factors (called cost-drivers). PROD (f's) is arithmetic product function that multiplies cost-drivers. Each of these cost-drivers has a range of numerical values (from very low to extra high). They may be categorized into four main groups:

- ***Product attributes*** : Required software reliability, Database size, Product complexity
- ***Computer attributes*** : Execution time constraint, Main memory constraint, Virtual machine complexity, Computer turnaround time
- ***Personnel attributes***: Analyst capability, Application experience, Programmer capability, Virtual machine experience, Programming language experience
- ***Project attributes*** : Modern practice use, Software tools use, Development schedule requirement

The difficulties with COCOMO Include the choosing of the particular project mode based on the 8 parameters, the estimation of product size, and the considerations of the 15 cost -drivers. These all require some past experience. Therefore, almost all experienced managers would attach some amount of buffers to the estimate.

Function Point Estimation The lines of code unit of measure have dominated the software estimating arena for many software engineering years. But it has had its share of problems and many different metrics have been proposed along the way. Function point was first introduced by [2]. It has gained popularity and is an alternative to the lines of-code metric for size of a software project. While many improvements and extensions have been made to this technique, we will describe the original version here.

Five components of software are considered in the function point estimation process:

1. External inputs
2. External outputs
3. External inquiries
4. Internal logical files
5. External interface files

Each component is assigned a weight based on three possible descriptions of the project:

1. Simple
2. Average
3. Complex

The important thing is that all of these efforts of estimates are indeed just estimates. Project managers must apply some intelligence and appropriate amount of buffer to these calculations before conveying any efforts estimates to the customers or the users or event to their own management.

II. Work Breakdown Structure

Estimating a complete project work effort is an important but difficult task, It can be made a little easier if the overall project is divided into smaller portions that provide a basis for the rest of planning activities such as scheduling and staff assignments. The work breakdown structure (WBS) is a depiction of the project in terms of discrete subactivities that must be conducted to complete the project. WBS first looks at the required deliverables of the software project. Then, for each of the artifact that needs to be delivered, a set of high level tasks that must be performed to develop the deliverable is identified. These tasks are also presented in an ordered fashion so that task scheduling can be accomplished from the WBS. The following is a framework for performing WBS:

- Examine and determine the required external deliverables of the software project;
- Identify the steps and tasks required to produce each of the external deliverables, including the tasks that would be required to develop any intermediate internal deliverable needed for final external deliverable;
- Sequence the tasks, including the specification of tasks that may be performed in parallel;
- Provide an estimate of the effort required to perform each of the tasks;
- Provide an estimate of the productivity of the personnel that is most likely to be assigned to each task;
- Calculate the time required to accomplish each of the tasks by dividing the effort estimate by the productivity estimate for each task;
- For each external deliverable, lay out the timeline of all the tasks needed to produce that deliverable and label the resources that will be assigned to the tasks.

For example, let's consider an external deliverable of test scenarios for a small software project that is estimated to be around 1000 lines of code or involve approximately 100 function points. As part of the WBS, we need to first list the tasks that are required to produce this deliverable. Such a list may look as follows:

- Task1: Read and understand the requirements document;
- Task2: Develop a list of major test scenarios;
- Task 3: Write the script for each of the major scenarios;
- Task 4: Review the test scenarios;
- Task5: Modify & change the scenarios.

These five tasks appear to be sequential, and they are at a macro level However, we can probably gain some speed if some of the major tasks can be subdivided into smaller pieces and be performed in parallel If would also seem that as some of the test scenarios are developed they can be reviewed and fixed. So, we may consider some overlapping of subtasks when we are ready to convert the WBS to a schedule. For illustration purposes, we divide Task 3 into Task 3a, Task 3b, and Task 3e to represent three equally divided sub-tasks of the script-writing activities. Task 4 can be decomposed to Task 4a, Task 4 b, Task 4c to match the three Task 3 subactivities. Similarly, Task 5 can be subdivided into Task 5a, Task 5b, and Task 5c to match the three subactivities of Task 4. Figure 1shows what the WBS network of tasks for this deliverable would look like. Clearly illustrating the WBS and the sequence along with which tasks may be carried out in parallel, thus figure can become a very convenient tool when the number of tasks and sequences is large.

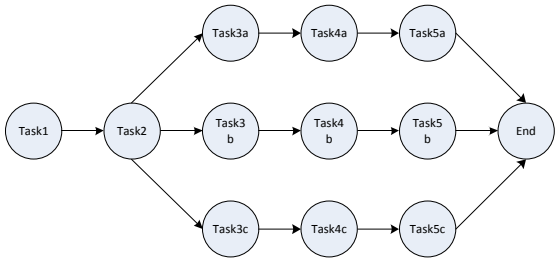

Fig.1

The next step is to estimate the effort required to complete each of the tasks. For Task 1, we need to estimate the effort required to read and understand the requirements of a project that is about 1000 lines of code or about 100 function points, For Task 2, we need to estimate the number of test scenarios that would need to be developed and how long it would take to come up with such a list. For Tasks 3a, 3b, and 3c, we need to estimate the effort needed to develop the test scripts for one-third of the scenarios. Similarly, we need to estimate the effort required to review one third of the scenario scripts for Tasks 4a, 4b, and 4c Estimating effort needed for Tasks 5a, 5b, and 5c would be very difficult because they depend on how many modifications are required as a result of Tasks 4a, 4b, & 4c. Nevertheless, all these initial estimates must be done. Fortunately, we do get to adjust our project because adjustment is

an intricate part of the four phases of project management. After these initial estimations have been made, we need to make an assumption and estimate the level of competency or the productivity of the people who will be assigned to all of these tasks. Then the estimated time for each of the tasks in Figure 3 can be computed by dividing the estimated effort by the estimated productivity. Figure 2 shows the same WBS tasks with the estimated time units required to perform these tasks and the order of the tasks. From this information we can establish the preliminary schedule as shown in Figure 3. Note that there are three main parts to the schedule; (1) the tasks**,** (2) the human resource assignment, and (3) the time units.

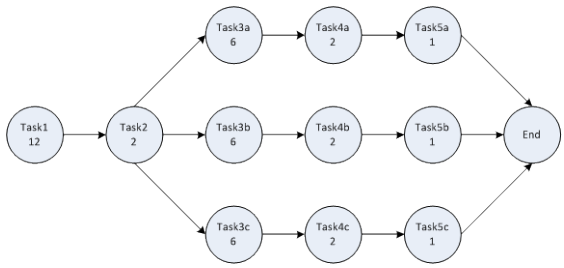

Fig.2

The transformation from WBS task network to an initial schedule directly moved two items: the tasks and the time units. The middle column in Figure 3 lists the presumed staff resource assignment, an important consideration that is the source for the productivity assumptions used to compute and estimate the time units required to complete the task, Earlier, it was also mentioned that the tasks may overlap. Once the initial schedule is formulated, the project management may look for the possibilities of overlapping the tasks, besides the already shown parallel tasks. In this example, the end of Task 1 and the beginning of Task 2 may overlap. The overlapping of subtasks, Task 3a 3b, and 3c with Task 4a, 4b, and 4c would be a lot trickier because a different person-a person who is committed to writing test scripts but may not have completed the writing task-must perform the review. Without including the column on resource assignment in the initial schedule, these kinds of subtleties may escape the project planners. In our example here, we have chosen to keep everything simple and showed no overlap of tasks in the initial schedule.

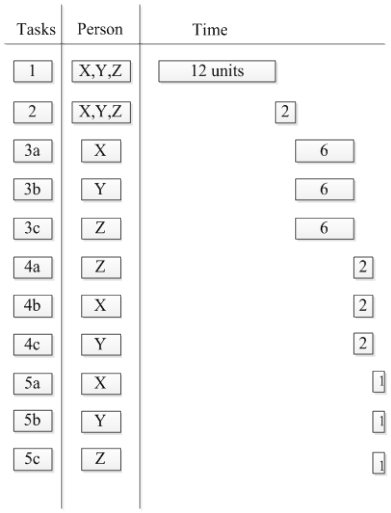

Fig.3

Considering all the different types of estimations that went into the task network of Figure 2, we should anticipate that the first schedule shown in Figure 3 will need to be modified as the project proceeds, This initial schedule should be reviewed by as many of the project constituents as possible before the schedule may be regard as a planned schedule.

Work breakdown structure is an important and necessary input to the creation of the initial schedule.Unfortunately, many software project schedules are constructed without developing a thorough WBS, and the result is an unattainable and unrealistic project schedule

III. Project Status Tracking with Earned Value

Keeping track of or monitoring project status is the activity that compares what was planned against what actually took place. There are multiple project' attributes that need to be tracked. Most of them are identified in the set of goals stated in the project plan. They are comparing the actual status of the attributes expressed as project goals against what was planned. They will discuss the tracking of project efforts using the concept of earned value (EV).

When using the earned value management technique, the fundamental concept is to compare the status of how much effort has been expended against how much effort was planned to have been expended as some point of time. First they will need some basic terminology, and then an example will be provided to clarify these definitions

- Budgeted cost of work (BCW) – the estimated effort for each of work tasks;
- Budgeted cost of work schedule (BCWS) – the sum of estimated effort of all tasks that were scheduled to be completed at a specific status-checking date; this according to the plan, to be completed at a specific status-checking date);
- Budget at completion (BAC) - the estimate the total project effort;
- Budgeted cost of work performed (BCWP)– the sum of the estimated efforts of all the tasks that have been completed at a specific status-checking date;
- Actual cost of work performed (ACWP) – the sum of the actual efforts of all the tasks that have been completed at a specific status-checking date.

A factor that should be remembered is that BCWS, BCWP, and ACWP are all stated in terms of a specific status - monitoring date. Thus those values will change relative to the status date.

Example: *Earned Value: date 4.5.2014*

Tabl.1

Work tasks	Estimated Effort [pers/days]	Actual Effort Spent So Far [pers/days]	Estimated Completion Date	Actual Completion Date
1	10	10	2.5.2014	2.5.2014
2	15	25	3.15.2014	3.25.2014
3	30	15	4.25.2014	
4	25	20	5.5.2014	4.1.2014
5	15	5	5.25.2014	
6	20	15	6.10.2014	

BAC for budget at completion:

BAC = 10 + 15 + 30 + 25 + 15 + 20 = 115 Pers/days

Status tracking date - 4.5.2014 BCWS includes Task1 &2:

BCWS = 10 + 15 = 25 Pers/days

Estimated Work completed at 4.5.2014: Task 1& 2& 4

BCWP= 10 + 15 +25 = 50 Pers/days

Actual effort expended at 4.5.2014: Task 1& 2& 4

ACWP= 10 + 15 +25 = 50 Pers/days

Earned value (*EV*) is an indicator that will tell us how much of the estimated work is completed on ***a*** specific date. It compares the sum of all the estimated efforts of the completed tasks as of the status date against the sum of the estimated efforts of all the tasks:

EV = BCWP / BAC

In terms of example, EV =50/115 = 0.43

They may interpret this to mean that the project is 43% complete as of 4/5/2014

There are two more status indicators that can be derived from the definitions. These are variance indicators that, once again, compare the planned or estimated value against the actual value., The first

one is a schedule variance (SV) indicator, which is defined as the difference between estimated efforts of the tasks that have been completed by the status date and the estimated efforts of the tasks that were scheduled or planned to have been completed by the status date:

SV = BCWP - BCWS

In example, on 4/5/2014, BCWP is 50 Pers/days, and BCWS is 25 Pers/days. Thus SV = 50 -25, or 25 Pers/days. They may interpret the project status as 25 Pers/days ahead of schedule from an effort perspective.

The second variance indicator is the cost variance (CV), which is defined as the difference between the estimated efforts of the tasks that have been completed at the status date and the actual efforts expended for the tasks that have been completed at that status date:

CV = BCWP - ACWP

In example, on 4/5/2014, BCWP is 50 Pers/days, and ACWP is 55 Pers/days. Thus CV = 50 - 55, or -5 Pers/days. In this case, on 4/5/2014, they have 5 Pers/clays of effort cost overrun.

The earned value management system provides us with a concrete way to monitor project status from a cost/effort perspective. However, the schedule variance is not an indicator of calendar time schedule but an effort schedule. More indicators may be constructed from this basic set of definitions, but we will not include thorn here, They have found that the set EV, SV, and CV provide a good indicator of project status, but we must still remember to look beyond the numbers, ask questions, and delve into other parameters when monitoring a software project. As a final reminder, if the monitored information indicates potential project problems, then adjustments must be made. Do not wait for some project-saving event to occur on its own.

IV. Measuring Project Properties and GQM

We have discussed the need to set goals for a software project during the planning stage so that these goals can be tracked and checked to see if they have been met, The goals are stated in terms of such properties as schedule, cost, productivity, maintainability, defect quality, and so on. The specific characteristics of interest must be well defined before any measurement of can take place. Besides setting and tracking goals, reasons for management include the following

- **Characterization** Allows to gather information about and intelligently describe a property;
- ***Tracking:*** Allows us to gather information about a property through such parameters as time or process steps;
- ***Evaluation***: Allows us to analyze the property via gathered information;
- ***Prediction***: Allows us to correlate properties and to extrapolate or conjecture about the property based on the gathered information,
- ***Improvement***: Allows us to identify areas of improvement based on an analysis of gathered information

It is critical for software engineers to join the rest of the engineering communities to adopt measurement arid quantitative analysis. Measurement is a vital part of quantitative management. Software (product or project) measurement is a mapping of an attribute of a software product or project to some set of numeric or symbolic entities. It can be deceivingly tricky to come up with good measurements.

1. Conceptualize the entity of interest such as the software product or project, the members of the project team, etc,

2. Clearly define the specific attributes of interest such as product design quality, programmer productivity, and project cost, etc.

3. Define the metrics to be used for each attribute of interest such as defects per class in a UML class design diagram, lines of code developed per programmer month, dollars expended per project month, etc.

4. Devise the mechanism to capture the metrics; this could include manually counting the number of defects in each designed class in the UML diagram.

The Goal-Question Metric (GQM) [3] introduced approach to software metrics. *GQM* has been used quite successfully by many organizations. This approach defines a measurement model based on three levels: ***Conceptual level****:* Establish a goal (For instance: Improve the time to locate a software *code* problem), **Operational level:** Develop a list of questions related to the goal (For instance: How does the program complexity influence software debugging time), **Quantitative level**: Develop metrics.

The nominal level allows us to distinctively categorize a property. For example, consider the case of measuring the number of software defects by source categories such as design, code, test, integration, and packaging.

The ordinal level provides an ordering of the property, For example when one is measuring customer satisfaction with categories of very satisfied, satisfied, neutral not satisfied, and very dissatisfied, This metric is more than just nominal because it also provides an ordering of very satisfied to very dissatisfied.

The third level of metrics is the interval level. The interval level allows us to describe equal intervals. Note that they could not have performed this type of operation with ordinal-level metrics. Consider the difference between very satisfied arid satisfied and the difference between satisfied and neutral in the ordinal metric example. These two differences are not necessarily of equal intervals.

The final metric ratio, allows comparing the ratio of two measurements because it has a defined 0 in the metric. For example, it makes sense to say program A, which has 100 lines of source code, is 4 times the size of program 8, which has 25 lines of source code. This is a result of the established 0 line of code as minimum size. The ratio scale is the highest metric level

Summary

A general formula for effort estimation that involves several parameters is shown. The principles behind the original COCOMO estimating methodology are explained and then its extensions and modifications into COCOMO II are introduced. The function point estimation technique for project size is shown as an alternative to the line-of-code estimation technique. The OO effort estimation technique is involved with estimating the number of key classes and the assumed productivity level of the software engineers. Another important planning technique, work breakdown structure, is demonstrated with a network of tasks and their respective estimated efforts. The significance of WBS to developing an initial project schedule, in a bar chart form, is explained with an example. Project monitoring involves the ongoing comparison between what is planned and what is actual. Earned value management is introduced as a viable technique for monitoring the project effort and project schedule. This process essentially compares the planned or estimated project task efforts against those project task efforts that were actually expended. They have explained the need for setting goals and tracking the goals as part of project management.

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ДИЗАЙН И ДИЗАЙНЕРСКИ ПРОДУКТ

Assoc. prof. Evtimova M.
Faculty of Business–Technical university of Sofia, Bulgaria
E-mail: emdete@abv.bg

Abstract: *The interrelation design-society-product is the basis for realization of the achievement in science, arts and social relations for development of a culture.*
KEYWORDS*: DESIGN, DESIGN PRODUCT, AESTHETIC CRITERION, SOCIETY, MARKET.*

Медии, интернет, както и всички реклами, ни заливат с термина „дизайнерски продукт“. Той става равнозначен на модерно, красиво, интересно и необичайно, присъства като необходимо качество на всеки нов представен продукт, който е произведен и е в процес на реализация на пазара.

Схема представяща зоните при които е най-ясна взаимообвързаната на дизайн и среда

Можем да си зададем въпросите - къде е границата между „Продукт“ и „Дизайнерски“ и има ли същностна разлика. От страна на потребителя понятието е по-скоро „новост“, „интересен като форма“ и след това – функционален. За определяне позицията на дизайнера, би трябвало да се проследи процеса на формиране на същностните характеристики на двете понятия, обединени в едно.

„Промишления дизайн“ и „продукт“ са определени в Националното ни законодателство в Закон за промишления дизайн и в Наредба за оформяне, подаване и експертиза на заявки за регистрация на промишлен дизайн, приета с ПМС №268, от 30. 13.1999г.Обн.ДВ, бр.9 от 1 февруари 2000г., изм. ДВ. Бр.14 от 14 февруари 2006г., изм. ДВ бр.32 от 25 март 2008г., изм. ДВ бр.52 от 8 юли 2011г. В ЗПД съгласно чл. 3, ал. 2: Относно понятието продукт „всяко промишлено или занаятчийско изделие, включително части, предназначени за сглобяване в комплексен продукт, опаковка, облекло, графични символи и печатни шрифтове, с изключение на компютърни програми“[1] Необходимо е в този анализ да се вземе под внимание и влагането на определено съдържание от страна на ИКСД (ICSID - International Council of Societies of Industrial Design)[2], Формулировката от 1959 година е следната „Индустриалният дизайнер е този, който е квалифициран чрез обучение, техническа подготовка, опит и визуално чувство за определяне на материали, механизми, форми, цветове, покрития и декорации на обекти, които се произвеждат в количество чрез индустриален процес. Индустриалният дизайнер може да бъде, в определени случаи, ангажиран с всички или само с един аспект на индустриално произведения продукт. Индустриалният дизайнер може също да бъде ангажиран с проблеми на опаковката, рекламата, експозицията и маркетинга, когато решението на такива проблеми изисква визуална преценка, като допълнение към техническите знания и опит. Художникът на индустриални продукти или продукти основаващи се на занаятите, където е нужен ръчен процес на производство се смята, че трябва да се назове индустриален дизайнер, когато творческият му продукт произведен въз основа на неговата рисунка или модел е за комерсиални ползи, или е произведен в количество и не е лично творчество на художник занаятчия."[3

Според тази дефиниция, са определени субективността на дизайнер и спецификата на продукта като полза за обществото:

- Дейността на дизайнера е обвързана с производството „чрез индустриален процес“;
- Знания, умения и опит: „квалифициран чрез обучение, техническа подготовка, опит и визуално чувство за определяне на материали, механизми, форми, цветове, покрития и декорации на обекти“;
- Подчертан е творческият характер на труда - „когато творческият му продукт“, както и обвързаността му с „комерсиални ползи“, но и преценка „изисква визуална преценка, като допълнение към техническите знания и опит“.

Дизайнерският продукт е по подразбиране, което насочва вниманието към задоволяване на пазара със стока:

- Значението на продукта - „или е произведен в количество и не е лично творчество на художник занаятчия“, го определя като задоволяващ общественото потребление;
- Зона за реализация на дизайнерския труд – „материали, механизми, форми, цветове, покрития и декорации на обекти“ както и „опаковката, рекламата, експозицията и маркетинга“.

Същностна разлика има след 10 години през септември1969г.:
„Дизайнът е такава творческа дейност, целта на която е формирането на хармонична предметна среда, най-цялостно удовлетворяваща материалните и духовни потребности на човека.
Тази цел се постига чрез определянето на формалните качества на предметите, създавани в индустриалното производство. Към тези формални качества на предметите се отнасят не само свойствата на техния външен вид, но преди всичко структурните връзки, които придават на системата необходимото функционално и композиционно единство, което съществува за повишаване ефективността на производството.“[4]

- Наново се подчертава обвързаността с „индустриалното производство“;
- Вече не става въпрос за определени сфери на дейност, като проявление на дизайна в продукт, а продукта на дизайна като същност изразена чрез връзката „хармонична предметна среда“ и човек, като „най-цялостно удовлетворяваща материалните и духовни потребности на човека;“

[1] http://ipbulgaria.bg/
[2] *http://www.icsid.org/*
[3] http://www.icsid.org/,
[4] Пак там - Стартира RenewID.com - онлайн кампания , като международната общност по дизайн може да разговаря и да допринесе за ново определение на промишлен дизайн, в периода до 29 Юни, 2015

- Спрямо дейността на дизайнерът, не се конкретизират зони, а е обобщено „предметна среда“. Посочва се удовлетворяване на „духовните потребности“, които в предишното определение са на заден план, спрямо „промишленото производство“.
- Характерът на „творческата дейност“ е подчертана, както и въздействието в духовната сфера на човека;

Определението за същността на „формалните качества на предметите“ подчертава, че дейността на дизайнера не е обвързана с конкретни дейности като част от създаването на продукта, а са неотменна негова същност ─ „структурните връзки, които придават на системата необходимото функционално и композиционно единство, което съществува за повишаване ефективността на производството." Многообразието на съвремието определя и многообразието на изявите на дизайна. Могат да се посочат следните видове дизайн:

В зависимост от измерността – двуизмерен (плоскостен), триизмерен (обемен) и/или комбиниран.

Промишлен дизайн. В зависимост от броя на закрилните с един промишлен дизайн решения – промишления дизайн на изделие като цяло, промишлен дизайн на част от изделие и промишлен дизайн за съвкупности от изделия.

Фирмен дизайн. Дизайн на създаваните продукти от фирмата, дизайн на интериора и екстериора, дизайн на визуално-комуникативните средства на фирмата - рекламен дизайн.

Инженерен дизайн. Това е конкретно определена сфера на дизайна. Създават се прототипи, образци на различни машини, технически съоръжения, уреди и инструменти за промишлено производство, реорганизира се средата за производство, оптимизира се средата и облеклото, осъществява се реклама.. За разлика от техническото конструиране художественото конструиране включва като задължителен елемент художествена дейност.

Графичен дизай. Основната задача на този вид дизайн е да извърши преход, прекодиране на научната и техническа информация на визуален език. Той е съществена част от рекламният микс на една фирма.

*Дизайн на средата***.** Същината е в организация и/или преустройство на предметната среда, интегрирането и обединението ѝ в сложна система, която да удовлетворява човека. Обект на проектиране са интериорът, екстериорът, организацията на градската среда, обзавеждането на изложбени зали, промишлени търговски изложения и други.

Моден дизайн. Спецификата е конкретна → човешката личност. Дизайна на облеклото удовлетворява потребностите ѝ и изразява модните тенденции**.**

В творческият процес, който протича при създаването на определен дизайнерски продукт, от значение е комплексния характер на проектирането. Тук се включват:

Научният дизайн – продиктуван от необходимостта за научно обоснована концепция на дизайн продукта. Включва познания и професионални знания от философията, изкуства, наука. Прави преценка чрез програмиране и прогнозиране на променящите се обществено – културни потребности. Изходните сведения, които той предлага на практиката, имат осреднен, абстрактен характер, очертаващ най-общото, типичното. Например →неговата роля е значителна за дизайнера в дизайн процеса, който се съобразява с ергономичните изисквания при реализиране на идея, която е може да е обект на философски постулати, съобразява се с технологиите, реализирани чрез научни постижения. Но конкретният продукт е съвкупност, осъществена чрез изразният език на пластичните изкуства. Дизайнерското проектиране като творческа дейност, изразява формираната идея чрез художественото проектиране и конструиране, формоизграждане, съобразявайки се и/или провокирайки нови технологии и материали. И именно тук е ролята на:

Дизайнерската експертиза с нейния оценъчен характер на функционалните, конструктивни и естетически функции за конкретизиране на ролята при създадения дизайн продукт в обществото. Но процесът обаче е многостранен:

Дизайнерския продукт и Пазар

Запознат с изводите на тази експертиза, при следваща разработка, дизайнерът е стимулиран да създаде продукт, който да удовлетворява в по- голяма степен необходимостта на човека и обществото като цяло.

Следователно реализирането на определена идея в дизайнерски продукт е началото на промяна на обществено, особено в културните му дадености, което спомага за създаване на пределен естетически критерий. Това е една от най-обобщените класификации на дизайна. В съвремието областите за реализация на тази специфична творческа дейност непрекъснато се разширяват. Разглеждайки тази отворена, развиваща се система е нужно да се отбележи, че „системообразуващ елемент на дизайна е художественото проектиране. Посредством него се създава образ на вещите, достига се до комплексни целесъобразни решения за изменение на предметите и средата в която човек живее.”[5]

С Навлизането на новите технологии се заражда и необходимостта от нови направления за изява на идеи чрез дизайнерския процес:

Уеб дизайн. (от английски Web дизайн). Вид графичен дизайн, специализиран за разработването на уеб приложения и различни дизайни, които имат за задача разработването на потребителски интерфейси за уеб сайтове и уеб приложения. Уеб дизайнерите създават логическата структура на уеб страници, чрез най-подходящите решения за представяне на информацията, по принципите на графичния дизайн.

Интериорен дизайн. Клон на дизайна, насочен към вътрешността на помещението, за да осигури комфорт и удобство чрез естетическите взаимодействия. Интериорният дизайн съчетава изкуство и промишлен дизайн.

Нови перспективни направления са:

*Екологичен дизайн***.** Проектиране на околната среда – участие чрез средствата и методите на дизайна при решаване на реалните проблеми за социалната защита на околната среда (и самите хора) от въздействието на замърсяването и отпадъците технологична цивилизация екологичен дисбаланс, от гледна точка на ценностите на природата и културата;

Био дизайн. Проектиране и строителство на морфологично био подобните структури и форми на продукти по аналогия с бионината, вплетени в архитектурни и инженерни принципи, въз основа на системно и целенасочено проучване на законите и принципите на формиране в природата, включително, биомеханика, бионика, етологията (наука за поведението живите организми в природата) и синергия (наука за принципите на самоорганизиращи се системи);

[5] Лисийска Здр. Основи на дизайна Бл., Пирин-принт ЕООД, 1994, с.51

Футуродизайн. Перспективен дизайн, обусловени на научно-технически, социално-културни и интуитивно-творчески процеси, иновационно проектиране и прогнозиране, ориентирани към различни нива и стадии на развитията на науката, техниките, икономиката, социалната сфера на обществото на бъдещето.

Кибернетико-евристичен – целенасочено направление в иновационния дизайн. Проектиране спрямо закономерностите и методите на евристиката (дисциплина, способстваща развитието и активизацията на творческото мислене и нестандартните способи), както и използване на възможностите на информационните технологии.

В труда си „Същност на дизайна“[6], Медведев систематизира видовете дизайн по отношение на категориите „утилитарен“ и „естетически“ по следния начин:

Нон-дизайн (non-design) - изследователски и програмни структури на взаимоотношенията между хората, техните действия, разработване на стратегии, програми за дейности за различни предприятия, организации, насочени към проблема за реконструкция на производство, свързан с развитието на нови продукти;

Системен дизайн - холистично семантичнен, организиран в „турообразуващи“ комплекси, системи (включително продукти) от различни видове и типове, обслужващи в една или друга област определен набор от нужди на хората в производството, социален живот, или за индивидуалния семейния живот;

Арт дизайн - при този вид, естетиката на дизайна е приоритетен принцип, насочени към организиране на естетическите впечатления, получени от възприемане на обекта. Това е „проектиране на емоции“, чиито цели се сближат с целите на декоративното изкуство.

Стайлинг (Styling) - специален вид развитие формално-естетическото подобряване на продукта, при което е засегнат само външния вид на продукта и е свързано с промяната на модела на пазара, а не на прототипа, с лека промяна на функционално действие и технология на производство (или дори липсата на промени).

Независимо от спецификите на различните видове дизайн, той е една голяма идея на съвремието и включва решаването на проблеми в различни области на средата в която човек живее и неговите потребности.

Развитието на видовете дизайн доказва значението му за оформяне на културните пластове на едно общество, чрез преплитане на изкуство и наука.

Чрез понятието „дизайн“ е определена и същностната характеристика на дизайнерския продукт → продукт, създаден чрез „творческа дейност“, характерна за изкуствата.

[6] Медведев В. Ю., Сущность дизайна: теоретические основы дизайна : учеб. пособие. – 3-е изд., испр. и доп. − СПб.: СПГУТД стр. 31

ANALYSIS OF PARALLEL RESONAT CONVERTERS WITH COMPUTER SIMULATIONS

Assist. prof. Dr. Eng. Stefanov G.[1] , Assos. prof. Dr. Eng. Sarac V.[2], Assist. Msc. Eng. Kukuseva Paneva M.[3]
Faculty of Electrical Engineering-Radovis, University 'Goce Delcev'-Stip, Macedonia [1,2,3]
goce.stefanov@ugd.edu.mk, vasilija.sarac @ugd.edu.mk, maja.kukuseva@ugd.edu.mk

Abstract: *In this paper analysis of power converters with parallel resonant circuit by using of computer simulations is made. The full bridge IGBT power converter is analyzing. The simulations are made in PowerSim simulation program. Calculation is the efficiency of the converter and is made harmonic analysis of the output voltage and current. Also, is made and compare on the obtained results of the parallel resonant converter with the results of the serial resonant converter in applications with variable RL-load.*

Keywords:POWER CONVERTER, EFFICIENCY, HARMONIC DISTORTION

1. Introduction

Power converters have great application in power electronics as in the devices for consumers (UPS, amplifiers) such and in industrial applications (driver converter, DC converter, and converter for induction heating). Basic elements in the power converter are semiconductors switching elements: diodes, thyristors, bipolar transistors, MOST transistors, IGBT transistors and GTO thyristors, [1], [2], [3]. The main target is semiconductors switching elements to operate with reduced losses of switching. The choice on the resonant circuit of the output of converter provides turn on and turns off of the switching elements in the bridge to be done at time as the voltage is zero or the current is zero. So the losses of power from switching are reduced, [1], [2].

Load resonant converters which used at devices for induction heating are with serial or parallel resonant circuit [1]. The resonant converters with serial *RCL* circuit are supply by a source of direct voltage. Output power in them is regulated by the control on difference between switching (operating) and resonant frequency. The output current of these converters, for switching frequency close to the resonant, has the shape close to a sine wave form and then transmitted energy is greatest. The resonant converters with parallel *RCL* circuit are supply by a source of the constant current. In these converters, output power is also regulated by control on difference between switching and resonant frequency. The output voltage of these converters, for switching frequency close to the resonant frequency has a shape close to a sine wave form and then transmitted energy is greatest [1].

The process on design of the power converter is defined with the purpose of the converter, and output load. Output load of converter defines the required output power, output voltage, output current, and output frequency. From the physical state of the output load on the converter depends configuration of hardware and software part of managing electronics. The work is simple if the output load is a stationary, time able not changed, such as output load in the mode of motor or regulated source of voltage. But the design of converter is complicated if the physical state of the output load is a dynamic, time-variable process and its dynamic affects on output variables of the converter: impedance, voltage, current, power, frequency. Such output load has in power converter burdened with parallel and serial resonant circuit in the mode of induction furnace, [1], [5], [6]. The mode of induction furnace changes the impedance of resonant circuit and it affects on the voltage, current and power on the converter. So the design on the converter with such load requires knowledge of the dynamics of the process. The design of converter is facilitated by using on the computer simulation programs, [5],[7].

The main task in this paper is the researching for operating of parallel resonant converter with output loads whose dynamics are changing and is affecting of sizes on the resonant circuit.

2. Power Converters at Devices by Variables RL Load

In the Fig. 1 is presented block diagram in the power converter at device to inductions headings.

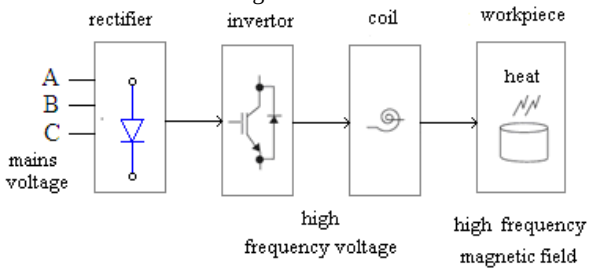

Fig. 1. *Power converter at device to inductions headings.*

The resonant converters used in applications where the dynamic of the process affects on the parameters of the converter. In the paper on the basis of a defined change on inductance and resistance on the resonant circuit, determined of the dynamics of induction device obtained by ELTA simulation program, is analyzed the work of full bridge IGBT converter with parallel resonant circuit, [5].

Definition of working conditions

We analyze the processink on the work piece metal with induction heating under follow operating conditions [5]: 1.Working piece metal 0.4% C steal 2T anneal, shape-cylinder, length 35cm, finite system length, R_{int} = 3cm, R_{ext} = 8cm, maximum temperature is 1000ºC, time cycle is 600s; 2. Maximum output power (Smax) is 100000VA; 3. Switching frequency (f_{sw}) 10 kHz was assumed for the design of maximum power; 4. IGBT devices are used.
With these conditions in ELTA simulation program is define the dynamics of the parameters (power, current, voltage, frequency, inductance, impedance) important for the design of the converter, [1], [5]. In Table 1 are given the results for changing the parameters of the system converter-inductor-work piece.

Table 1. *Parameters of the system converter-inductor-work piece*

	L (μH)	C_{reson} (μF)	C_{real} (μF)	R (Ω)	I_{ind} (A)	U_{conver} (V)	P_{conv} (kW)	η_{ele} (%)	PF
	11.89	21.4	13.9	0.37	571	225	92.3	0.76	0.5
	23.93	10.6	13.9	1.14	238	285	65	0.96	1
% (min/max)	49.6	49.5		18.4	41.7	79	70.4		50

From Table 1 can be concluded:

- The changing on temperature of the work piece from 20 to 1000 ° C produces change on the inductance for 49.6%.
- C_{reson} is value on capacitance required for compensate of changes of inductance for preserve the resonance frequency from 10000Hz.
- C_{real} is a real value of the selected capacitor.
- The changing on the inductance produces change of power of the converter for 30%.
- When the inductance is minimum, the power and the current have a maximum value.
- The changing on power of the converter shows that in such variable loads is necessary to build a system for controlling on output power.

Construction of converter

From the results for the parameters of the induction device obtained by ELTA simulation program, in PowerSim program with computer simulations the operating of the converter is analyzes [4].

Full bridge parallel resonant converter

In the Fig. 2 is show the circuit for simulation of the full bridge IGBT converter with parallel resonant circuit.

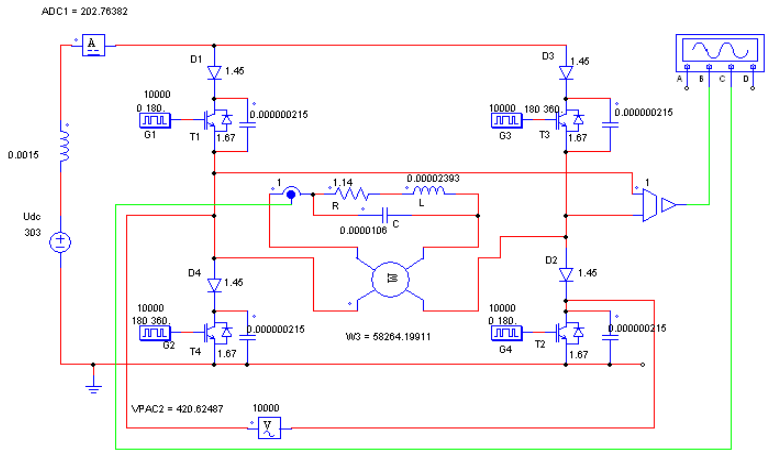

Fig. 2. *Circuit for simulation of the full bridge IGBT parallel resonant converter.*

In this paper the results to the parallel converter are comparing with the results for full bridge converter with serial resonant circuit obtained in [5]. In the simulation of the two types of converters took into consideration output power in both cases be the same.

Maximum inductance

From Table 1 can be seen that when the inductance and the resistance of the circuit are maximum, the capacitance is minimum, the output voltage of the converter is maximum and the output current is minimum. For this state, in Fig. 3 are given wave forms of the voltage and the current of output from the converter for full (100 %) output *RCL* load. In the Fig. 3a is shown wave forms for the converter by serial resonant circuit obtained to paper [5], and in the Fig.3b is shown wave forms for the converter by parallel circuit obtained by simulations in PowerSim program of the circuit of the Fig. 2.

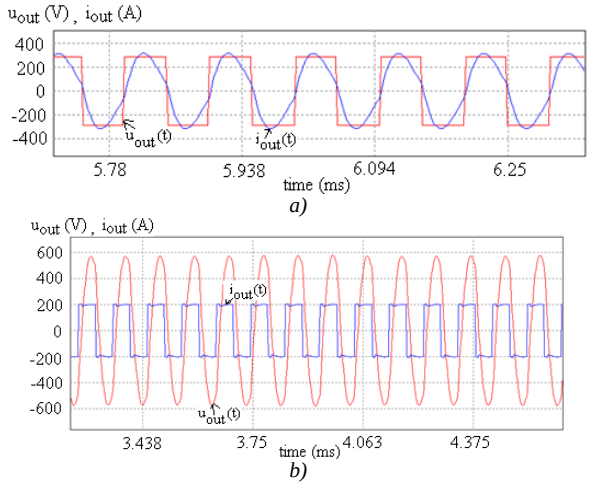

Fig. 3. Wave forms of the voltage and the current of output from converter for maximum inductance and 100 % *RLC* load: a) wave forms for the converter by serial resonant circuit in paper [5], b) wave forms for the converter by parallel circuit from Fig. 2.

From Fig. 3 can be seen that the output voltage in the converter by serial resonant circuit is with rectangular form, and the output current is with sine form, and in the converter by parallel circuit the output voltage is with sine form and the output current is with rectangular form.

The harmonics distribution of the output voltage (voltage amplitude spectrum) for maximum inductance and 100 % *RLC* load for serial resonant converter is shown in the Fig. 4a, and for parallel converter is shown in the Fig. 4b.

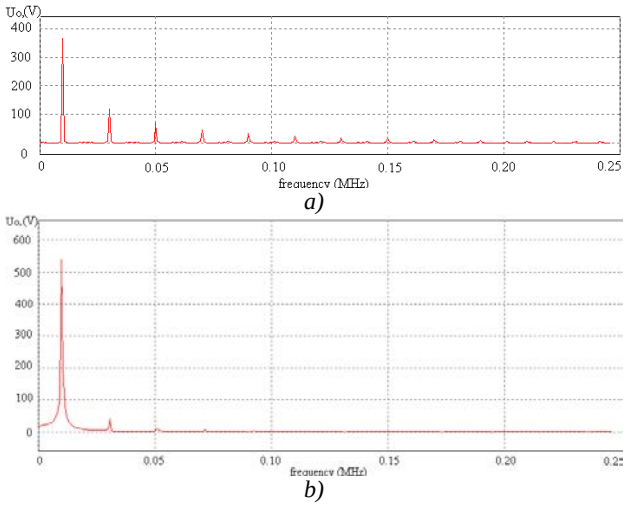

Fig. 4. *Harmonics distribution of the output converter voltage for maximum inductance: a) for serial resonant converter, and b) for parallel resonant converter.*

The harmonics distribution of the output current (current amplitude spectrum) for maximum inductance and 100 % *RLC* load for serial resonant converter is shown in the Fig. 5a, and for parallel converter is shown in the Fig. 5b.

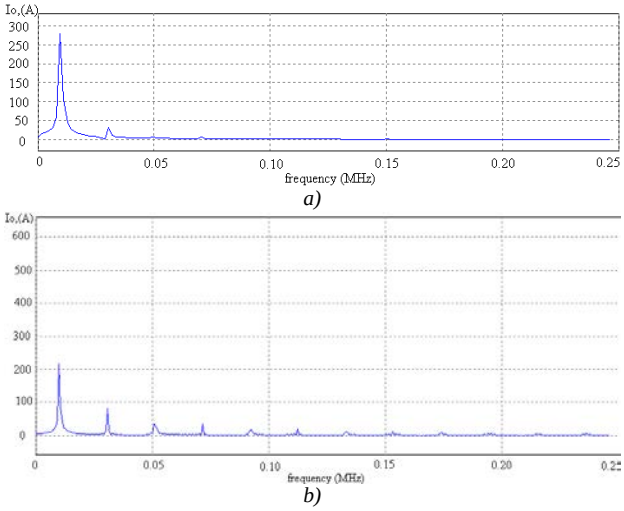

Fig. 5. *Harmonics distribution of the output converter current for maximum inductance: a) for serial resonant converter, and b) for parallel resonant converter.*

The voltage total harmonic distortion of the output on the power converter is calculates with the equation, [1]:

$$THDV = \sqrt{\frac{\left|U^2_{o(3)}\right| + \left|U^2_{o(5)}\right| + \left|U^2_{o(7)}\right| + \left|U^2_{o(9)}\right| + \left|U^2_{o(11)}\right| + \left|U^2_{o(13)}\right|}{\left|U^2_{o(1)}\right|}} \quad (1)$$

Where: $U_{o(1)}$, $U_{o(3)}$,$\cdot\cdot U_{0(13)}$ are effective values on the first, second,…..thirteenth harmonic.

The harmonic effective values of the output voltage for serial and parallel converter base in figure 4 are given in the Table 2.

Table 2. *The harmonic effective values of the output voltage for serial and parallel converter and 100 % RLC load*

	$U_{o(1)}$ (V)	$U_{o(3)}$ (V)	$U_{o(5)}$ (V)	$U_{o(7)}$ (V)	$U_{o(9)}$ (V)	$U_{o(11)}$ (V)	$U_{o(13)}$ (V)
serial circuit	258	72	22.9	22.7	15.5	13.5	8.1
parallel circuit	381	26.01	6.20	3.84	2.05	0	0

So voltage total harmonic distortion of the output for both converters is:

THDV = 31.7 % for power converter by serial circuit

THDV = 7.11 % for power converter by parallel circuit (2)

The current total harmonic distortion of the output on the power converter is calculates with the equation:

$$THDC = \sqrt{\frac{\left|I^2_{o(3)}\right| + \left|I^2_{o(5)}\right| + \left|I^2_{o(7)}\right| + \left|I^2_{o(9)}\right| + \left|I^2_{o(11)}\right| + \cdots + \left|I^2_{o(19)}\right|}{\left|I^2_{o(1)}\right|}} \quad (3)$$

Where: $I_{o(1)}$, $I_{o(3)}$, $\cdot\cdot I_{o(19)}$, are effective values on the first, second,….. nineteen harmonic. The harmonic effective values of the current for serial and parallel converter base in Fig. 5 are given in the Table 3.

Table 3. *The harmonic effective values of the output current for serial and parallel converter and 100 % RLC load*

	$I_{0(1)}$ (A)	$I_{0(3)}$ (A)	$I_{0(5)}$ (A)	$I_{0(7)}$ (A)	$I_{0(9)}$ (A)	$I_{0(11)}$ (A)	$I_{0(13)}$ (A)	$I_{0(15)}$ (A)	$I_{0(17)}$ (A)	$I_{0(19)}$ (A)
serial circuit	199	22.2	5.2	0	0	0	0	0	0	0
parallel circuit	153	44.53	25.12	21.16	11.16	10.50	9.84	7.40	6.84	3.95

So current total harmonic distortion of the output for both converters is:

THDC = 11.5 % for power converter by serial circuit

THDC = 38.73 % for power converter by parallel circuit (4)

In the Table 4 are given the cumulative results from analyze on the tables 2 and 3 and the equations (1) and (3), and in the Table 5 are given the results from analyze in the Fig. 3, 4, 5 and Table 1.

Table 4. *Total harmonic distortion on output voltage and current at serial and parallel converter for full (100 %) RLC load*

	THDV(%)	*THDC*(%)
serial circuit	31.7	11.5
parallel circuit	7.11	38.73

Table 5. *Parameter of the resonant circuit and output parameter at serial and parallel converter and 100 % RLC load*

	L (mH)	*C* (μF)	*R* (Ω)	I_{out} (A)	U_{out} (V)	S_{conv} (kVA)	I_{DC} (A)	U_{DC} (V)	P_{DC} (kW)	*PF*	P_{conv} (kW)	$\eta_{conv.}$ (%)
serial circuit	0.02393	10.6	1.14	225.68	287	64.77	207.18	290	60.08	0.90	58.34	97.10
parallel circuit	0.02393	10.6	1.14	197.80	431.73	85.40	202.76	303	61.45	0.68	58.26	94.81

In the Table 5 sizes are:

- U_{out} and I_{out} are effective values of the output converter voltage and current
- *PF* is power factor of the converter
- $S_{conv} = U_{out}I_{out}$ output apparent power
- $P_{conv} = S_{conv}PF$ is output power of the converter
- $\eta_{conv} = (P_{conv}/P_{DC})100\%$ is efficiency on the full bridge converter

Affection on the pulse width of gate from IGBT of total harmonic distortion

In the Fig. 6a are shown wave forms on the output voltage and the output current in serial resonant converter by 50% load *RLC* load in case of maximum inductance, [5], and in the Fig.6b wave forms in parallel resonant converter for same case. This wave form are obtained with simulations on the circuit from Fig. 2 in PowerSim program.

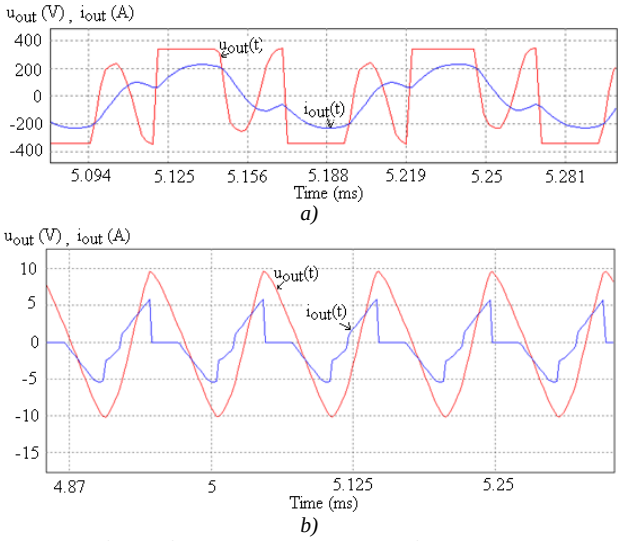

Fig. 6. *Wave forms of output voltage and current for 50% load RLC load in case of maximum inductance: a) for the serial resonant converter, b) for the parallel resonant converter.*

In the table 6 are given the results for the voltage total harmonic distortion and the current total harmonic distortion obtained with same analyze as for full output *RCL* load and used on the equations (1) and (3).

Table 6. *Total harmonic distortion on output voltage and current at serial and parallel converter and 50 % RLC load*

	THDV(%)	THDC(%)
serial circuit	145.0	24.6
parallel circuit	6.5	29.9

3. Analysis of results

Based of the results in point 2 can be concluded:

- Both types' resonant converters, parallel and serial satisfy the requirements for power and current defined in the Table 1.
- For same output power the parallel resonant converter works with more voltage and less current of serial converter.
- Also, for same output power in parallel resonant converter power factor *PF* and efficiency η are smaller from serial converter.
- In the parallel resonant converter current total harmonic distortion is greater, and in serial converter voltage total harmonic distortion is greater.
- In the converter with 50% load *RCL* load the voltage total harmonic distortion in serial resonant converter is increased. The sum on effective values on harmonics is greater than effective value on basic harmonic.
- It should be noted is that in parallel resonant converter to 50% load *RCL* load, the output power is significantly reduced.
- In the serial resonant converter, IGBT transistors operate with greater current (greater stress) than the parallel resonant converter for same output power.
- Since the mode of inductiion device has a variable dynamic, the converter which operates with such a device must monitore and regulate the output power with adequate methods of controlling.

4. Conclusion

In the paper is shown the procedure for construction of IGBT bridge parallel resonant converter with computer simulations. Here is analysis power converter with output load in mode of the induction device. Operation of the parllel converter is compared with the operation of the serial converter. The parameter of the resonant circuit and the required output power is obtained in the program package ELTA, with simulation of device for induction heating. In the analyse of the power converter is used PowerSim simulation program. The analyzed is the operation of the converter with change on the pulse width of the gate of IGBT transistors, as and changes of the output voltage and the current on the converter with change on the dynamics of resonant circuit. Also are analyze harmonics generated from the operation of the converter and is determined total harmonic distortion of the output voltage and current.

5. References

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RELIIABILITY IMPROVEMENT PROBLEM OF INSTRUMENTATION AND CONTROL SYSTEMS SOFTWARE

ЗАДАЧА ПОВЫШЕНИЯ НАДЕЖНОСТИ ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ СИСТЕМ УПРАВЛЕНИЯ ТЕХНОЛОГИЧЕСКИМИ ПРОЦЕССАМИ

Prof. Dr. Eng. Antamoshkin A., Prof. PhD Antamoshkina O.
Institute of Informatics and Telecjmmunications – Siberian State Aerospace University, Krasnoyrsk, Russia

Abstract: *The problem of increasing reliability of multi-version software of modern control systems for industrial automation was reduced to a problem of pseudo-Boolean optimization problem of knapsack type. For solving this problem, various methods were suggested.*
***KEYWORDS**: CONTROL SYSTEMS, MULTI-VERSION SOFTWARE, PSEUDO-BOLEAN OPTIMIZATION*

1. Introduction

Modern instrumentation and control systems include tens and hundreds of complex hardware, software and firmware components such as sensors, executive elements, communication channels, information processing systems and software modules. Crucial units are equipped with duplicated sensors, actuators, telecommunication channels, servers for information storage and processing, client terminals. Producers of industrial automatic equipment have extensive statistical information on refusals for each type of devices [8]. Having such information, the designer can estimate risks of refusal of each subsystem and design crucial components so that risks reduce to an acceptable rate due to use of the most reliable devices in combination with their duplication and reservation. However, complex systems demand developing of an instrumentation and control software subsystem which allows the whole system to function as a unit organizing interaction of its components depending on environment conditions and process state. The software faults including those concerned with incorrect mathematical models application can lead to refusal of the whole system and duplication of the identical copies of the software does not allow to fix the problem in this case. One of the possible ways of reliability increasing is multi-version programming.

2. Causes of failures and statistical data on them

Producers of instrumentation and control devices supply their consumers (usually, various design and implementation companies) with all necessary procedural guidelines [8, 11] on the corresponding software development. However, development of the software is always concerned with the risk of errors at various stages of development. At the stage of the program code writing, errors revealed by the compiler are insignificant here since they come to light before input of the program module in operation. The same can be told about the gross logical errors in the program code which are always revealed at a stage of testing. Other errors which are insignificant in usual operating modes but shown when several conditions satisfy simultaneously have the greatest impact on reliability of a software system. As a rule, program modules are tested for their working capacity in extreme operating modes. At the same time, errors can be shown at achievement of maximum values of several parameters simultaneously.

Errors in complex mathematical models applied in the program code are even more “artful”. Modern instrumentation and control devices include software modules of various complexity. A software module can implement very simple or extremely complex logical principles for controlling actuators in accordance with data from many sensors and information stored in software module database. Let us consider a software module controlling the subsystem of distribution cameras of aerotanks in a city sewerage system.

Eight regulating locks are a part of an actuator subsystem. Sensors of drains level and sensors of locks state form the instrumentation subsystem. The main function of the distribution cameras control algorithm is automatic positioning of the locks depending on given difference of drains levels in distributive cameras. A problem of this subsystem is maintenance of the given levels difference in distributive cameras by means of regulation of the regulating locks. Mathematical model for calculating the drain expense proceeding through the lock is $Q = 1.86 \cdot B \cdot (L - S)^{3/2}$, where B is width of the bottom of the lock, L – is the water level in the distributive camera, S is the Schieber valve position. Values of L and S are also estimated with use of the corresponding mathematical models. Moreover, a set of conditions for running this algorithm is given. The algorithm formulates tasks for the actuator adjusting the position of Schieber valves.

In addition, the software module contains a set of algorithms for running in emergency situations such as malfunction of sensors and actuators.

The parameters of a developed software modules must be adjusted. Incorrect program code of each of the algorithms of the software module or incorrect parameter values can lead to the fault of the software module and incorrect functioning of the whole system. Since this software module controls the supplementary functions of the system its refusal will not immediately lead to an accident of the who system. At the same time, in the same system, there are slightly less complex modules operating its crucial elements. Failure of the module can be found by appropriate monitoring means. At the same time, incorrect operation of the module (incorrect realization of mathematical models) leads to work of the whole system in a non-optimal mode that results in fast wear, increase of risk of emergencies in other parts of system working with the raised loading and, in case of our system, to serious ecological consequences in medium-term prospect. Detection of such implicit errors is extremely complicated.

In case of refusal of the program module owing to hardware failure, efficient means of increase of reliability of system is duplication of hardware resources: sensors, servers, telecommunication channels. The violation of logical principles given by the mathematical model which does not lead to its stop will repeat on any number of its copies.

3. Methods of multi-version programming and assessment of errors emergence probability

The technology of highly reliable multi-version programming is traditionally applied in military areas, mostly in space systems. Land spacecraft control systems are equiped with the software where the separate modules duplicate functions of each other. Versions of the module are developed by independent teams of computer programmers and tested separately. Besides, different development tools are often used for each version. Versions are executed in parallel, the results of running of each of them are transferred to the auxiliary module which is carrying out the comparison of results. If results (with given tolerance) coincide, the result of one of modules is transferred to an actuator. In case of

discrepancy, for example, the overall result gets out "by a majority vote" (the odd number of module versions is required). Anyway, application of multiversions allows to reveal existence of a problem in a program code. The revealed error in the program code can serve as a signal to transfer of the system into a special emergency mode, production stop etc., up to the identification of a cause of the error and its elimination. Thus, in many cases, instrumentation and control systems don not demand existence of odd number of multiversions. Existence of at least two independently developed versions allows to reveal an error in most cases.

Let the probability of emergence of an error be equal to p_i in the *i*th of the version of the software module. Then the probability of simultaneous emergence of an error in all modules is $\prod_{i=1}^{N} p_i$ where *N* is the number of versions of the module and the probability of detection of an error is $1-\prod_{i=1}^{N} p_i$.

Obviously, this value tends to 1 with the increase of *N*. Since the software modules pass through various testing procedures, the probability of error in each of versions is comparatively small. For example, if the error probability in each of two versions is equal to 0,001% then the probability of simultaneous error in both modules reduces to 0,0000001%.

Various models can be used for an assessment of estimated number of errors. For example, in [6], the following assessment of initial number of errors D_0 is offered:

(1) $$D_0 = V / 3000,$$

where *V* is the program code volume in bits of information. In turn, this volume is estimated as $V = N \log_2 \eta,$ where $\eta = \eta_1 + \eta_2$ is number of unique commands and operands of the program code, $N=N_1+N_2$ is number of their calls in the software.

The number of errors at the *m*th stage of testing is estimated by the Halsted model [9] as

(2) $$D_m = E^{(2/3)} / 3200,$$

where *E* is an estimation of the system complexity: $E = \eta_1 N_2 N \log_2 \eta / 2\eta_2$.

These complexity models and models for estimating thee number of mistakes can be used as rough estimates. Let each of the *M* modules have some versions, V_j versions for the jth module. Let P_{ji} be the probability of no-failure operation of the *i*th version of the *j*th module. If refusal of any of modules leads to refusal of the whole system, the probability *P* of no-failure operations of the system can be expressed as follows: $P = \prod_{j=1}^{M} \left(1 - \prod_{i=1}^{V_j} \left(1 - P_{ij}\right)\right)$.

In turn, the probability of no-failure operation can be estimated through the errors quantity (1) - (2).

4. Software system reliability optimization model

Complexity of each of modules can be considered approximately identical regardless of its exact realization. Thus, knowing complexity of the only version of each module, the assessment of probability of no-failure operation of the whole system depending on number of versions of each of modules and probability of no-failure operation P_i of the only version can be estimated: $P = \prod_{j=1}^{M} \left(1 - V_j \left(1 - P_j\right)\right)$. At the same time, the increase in number of versions of each of modules is leads to increase in cost of system. For instrumentation and control systems, we will consider accepted the number of versions of the module which does not exceed 2. We introduce the Boolean variables x_j equal to 1 if the *j*-th module must be duplicated and the constants C_j equal to the cost of development of the *j*-th module. Then, if the total budget *C* for development of the whole software system is known, we have an optimization problem:

(3) $$P = \prod_{j=1}^{M} \left(1 - \left(1 + x_j\right)\left(1 - P_j\right)\right) \to max,$$
$$\sum_{j=1}^{M} \left(1 + x_j\right) \cdot C_j \le C.$$

Analogous optimization problems of “knapsack” type are investigated in [1, 2, 7]. In [4, 10], author propose methods able to achieve “good” (precise enough) sub-optimal solution of such problems up to millions of variables and, thus, such methods can solve problems similar with (3). For problems with monotonic objective function, greedy heuristics [3] or special agglomerative greedy heuristics [5] can be successfully implemented.

5. Conclusion

A problem of instrumentation and control systems fault-tolerance increasing cannot be completely solved with hardware duplicating only. In addition, software modules must be duplicated, too. A problem of building an optimal set of the software modules can be formulated and solved as a pseudo-Boolean optimzation problem.

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Ролята на софтуера при съвременните изкуства и дизайна

инж. дизайнер Елена Г. Димитрова
Технически университет – София, България
el.g.dimitrova@gmail.com

Abstract: *In the contemporary N-forms of art, the body art is one of the traditional forms. This form of art combines the skills of the artist to create his/her idea on the specific physical features of the model.*

To express its essence in formulating the final version of the composition is used Adobe Photoshop. A conceptual project – sketch is create with color schemes and positions of the motives on the human body. The performance is interpretation of the legend of Orpheus and the realization of the idea is themed antiquity and modernity.

Besides being the artist of the body-art, as a director and scriptwriter I created a special choreography in which the movements evoke deep emotional states of the characters.

To form the complete presentation of the event, a promotional products are provided. They include poster, invitation and additional materials, such as schedule and photographs of the body-art. The use of the software is necessary in design.

Keywords: арт, пърформанс, боди-арт, дизайн, изкуство, дигитално изображение, софтуер, фотография, скица, традиционни художествени техники, дизайн продукт

1. Арт пърформанс

Пърформансът е част от съвременните Н-изкуства. Терминът води началото си от 60-те години в САЩ. Използван е за да опише художествено събитие, което се провежда на живо, включващо поети, музиканти и други, заедно с визуалните артисти. Заслужава си да се отбележи, че още през 20-те години дадаистите правят първите опити за „смесване" на поезия и визуални изкуство.

През 70-те години пърформансът започва все повече да се използва като неговата дефиниция става по-стеснена: пърформанс изкуството, което се изпълнява на живо пред публика или се представя, но не е театър. От 80-те години пърформанс изкуството започна все повече да инкорпорира в себе си новите технологии. При използването на новите медии в комбинация с традиционните техники и похвати артистите представят тази Н-форма отвъд допустимите граници.

Пърформанс изпълнението може да има сценарии или не, да е спонтанно или внимателно планирано, с или без участието на публиката. Артистът може да присъства или да отсъства, пърформансът може да се случи в различна среда и да е с различни дължина във времето.

Боди-арт (от анг. body –art) означава тяло/изкуство или изкусвото рисуване върху човешко тяло. Като движение в изкуството, бодиартът се разпространява широко през 60-те и 70-те години на XX век. Представянията му са под формата на пърформанси или документални снимки и видеозаписи. През 60-те години се възприема като реакция на минимализма с неговата хладност и дистанцираност. В контекста на това изкуство можем да разглеждаме акции на Ив Клайн, Пиеро Манцони, Марина Абрамович и др.(фиг. 1)

Фиг. 1 През 1960 г. Ив Клайн създава „Антропометрии", сложен пърформанс, в който освен голите хора - в ролята на четки на художника, участва самият той като диригент на струнен оркестър.

Боди-артът като Н-изкуство представлява съчетание от знанията и уменията свързани с традиционните форми на изобразителното изкуство пресъздадени върху специфичните физически дадености на модела.

Този вид пърформанс съчетава в себе си реализираната идея на автора под формата на рисунък и таланта на модела.

Създаването на боди-арт пърформанс може да представлява цялостно съчетание от традиционните техники в изобразителното изкуство в комбинация с музика и танц. Но при предварителната подготовка, особено при оформянето на окончателния вариант на композицията съвременният дизайнер използва софтуер – в случая Adobe Photoshop. Прави се концептуална проекто - скица с цветовите схеми и позициите на мотивите върху човешкото тяло

Представянето на творческата идея представеният боди-арт пърформанс е интерпретация на легендата за Орфей и Евридика.

2. Подготовка и реализация

При изготвянето на проекта за реализация на всеки боди-арт пърформанс биват създадени:

- скица на ръка
- изчистване на формата с помоща на софтуер
- създаване на симулирано изображение

При избор на сюжет за провеждане на арт пърформанса е небходимо да се направи скица с детайлите и палитра на използваните за целта цветове, съобразявайки се с особеностите за този античен период. Използвани се традиционни изобразителни техники за направената проекто-скица. (фиг. 2)

Фиг. 2 Проекто-скица на модела

Използвани са символи от тракийски съкровища и предмети. (фиг. 3)

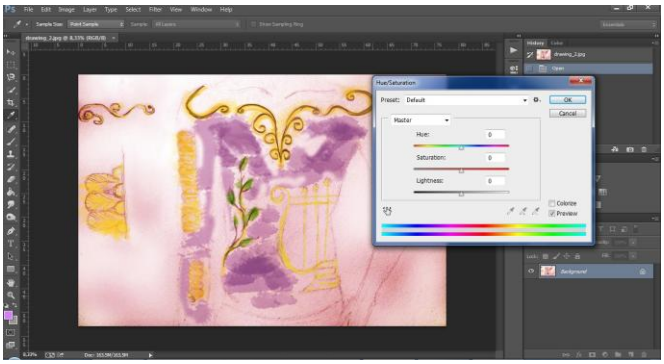
Фиг. 3 Тракийски шлем

Прехвърлянето в електронен вариант е необходимост, която спестява основно време и средства, но с помощта на софтуерните профукти се създадат и много различни варианти на база на създадената на ръка скица.

Създаването на електронните ѝ варианти може да бъде осъществено по различни начини. Могат да се комбинират два или повече софтуерн продукта за създаването на дигиталното изображение - като например програмите Adobe Illustrator и Adobe Photoshop. Adobe Photoshop е програма, която се занимава с обработката и създаването на растерни изображения. С нейна помощ могат да се направят различни видове манипулации върху фотографии и дори да се създаде дигитална рисунка.

От своя страна Adobe Illustrator дава възможност за направата на векторни изображения и обработка на текст. Програмата разполага с инструменти за манипулация на линията.

С помощта на компютърните програми става доизчистване на елементите и добавяне на допълнителни детайли към дизайн скицата. (фиг.4)



Фиг. 4 Дигитални разработки на проекто-скицата с помоща на Adobe Photoshop

На етап от разработката може да се изготви и аналитична скица подпомагаща изображението и определяща някои ключови моменти и отделни части от самия мизансценс (миманс) като творчески акт.

След като се установи общия вид на разрботката за боди-арт пърформанса се създава симулационен модел върху гола фигура. Това дава ясна представа за позициите на всеки детайл върху спецификата на човешкото тяло. Тук трябва да се отбележи, че всяко тяло има собствена специфика и една разработка за такъв вид пърформанс може да се използва за различни персентили.

3. Подбор на музика

Общият вид на пърформанса се придобива и от избора на подходящ музикален съпровод. Важна стъпка в избора на музика е настроението, което трябва да се създаде в изпълнителите и да се предаде на зрителите. Музиката трябва да подпомага, но не и да бъде водещ елемент в цялостния облик на този вид пърформанс. В зависимост от времетраенето може да бъде създадена специално авторова музикална композиция или да бъдат миксирани повече от две мелодии.

За фон на този пърформанс беше подбрано музикалното произведение - Bulgarian Ethno Music на групата BULGARA, чийто съпровод се характеризира със съвременно звучене с присъствието на традиционните български музикални инстременти.

4. Развитие на действието

Осъщественият боди-арт пърформансът е част от цикъла пърформанси „Живи легенди". Като режисьор и сценарист на пърформанса създадах специална хореография, като акцентирах на психологическия смисъл на движенията , които чрез естетическата пластика да пресъздават дълбоките душевни състояния на Орфей.

5. Пространство

Пърформансът се реализира на живо пред аудитория в присъствието на автентични артефакти или други елементи подчертаващи изпълнението. Необходимо е пространството да бъде с добро изложение спрямо зрителите. Изпълнението се осъществява както на предварително построена сцена, така и на терен подпомагащ театралната игра. За провеждането на боди-арт пърформанса „Интерпретация на легендата за Орфей и Евридика" е избрана сцената наравена в хотел Аква Азур в св. Константин и Елена.

6. Материали и аксесоари

Нужни са удобни текстилни платове, които подлежат на предварително третиране. Боди-артът се извършва както директно върху кожата, така и върху дрехата на моделите. Аксесоарите са необходими за арт пърформанса и са свързани с тематиката на изпълнението. Те не трябва да бъдат прекалено експонирани и натрапчиви. Необходимите са и лавров венец, лира и др., които присъстват като отличителни елементи в легендата.

7. Хореография

Участниците в пърформанса са момче и момиче, които изпълняват ролите на Орфей и Евридика. Първостепенен е образа на Орфей. При градирането на легендата, Орфей и Евридика преминават през няколко душевни състояния, което се подчертава чрез пластичния израз на определени движения. Този специфичен танц е предварително режисиран.

8. Маркетинг и реклама

От съществено значение е тази арт проява да бъде споделена с голям кръг от хора. Няма ограничение във възрастта, образователната степен или пола, той е начин за двустранна комуникация между автора и неговата публика. Затова се налага да се създаде кампания и да бъдат изготвени съответните рекламни материали. Такива материали могат да бъдат: плакати, билбордове, покани, дипляни и др. като могат да се използват и медиите – радио и телевизия.

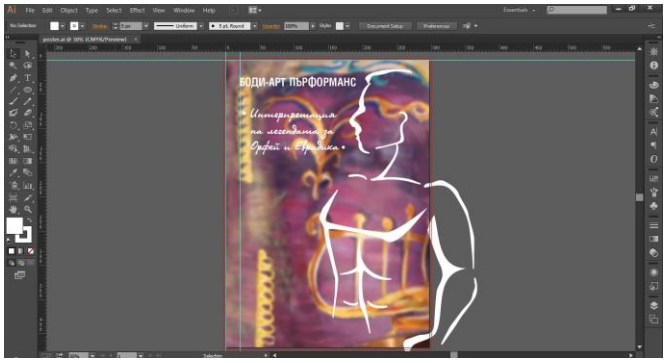
За това събитие са изготвени плакат и дипляна, които дават изчерпателна информация за мястото, времето и деня на провеждане на пърформанса.

9. Създаване на рекламните материали

При плаката се използват фотографии от проведени пърформанси, както и материали от проекто-скицата. Необходимо е да се отрази местото, времето и деня на провеждане, наименованието и вида на събитието.

Цветността и композиционната цялост се реализират чрез софтуер.

Големината на плаката е А3 като при запазване на файловете за печат се ползва CMYK гама. Разделителната способност на всяко изделие, което ще бъде печатано е 300 dpi (dots per inch). (фиг. 5)



Фиг. 5 Създаване на плакат за боди-арт пърформанса с Adobe Illustrator

Необходимо е всички текстови полета да бъдат предварително обмислени като:

- редакция на информационен текст
- вид шрифт
- големина
- цвят
- направени в криви

За създаване на дипляната се ползват както илюстрации от отделни моменти характеризиращи боди- арта, така и текст за същината на самия пърформанс, както и кратка версия на легендата.

Софтуерният продукт за изготвяне на тези материали е Adobe Photoshop и Adobe Illustrator.

Същността на специализирания софтуер при съвременните изкуства и дизайна може да бъде в следните направления:

- при оформянето на окончателния вариант на композицията;
- в концептуалната проекто – скица;
- създаване на неограничен брой цветовите решения;
- позиционирането на мотивите върху човешкото тяло при боди-арта;
- уточняване на специфичния миманс на перформанса;
- цялостното оформление на рекламните продукти.

В съвремието дизайнерската работа е *немислима без* подбора на шрифта и изчистване на мотивите в боди-арта.

Спецификата на съвременните Н-изкуства налага използването на съвременните технологии, а реализацията на рекламен дизайнерски продукт е немислима софтуера - например като Adobe Photoshop и Adobe Illustrator.

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