SYSTEMS OF TEACHING ENGINEERING WORK
ON BASE OF INTERNET TECHNOLOGIES

Irina Petrova, Viktoriya Zaripova

Abstract: the presentation graphical information about physical processes in WEB

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Rapidly developing Internet technologies are often used now as a basis for building a CAD system and in particular the automated systems for technical solutions searching. Such a system enables the developers to use large and permanently widening databases, to discuss and evaluate job results together. Moreover, these systems are open and accessible for changes and additions

Examples of such systems are as follows: a system for designing the power supply circuits - Webench (http://webench.national.com, developed by the National Semiconductor company together with Californian company Transim), a system for automated mechanical modeling – Euler (http://www.euler.ru/default.asp) and Comsol Multiphysics (www.comsol.com).

One of methods of searching the new technical solutions is to use a knowledge base of physical and technical effects [1,2,3,4,5,6,7,8,9]. The following principles lay in the basis of this method:

1. Physical principle of action of any device is based on transformation of input quantity into output quantity by means of using some physical-technical effects (PTE). PTE is the smallest indivisible transformation.

2. Transformation of quantities can be made both within a chain of the same physical nature, and between two chains of different physical nature as well.

3. Each PTE has certain geometrical and physical characteristics, as well as performance characteristics, these values are determined by experts or may be calculated by formule.

The article considers conceptual model of a system of new technical solutions searching, the system is realized with the help of Internet technologies. Great attention is paid to graphical visualization of technical solutions searching results, that enables a designer to more effectively analyze the results obtained.

Work of designers and experts requires their independence from hardware-software tools. The environment should have friendly and intuitively understandable interface, to provide high speed of input data processing and correction, to enable work with optimal speed not depending on connection parametres.
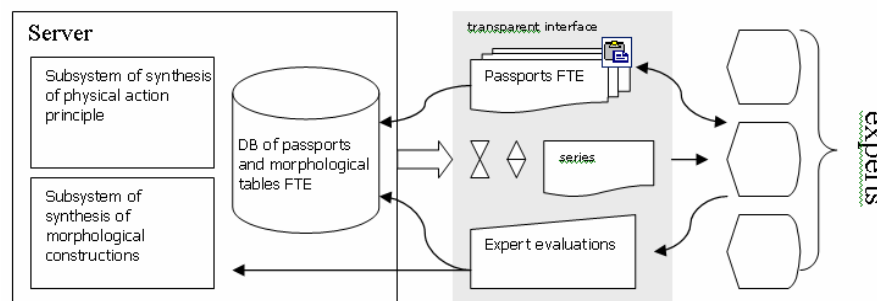

Fig. 1. Scheme of experts' work with automated system of technical solutions on the basis of PTE.

Fig.1 shows a conceptual model of the system of searching the new technical solutions basing on PTE knowledge base.

The knowledge base contains PTE technical logs and morphological matrices of variants of constructive elements of the PTE given. The figure 2 shows an example of such log.
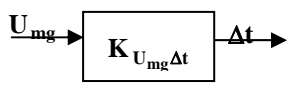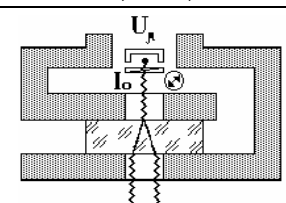
1.	Faraday effect (magnetooptic)	
2.	$\Delta t = K_{U_{mg}\Delta t} \cdot U_{mg}$	
3.	Difference in refractive index of rays with left-hand and right-hand polarization leads to phase displacement or time displacement: $$\Delta t = \frac{V\, l\, H\, \lambda}{c\,\pi} = \frac{V\,\lambda}{c\,\pi} U_{mg}$$	
4.	$$K_{u_{mg}\Delta t} = \frac{V\,\lambda}{c\,\pi}$$	
5.	**V** – Verde constant [1/A] ; **H** – magnetizing force,, [A/м] ; **l** – length of magnetizing lines of force in the sample, [m]; λ - light wavelength, [m] ; **c** – light speed in vacuum, [m/c]; U_{mg} - magnetic voltage [A]	
6.	Verde constant V [1/A]: Glass (0,2 – 0,35) 10^{-4} Gases (2 – 3,2) 10^{-10} Liquids (water, spirit) 0,04 10^{-4} gamete-type ferrite 0,12	sensitivity (calculated by p.4) Operating speed: 10^{-9} [s] Reliability: 10^{-6} [1/час] Error: 0,1 – 1 %
7.	1. U. Sherkliff. Polarized light. - M: "Mir, 1965. – 357 s. 2. V.V.Sizov., Yu. Uhanov. Magnetooptical effects of Faraday and Fogt, applied to semiconductors. – Kiev: "Naukova Dumka, 1979, s.26-28..	
8.		Faraday effect means appearance of time delay between rays with left and right circular polarization due to a difference in refractive index of these rays.

Fig. 2. PTE log

PTE log includes text description of the effect action principle, mathematical formulas of transformation of input quantity into output quantity, formula of transformation coefficient, functions of geometrical size of the construction, physical values and constants, formulas for performance data calculation, numerical range of performance data calculated by formulas or defined by experts, graphical imaging of structural scheme of transformation (2d graphic), dynamic graphical picture of action principle (3d graphics).

PTE morphological matrix includes a lot of static sketches (2d graphics) of separate details, sketches of several variants of PTE constructions can be produced of them (Fig.3).

So, a knowledge base should include text information, mathematical formulas in usual for perception view, large amount of graphical information (static - 2d graphics) and dynamic (3d graphics).

A constructor's work with the system may be divided into 2 stages:

1. Synthesis of physical principle of action

2. Morphological synthesis

A sub-system of synthesis of action's physical principle enables to produce variants of series of PTE subsequent transformations for given input and output quantities, to calculate performance data of produced chains, and to carry out multi-criterial selection of the best solutions according to the set of performance characteristics.

A sub-system of morphological synthesis enables to produce various constructive realizations of each PTE in selected variant of technical solution and to evaluate these realizations according to the set of performance characteristics.

Finally a constructor gets several variants of sketches of technical solutions which meet the requirements of the problem put by.

Fig. 3. An example of morphological matrix

Taking into account the large amount and diversity of data to be stored in the knowledge base, the Oracle 8i database management system was selected; it is stable, scalable system for managing the relational databases, it is able to effectively store and process a large amount of data in conditions of multiuser access. The Oracle 8i system makes:

- Support of large and super-large databases in operational transactions mode
- Objective extend of data relational model
- Use of built-in Java-machine for development of server component of the system together with the PL-SQL language.
- Possibility of storing of unstructured information, that meets the principles of development of Internet applications
- Powerful system of users administering

As an additional tool for storing the complicated structure information (for example, information on morphological matrix), the extendable language - XML is used on the server side, definitive features of this language are:

- Flexible structure, which is defined by the developer himself,
- Possibility to lay down the rules of drawing up of XML elements, that facilitates the interface generation
- Built-in support by all the Internet-oriented applications
- A lot of extensions like XQL – extendable language of requests, MathML – mathematical mark-language, etc

To generate graphical images of PTE and constructive elements of morphological matrix on the server side the Macromedia MX editor is used, it has the following advantages:

1. Multi-platformness
2. Small size of created files (less than several dickers of kilobytes)
3. Possibility to create complicated animation
4. Built-in programming language
5. 5 Support of XML format of data representation
6. 6 To process the information coming from the client side and to create user interface the PHP language was used:

   - compatible with such systems and products as Oracle, XML, MSSql, supports many modern Internet protocols
   - Integrated into various WWW-servers: Netscape, IIS, Apache
   - Has efficient productivity
   - Easy to study and use
   - Includes multi-functional tools for data processing

Information on effect may be presented in three view: text view (detailed description of action), in formula view and in graphical one. According to joint opinion of several experts the quality of the last one is very important characteristic of degree of completeness of effect description. (Table 1)

Table 1. Comparative analysis of information type

Characteristics	Positive\negative mark	Text information	Formula	Figure (picture)
Quickness of perception	+	6	4	9
Perception completeness	+	9	7	6
Need in additional knowledge for treatment	-	8	9	5
Wrong treatment (interpretation)	-	5	7	5
Large amount of information are perceived easier	+	3	4	8
Total		5	-1	13

A picture is a good helper for information correct perception and memorization, as well as for instant interpretation.

The task is to elaborate easy and comfortable graphic system for building images of PTE for working in the Internet. This system should have the following characteristics:

1. Understandable interface
2. Quickness and easiness in image elaboration
3. The image elaborated by the system should be understandable for other experts
4. Graphic compatibility of images while building chains
5. Automated support of change of the system version

As the task solution a web-interface was suggested? Which operates with a set of graphic primitives for building PTE images.

To analyze PTE graphic images a control set of PTE was selected, it included 25 PTE. This PTE set consists of electrical, mechanical, magnetic, heat and hydraulic chains. To describe each chain the following set of input and output quantities was used: reaction value (I), actuating quantity (U), charge (Q): they are interrelated as follows:

$$U = I \cdot R \qquad \text{or} \quad I = G \cdot U \,(G = 1/R) \tag{1}$$

$$Q = U \cdot C \qquad \text{or} \quad U = Q \cdot W \,(C = 1/W) \tag{2}$$

$$I = dQ/dT \qquad \text{or} \quad Q = \int I/dT \tag{3}$$

Where:

G – conductivity parameter

R – resistance parameter

C – permittance parameter

W – parameter of rigidity for chains of any physical nature

For interrelation of chains of different physical nature the following effects were used: pyroelectric effect, electrocaloric effect, magnetic rigidity change effect, magnetoelectric effect in antiferromagnetics, piezoeffect, reverse piezoeffect, resistive-strain sensor, Hall effect, piezomagnetic effect in antiferromagnetics, magnetostrictive effect, thermobimetallic effect, field effect in в MIS-structure, deformation effect of p-n junction.

The following statements were suggested as the basis for elaboration:

1. Any image consists of some set of graphic primitives, which represent arbitrary graphic element with geometrical properties.

2. Any element of an image can be

    a. Static – information relatively stable concerning its contents, it is used as a background. For example, grid chart, motionless parts of the image, unchangeable parts of the image, and as a rule the contact points

    b. Dynamic information changeable within certain time interval by the information content or its screen position.

3. Base of graphical data serves for organization of storing the graphical objects which correspond to elements of information models to be formed; the models are selected on request of graphical software.

4. Main functions of graphical software:

    a. Graphical or geometrical transforming;

    b. Graphical data base management;

    c. Realization of interfacing of computer-user dialog;

    d. Forming of requests to the applied software during the computer-user dialog;

    e. Control of visual information input-output

To represent graphically a chain nature the following colours were suggested:

1. Gray and black – for mechanical chain

2. Red colours – for electrical chain

3. Green – for magnetic one

4. Yellow – for heat one

5. Blue – for hydraulic one

Analysis of representation of PTE action principle taken from control PTE set gave opportunity to find out 30 graphic primitives.

Examples of primitives are shown on Fig. 4

Increase of dynamic primitives size shows increase of the corresponding value (and verse) .

Static primitives   Dynamic primitives

Fig. 4 Image of primitives

To build images a special 3-d grid chart was elaborated (Fig. 5 a.). This grid's size corresponds with the size of working sheet. The grid consists of four parts: contact points (b), central part of the image (c), inclusions (d). To make the effects' images coincide each other it necessary to place blocks exactly on coincide points, while the lower blocks should be 0.5 cm lower than the grid level; it gives increase in drawing area height up to 6.5 cm. Such approach ensures three-dimension imaging.
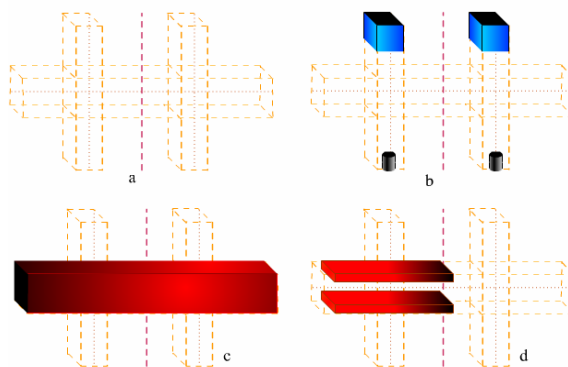

Рис 5. Grid Chart and its application

Apart from primitives of general purposes the primitives of special purposes were developed as well, and they have their own dynamics, they are: spring, condenser, resister, superstructure block. Their view and dynamics depend on image of a concrete effect. As these images can't be changed in size due to violation of three-dimensionness so they should be restricted by size of their central part of the image or by size of inclusion area (Fig. 5).

All animation in images has a length of 20 or 40 stills, this quantity doesn't depend on picture frequency, it is stipulated by logical dividing of animation into 2, 4 and very rarely into 3 stages, which as a rule are pulsation or figure's place change. While constructing animation the developer has opportunity to change the initial still of each animation insertion thus providing an effect of motion.

Methods of PTE images preparation is elaborated, it consists of following stages:

1. Loading of the page of PTE image editing
2. Automated creation of a working area with the size 10x6.5.
3. The working area has two levels: grid level and a level of image itself
4. With the help of library of primitives to create necessary image, observing the following rules:
    a. the primitive is automatically snapped to grid lines and to borders of primitives already placed on the sheet
    b. Central line of the last upper and last lower primitives should coincide with central line of the grid's points of contact

    c. There should be added last lower primitives, which should 0.5 cm go beyond the grid line.

    d. Animation is placed on primitives "next nearest" to avoid the ripples (flicker).

    e. A developer can set animation consecution himself having determined the initial still for each animation involved into the effect.

    f. All primitives not involved (due to any reason) into the library can be drawn by the developer himself, strictly following the size of three-demension grid.

5. After an image is drawn the system automatically makes a story board (shooting sheet) for 20 stills in order to provide animation effect

6. The grid level is removed

7. The file is published and saved with the name of the effect to which it is intended for.

Conclusion

1. To build-in a three-dimension graphic image of a PTE into web interface the Macromedia Flash development environment was selected. It provides:

    a. Minimal volume of finite file

    b. Being automatically built-in into web interface

    c. Has its own developed programming language

2. Basing on analysis of control set of effects (25 ones) the rules for building the PTE images were developed, as well as a grid chart which defines the building process.

3. 30 primitives are selected and elaborated: 20 general primitives including animation primitives and 10 applied primitives; as well as 10 pourings - 2 ones for each nature. The set of primitives is enough for elaboration of images of moderately complicated PTE, i.e. PTE with no more than 1 applied primitive with simple animation. The primitives set is open structure.

4. Methods are elaborated for preparation of PTE images

Bibliography

1. Andreychikov A.V., Andreychikova O.N. Computer-aided Inventing (methods, systems, examples of application). – M.: Mashinostroenie, 1998. – 476c

2. Zaripov M. F., Petrova I.Yu. Subject-oriented Environment for Searching of New Technical Solutions - «Intellect». /IV S-Pb international conference «РИ-95», S. – Pb., 1995, pg. 60-61.

3. Zaripov M. F., Petrova I.Yu., Conceptual Model of Chains of Various Physical Nature, and Methods of Finding of Generalized Technique for Characteristics Improvement. In Collected Articles "Databanks for Agriculture sensors CAD" /Tashkent: ТИИИМСХ, 1988, pg. 4-14.

4. Kamaev V. A., Karachunova G. A., Zhukova I. G. Automated system of synthesis of measuring device functional-physical structures. / In Collected Articles "Innovation Education and engineering creation", M: «Evristica» Association, 1994. – pg. 91-94.

5. Odrin V.M. Morphological synthesis of systems. Preprint 86-3. Kiev: Naukova Dumka, 1977. – 35s.

6. Zaripov M.F., Zaripova V.M. Project of creation of Knowledge Base on Physical and Technological Effects. IMEKO TC-1. ISBN 83-7085-647-0

7. Zaripov M.F., Zaripova V.M. Use of Integrated Base of Knowledge on Physical Effects During Training the Engineers. SEFI 30th Annual Conference.

8. Zaripova M.F., Zaripova V.M. "Paired comparison method used for evaluation of performance specification of the technical implementation of the industrial control systems elements" Datchiki & Systemi (Sensors & Systems) №3, 2004

9. Zaripova V.M. "Morphological analysis and synthesis of the constructive implementation of the physicotechnical effects (client-server technology)". International Scientific and Technical Conference&Russian School of Young Scientists and Specialists. "System Problems of Quality, Mathematical Modelling, Information and electronic technologies", 2003

Author's Information

Petrova Irina Yurievna – vice-rector Astrakhan State University, e-mail: petrova@aspu.ru

Zaripova Viktoriya - leading programmer, Astrakhan State University, e-mail: vlitera@rambler.ru