E-Learning: Application of Compositional and Structural Modeling

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Abstract: **It is proposed to use the elements of compositional and structural modeling (CSM) to solve the problems related to the development of web-based interactive multimedia software applications for distance learning and training. When developing learning and training software with CSM approach, the mathematical model of learning and training system with problem solution finding algorithm developed makes it possible to implement a methodology of using interactive multimedia means in distant learning and training. The approach proposed to develop distance learning and training courses increases the technological flexibility of learning and training processes. Based on the approach proposed, a number of learning and training courses has been already developed.**

Keywords: **e-learning, distance learning, compositional and structural modeling, multimedia programs for educational purposes, the application software system.**

I. Introduction

The level of education of the information society is an essential element of its development. Education is referred to strategically important areas of implementation of telecommunication and information technologies in Ukraine, because the level of knowledge of each person creates the foundation for the development of our state. The continuous development of information systems and technologies, which is accompanied by their implementation in everyday life, the gradual transition to high-tech production and, in general, an increase in the rhythm of life, require from each individual continuous improvement of the acquired level of knowledge and mastering of substantially new knowledge. In other words, it is about the need for lifelong learning.

To solve this global task, all available means are acceptable. These include both classical and modern forms of learning [1-4]. Here the important place belongs to distance learning through global computer networks with using communication and information technologies, because it has a number of very important advantages in the context of today's situation compared then traditional:

■ satisfies the individual choice of training trajectory: mode, time and speed;

■ satisfies unimpeded access of students to training materials;

■ satisfies constant contact with the tutor: the student can contact the tutor at any time and ask for help;

■ provides the opportunity to hire foreign tutos. Using the Internet, they have the opportunity to simultaneously train all those who want from different parts of the world. Tutors do not need to move from country to country to hold classes;

■ satisfies constant communication between students for the purpose of discussion current issues during the processing of the training material, and for contacting for mutual interests;

■ brings economic benefits. An increase in the number of students does not require significant additional costs. In this sentence and further, the word "student" should be understood by everyone who is studying on the distance learning program (in particular, students from secondary schools, university students, retraining people, and, in general, raise their level of knowledge, etc.).

Today distance learning technologies are developing intensively. Native and foreign scientists have significant achievements in the study of the methodology of creating interactive distance multimedia educational programs: O.M. Dovgyallo, V.N. Kukharenko, M.I. Zhaldak, V.V. Lapinsky, V.M. Tomashevsky, P. Commerce and others [2-7]. They have a number of significant results in developing models, methods and technologies for distance learning, but a number of problematic issues still need to be addressed.

The primary problem that is currently being addressed is the construction of a methodology, which would include, on the one hand, methods of increasing the productivity during the simulation of distance learning processes, and, on the other, methods for research and analysis of the effectiveness of the type of study.

In the works [8, 9] proposed models and methods that, in general, allow us to talk about the creation of elements of the methodology of constructing distance learning courses (DLC). It is in this, as well as the possibility of using the proposed approach to various technologies for designing and creating software (including object-oriented) and is the relevance of the study.

II. Purpose and Tasks of the Investigation

The purpose of the research is to develop elements of the methodology for constructing interactive remote multimedia educational programs.

In accordance with the stated goal in the article put and solve such problems:

■ to examine the principles of compositional and structural modeling technology;

- to construct a mathematical model of the teaching system;
- to study the application of compositional structural modeling technology elements (CSM-technology) in DLC;
- to realize the method of service by means of interactive multimedia in distance learning.

III. Elements of Compositional and Structural Modeling Technology

Consider the elements of CSM-technology in order to use some of them to build a DLC [10, 11]. This technology allows to increase the productivity of the developers of application software systems (ASS) (which includes also education software systems), improve the quality and reliability of such systems through the development of unified mechanisms, language models, methodologies for building ASSs.

The monolithic way of designing applications, and, consequently, their next programming, is characteristic of 1st generation software. The complexity and rising cost of ASS allows us to conclude that this method is inadequate.

Technological programming principle is the modularity in which the program is designed as a chain of components ("bricks"), called modules. Each of these "bricks" acts as a separate program unit. It is designed autonomously, autonomously programmed and tested, used in a wide variety of programs as an integral part, when only for its functional purpose, the module meets the needs. Modularity provides a structural adaptation of the algorithm to the problem to be solved, it can be connected to new "bricks", modify and renew the old ones up to the design of a completely new algorithm.

The conceptual foundations of macromodule programming are considered. In particular, the description of syntactic models of the languages of the macromodual programming environment and the description of the verification of composite schemes should be used to achieve the set goals.

When constructing DLC for CSM-technology there is a series of optimization problems that are generally characteristic of different stages of ASS development. In particular, the problem of choosing an optimal algorithm in a given set of competing algorithms under various practically important assumptions about the properties of the latter can be formulated in this way.

Let the set of algorithms $A_j \subseteq A$ is defined for solving the problem $z_j \in Z$, by means of which this problem can be solved. Algorithms $A_{ji} \in A$ are in accordance with the sequence of characterizing their parameters $\alpha_{ji} = \{\alpha_{ji}^k : k = 1, \ldots, q\}$. In the set A_j it is necessary to choose the algorithm A_{je} such that

$$\phi(\alpha_{je}, \gamma_{je}) = ext_i\, \phi(\alpha_{ji}, \gamma_{ji}) \quad (1)$$

with some limitations on α_{ji}.

This problem in the general case is a complex task of multicriteria optimization and, taking into account the needs of the practice of constructing a DLC, may acquire (by equating individual parameters a_k to zero) different partial formulas of the type:

– among all the algorithms A to find at least one algorithm that can solve this problem;

– in the set of algorithms A to find the most effective one by one indicator, for example, for the speed to solve this problem, and so on.

Practical interest is the search for such an algorithm, all indicators which would most closely match the requirements of the user in solving this problem.

IV. Applications of CSM-Technology Elements for Distance Learning

Demonstration of the use of elements of CSM-technology in the DLC may be, in particular, a number of examples of serving the technology under consideration for the implementation of learning tasks.

A mathematical model of the learning system is constructed by introducing so-called expansion functions $G_{\langle x^*, y^* \rangle}$ in the state space, defining the operations of their sum $G_{\langle x^*, y^* \rangle} + H_{\langle u^*, v^* \rangle}$, the product $G_{\langle x^*, y^* \rangle} \circ H_{\langle u^*, v^* \rangle}$ and the complex function $R_{\langle r,s \rangle}(x)$, which is given by a recursive scheme:

$$R_{\langle r,s \rangle}(x) = G_{\langle x^*, y^* \rangle}(x) \mid R_{\langle r,s \rangle}(x) + H_{\langle u^*, v^* \rangle}(x) \mid R_{\langle r,s \rangle}(x) \circ H_{\langle u^*, v^* \rangle}(x) \mid H_{\langle u^*, v^* \rangle}(x) \circ R_{\langle r,s \rangle}(x) \quad (2)$$

The problem on a mathematical model C is called a pair of states $\langle x_0, y_0 \rangle$.

The complex function $R_{\langle r,s \rangle}(x)$ is called the solution of the problem $\langle x_0, y_0 \rangle$ on the model C, if the following conditions are satisfied:

1) x_0 belongs to the area of function definition $R_{\langle r,s \rangle}(x)$, i.e. $x_0 \in Z = \{z : z \geq r\}$.

2) $R_{\langle r,s \rangle}(x_0) \geq y_0$.

It is shown that in order for the function $R_{\langle r,s \rangle}(x)$ to be a solution of the problem $\langle x_0, y_0 \rangle$, it is necessary and sufficient that the condition $x_0 \geq y_0 \bar{s} \vee r$.

The algorithm for constructing a solution of the problem $\langle x_0, y_0 \rangle$ on the C model reduces to the execution of such a sequence of steps:

1) put $W_1 = \{G^1_{\langle x(j), y(j) \rangle}(x) : G^1_{\langle x(j), y(j) \rangle}(x) \in \Im, x(j) \leq x_0, j = 1, \ldots, m_1\}$

2) let $G^1_{\langle x,y\rangle}(x)=\left(\sum_{j=1}^{m_1} G^1_{\langle x(j),y(j)\rangle}\right)(x)$

and $d_1 = G^1_{\langle x,y\rangle}(x_0)$, where

$$x = \bigvee_{j=1}^{m_1} x(j),\ y = \bigvee_{j=1}^{m_1} y(j);$$

3) organize the iterative process of constructing W_i sets in this way:

$W_i = \left\{G^i_{\langle x(j),y(j)\rangle}(x): G^i_{\langle x(j),y(j)\rangle}(x) \in \Im \setminus \bigcup_{l=1}^{i-1} W_l, x(j) \le d_{i-1}, j=1,\ldots,m_i\right\}$

$G^i_{\langle x,y\rangle}(x)=\left(\sum_{j=1}^{m_1} G^i_{\langle x(j),y(j)\rangle}\right)(x)$ and

$d_i = G^i_{\langle x,y\rangle}(d_{i-1}),\ x = \bigvee_{j=1}^{m_i} x(j),\ y = \bigvee_{j=1}^{m_i} y(j);$

4) the iterative process stops on condition $W_i = \varnothing$;

5) if $W_i = \varnothing$ on the $k+1$ step of the iterative process, then put

$$R_{\langle r,s\rangle}(x)=\left(\prod_{i=1}^{k} G^i_{\langle x,y\rangle}\right)(x) \quad (3)$$

The statement and the given algorithm allow to strictly solve tasks of control of the correctness of tasks execution, in particular, the construction of schedules of functions. This is achieved by determining the conditions under which the given graph can be constructed, as well as all possible ways of constructing the graph, which we obtain as different (relative to the commutativity) of the solution of the problem on the formal model.

We will describe the details of the program implementation of one example, this is the construction of graphs of functions. The essence of this task is to enable the student to master the construction of graphs of such functions, which are a composition of other (simpler functions). It is obvious that modules for this task will be represented in the context of CSM-technology. These are programs that realized the construction of a graph of a simple function or their composition. Modules are also a program that allows graphs to be displayed as sets of pixels, and also coordinate plane with the necessary infrastructure.

The requested software is written in Java. Each module of the software system is an applet. For simplicity, an integrated programming environment Borland JBuilder was used.

Particular attention is paid to organizing the code. Note that modules are not static units. Therefore, the nuances of data transfer between them are noted during the application of the `AppletContent` interface. It is known that the interaction between applets located on the same HTML page only involves calling from one of the applets (applet client) to the method specified in another applet (applet server). In our case, the applet server is an applet "Coordinate system". The rest of the applets are client applets. Each client applet has an approach to the method `AddPoint(int Value_Of_Function,int red_Ingrad,int green_Ingrad,int blue_Ingrad)` of the applet server. This is realized using the applet context.

```
appletServer=getAppletContext().getApplet
("CoordinatePlane");
((Applet1)
appletServer).AddPoint(y,red_Ingradient,
green_Ingradient,blue_Ingradient);
```

The `AddPoint` method adds a new point to the value array. The above fragment of the listing states that this method is parametrized, not only the value of the function is transmitted, but also the values of the three values of the type int, constituents of the color, which will display the graph. After the formation of an array of values, the `paint()` method, which is blocked by us, is executed. This brings up a new graph. Construct graphs of the functions $y=-(f(x))$, $y=f(|x|)$, $y=|f(x)|$, $y=|f(|x|)|$ and $y=f_1(x)+f_2(x)$ involves getting one (`Value_Of_Function_Array_Second[]`) or two arrays in the corresponding applet (`Value_Of_Function_Array_First[]`, `Value_Of_Function_Array_Second[]`) values of the function for its next (their) processing. To do this, the following methods are defined in the "Coordinate system" applet.

```
public int[]
get_Value_Of_Function_Array_Second() {
return Value_Of_Function_Array_Second;
}

public int[]
get_Value_Of_Function_Array_First() {
return Value_Of_Function_Array_First;
}
```

The nature of these methods is trivial. They return the value function arrays. Next, using the context of the applet, this data is reading, for example

```
appletServer=getAppletContext().getApplet
("CoordinatePlane");
Value_Of_Function_Array_Local=((Applet1)

appletServer).get_Value_Of_Function_Array
_Second();,
```

after which the processing of the array

```
Value_Of_Function_Array_Local
```

is in progress.

Practical implementation ends with consideration of the use of interactivity in the DLC "Placing Productive Forces of

Ukraine", which was used to train students at the International University of Finance. The "Course of Communication and Information Technologies", "Interactive Training Program for Teachers Using Telematics in Distance Learning" and others were built.

It is noted, in particular, how and by what means of interactive multimedia the lecture material of the course is presented, how the control of the knowledge received by the student is organized and what are the features of the course design.

V. Conclusion

Applying the method of using interactive multimedia tools in the DLC, an approach has been developed on the use of CSM-technology in the development of DLC fragments. The mathematical model of the teaching system with the algorithm of finding solutions of problems in the construction of teaching programs for CSM-technology is proposed.

The approach to constructing interactive teaching programs with the help of CSM-technology is developed. It is demonstrated on a concrete example of the application of CSM-technology in distance learning courses. A number of problems that arise during the learning process are solved, in particular during the construction of graphs of elementary functions.

Approaches to modeling different processes of distance learning can be the basis of the tool environment for supporting the development of distance learning courses, taking into account the whole complex of methodological problems that arise in this case.

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