LEARNING UNARY LOGICAL OPERATIONS THROUGH THE MODERN INTERACTIVE EDUCATIONAL APPLICATION – ARHICOMP

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Abstract

The aim of this work is to show the use of modern interactive educational applications through the example of the educational game ArhiCOMP in the course Computer Architecture and Organization 1. With the use of Bayesian networks the work presents a method for modeling items studied in the course. The pedagogical side of the application is supported by many techniques used in the field of amusing learning. Besides, the work also describes the interface design, as well as implementation of items a student should learn through solving the tasks in this game.

Keywords: unary logical operation, education game, Bayesian networks, Net - generation.

INTRODUCTION

Today's generation of students belong to the generation born in the Internet era. Modern psychologists, sociologists and pedagogues call them the Net-generation. The Net-generation students prefer acquiring knowledge on the Internet and solving interactive tasks to attending classic lectures and solving tasks on the blackboard. The Net-generation students learn well through discoveries – either individually or with their mates. This research style makes them capable of better acquiring information and using it in a creative, conceptualized way [1].

The Net-generation is more comfortable in the environment full of pictures than in a text. Research shows that the Net-generation students will refuse reading huge quantities of text from a field, regardless of whether it is a long text of a lesson or task. They prefer solving concrete tasks from a field to thinking about a field or proving orally how much they are familiar with the field.

Having in mind the new learning trends initiated by the needs and interests of new generations of students, within the lectures in the subject Computer Architecture and Organization 1- AOR1, taught in the first year at the Electrical Engineering and Computing Science College in Belgrade, during the winter semester of the school year 2009/2010, new types of teaching material were applied in the form of educational games. The content of the educational games was designed as a platform for learning through tasks whose solving was stimulated by the game content and directly facilitated acquisition of knowledge in the said subject.

MODERN EDUCATIONAL MULTIMEDIA APPLICATIONS

Educational multimedia applications have been used in education for a long time. Applied in e-learning they obtain new and dynamic form. These new programs (smart games) are interesting to users, especially younger ones. Authors of educational

programs and simulations are trying to make teaching and the way of presentation stimulating. Very serious teaching contents are placed in the form of 3D interactive simulations, amusing games and quizes. According to the interaction type [2], educational multimedia applications are divided into the following types:

- assistance (learning through references),
- passive tutor - guide (learning through auto-control – self-studying)
- training (learning through practice),
- active tutor (guided learning),
- simulation (learning through finding, discovering),
- game (amusing learning),
- problem solving (learning by doing),
- intelligent dialogue (Socratic learning).

Over the past thirty years, significant research has been conducted with the aim of development of computer programs that assist learning and teaching. These programs are called intelligent tutor systems – ITS [3]. Such systems can be used in everyday learning and teaching, as well as in distant learning.

In intelligent tutor systems, powerful theories about decision making have been developed, and they have been developed especially for situations in which there is uncertainty. One of them is Bayesian probability theory [4], which deals with making conclusions in uncertain situations. Bayesian networks represent one of the actual approaches to solving the learning process modeling, combining strict probability formalism with graphic representations and efficient conclusion making mechanisms. The task of Bayesian networks in learning systems is to connect the main units from the knowledge domain, which can be fields or sub-fields.

With the use of modern interactive multimedia applications in such learning systems many researchers are trying to make a compromise between the necessity of learning with the aim of acquiring a suffucient level of knowledge in a field, and the desire of modern generations of students to acquire knowledge in an interesting and dynamic way. Such new systems are based on the use of Bayesian networks. By shaping the teaching contents into sub-fields in which knowledge is acquired in an amusing way, through playing, the probability to achieve the desired knowledge level in a field as a whole is increased. With the use of the huge potential of computer graphics and interactiveness in multimedia applications, direct correlation is created between the dynamics of students' acquisition of new knowledge and the time the students spend with this type of applications. Educational strategies include learning strategy, strategy of impression and practice strategy. A mnemo-technical rule says that in order to memorize a term or definition more easily, they should be made interesting. Motivation is increased as well when we do something amusing. One of significant techniques in that sense is visual representation. If a piece of information can be represented by a visual picture or animation, it should be represented in that way. In the field of visual representation, simulations with installed interaction degree represent the most efficient method. Tasks in the form of interactions demand that students through solving them recognize simulation of an algorithm or process functioning, but they are not afraid of incorrect answers or actions.

Most students learn many task solving methods in the field of technical sciences through repetition, after which it is usually needed that they repeat a particular series of actions through several different examples. The use of learned items is carried out through solving concrete tasks. A large number of tasks with different examples enables students to rehearse the learned material well. When students see the results of learning, they will try to be better in every following rehearsal, and in that way they will start competing with themselves. The competing spirit is in the human nature, and thus playing and achieving the best possible results makes a basis of today's modern interactive learning applications – educational games.

ANALYSIS OF LEARNING PROBLEMS THROUGH AN EDUCATIONAL GAME

The possibility of visual representation of the task solving method for rehearsing material in the course AOR1 enabled their implementation in the form of an interesting game. The teaching unit "Unary logical operations" is aimed at teaching students about the way of

performing logical operations at the level of registers in the computer system, through comparing the register binary contents before and after performing of the given operation. When it comes to operations for moving to the left or right, what is illustrated is the way of hardware implementation of the arithmetic operations division or multiplication with a degree of number 2. If students want to know how to apply an unary logical operation, i.e. if they want to know the register contents after the applied logical operation, they have to know basic rules of the binary digit system and rules referring to unary logical operations, such as the rule for logical shift to the right [5]:

"Logical shift to the right is applied on checking the bit content in the register and division by 2n, where N represents the number of moves. The free spaces are usually filled by logical zeros (0)."

Acquisition of basic terms is facilitated with the use of appropriate graphic representations, as shown in Figure 1, which presents the contents of the accumulator register in the arithmetic-logical unit before and after the shift operation. The arrows show the moving direction and new positions of bit in the register, as well as the contents of Carry flag in the condition register.

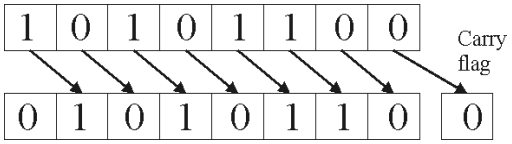

Fig. 1. Logical shift to the right in the register

Good knowledge of the set of rules from the field of unary logical operations is a precondition for future successful acquisition of knowledge in other fields within the course AOR1 or related courses in higher years of studies.

In laboratory exercises in the subject AOR1 students brush up and improve their knowledge acquired in lectures, through concrete tasks and with supervision and help of assistant lecturers. Attending exercises without previously acquiring basic terms from the field being taught in lectures directly results in difficulties in individual realization of the laboratory exercise. For the purpose of motivating students to get ready for laboratory exercises and be more active in individual task solving in the exercises, the educational game *Arhi COMP* has been created. This educational game contains interactive tasks [6,7] implemented in the graphic environment, which directly associates with the field of the application use. The game has been designed to help students learn basic terms referring to unary logical operations and practically apply them, through solving given examples with randomly generated content of virtual registers, which are integral part of the arithmetic-logical unit of computer systems.

The basic terms that explain the principle of logical operation functioning are reached by selecting the Help option in the game. When a student starts learning with the use of the game or faces a difficulty during solving a task generated by the application, Help serves to accelerate finding the right solution. This means that formulation of definitions and theorems within Help is the key moment in designing the entire application. The purpose of learning through the game is to enable students to learn the rules and check them in practice on the example of all unary operations. Multiple repetition of tasks with performing the same operation increases the probability of learning characteristics and use of particular operation. Quality evaluation whether an operation is acquired or not is performed through visual indication of the number of successful and unsuccessful tasks (score) with the same operation, and comparison with preset criteria. The model of the educational game *Arhi COMP* is shown in Figure 2.

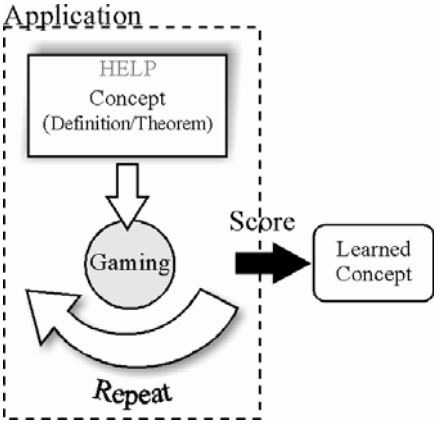

Fig. 2. The model of the educational game

Entire design and architecture of *Arhi COMP* was made in ActionScript 3.0 object oriented program language supported in the package Adobe Flash CS3. Construction of the game interface demanded a longlasting and extensive analysis, whose main objective was adjustment of the environment and the ways of task implementation to affinities, formerly acquired knowledge and age of end users (students from 18 to 20).

BAYESIAN NETWORK AS A TOOL FOR ANALYZING FUNCTIONALITY OF THE EDUCATIONAL GAME

During development of an educational game, it is needed to model information that is a precondition for solving a task within the game, on one hand, while on the other hand it is needed to formulate criteria for evaluation of students' acquired knowledge, having in mind the necessary formerly acquired knowledge and new knowledge acquired by learning the defined terms.

A Bayesian network (BN) [8,9,10] consists of directed acyclic graph (DAG) and a corresponding set of conditional probability distributions (CPDs). Based on the probabilistic conditional independencies [6] encoded in the DAG, the product of the CPDs is a joint probability distribution (jpd). In other words, Bayesian networks serve as both a semantic modeling tool and an economical representation of a jpd. There are many inference algorithms in BNs for computing probabilities of variables given other variables to take on certain values. For example, given that variable B has value b and variable D has value d, what is the probability that variable A is a? There are also numerous implementations of BN software [11].

Each concept is represented by a node in the graph. We add a directed edge from one concept (node) to another, if knowledge of the former is a prerequisite for understanding the latter. Thus, the DAG can be constructed manually with the aid of the course textbook. The next task in the construction of the BN is to specify a CPD for each node given its parents. For variable ai with parent set Pi, a CPD p(ai|Pi) has the property that for each configuration (instantiation) of the variables in Pi, the sum of the probabilities of ai is 1.0.

The functionality analysis of the educational game *ArhiCOMP* with the use of Bayesian network was carried out by defining the knot Register contents, whose parents are Unary logical operations and Binary digit system. The values of CPD p(Registry content | Unary logical operations, Binary digit system), are shown in table 1.

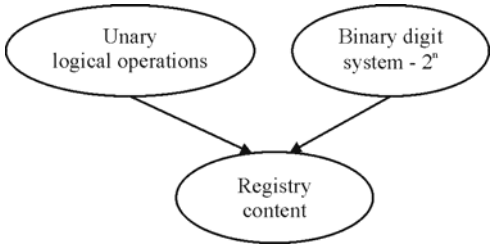

Fig. 3. Sub-DAG for the Registry content construction

Tabele 1. The CPD corresponding node in Figure 3

Parent Nodes		**Register content**	
Unary logical operations	Binary digit system	know	not know
know	know	0.75	0.25
	not know	0.29	0.71
not know	know	0.50	0.50
	not know	0.15	0.85

The knot is defined as the expected result of performing the selected unary logical operation, while the parents are defined on the basis of expected former knowledge needed for achieving the correct result in the educational game.

The values for CPD stated in the table were obtained by an analysis of the number of accesses to the application and obtained results during solving tasks within the application, by monitoring activities of 200 students in the Moodle system for electronic learning, through which access to the game *ArhiCOMP* was enabled in the laboratory environment or from home. Besides, the analysis included a control group of students who hadn't attended the lectures in AOR1, for the purpose of better evaluation of the probability to reach the correct result without former knowledge or with partial former knowledge. As shown in Table 1, the probability that the tasks will be

solved successfully is the highest (0.75) when students know basic terms from unary operations and the binary digit system, while the probability to reach the correct result with no former knowledge or by guessing is very low (0.15). games.

EDUCATIONAL GAME – ARHICOMP

Starting from the fact that a well designed visual environment can attract the attention of students and motivate them to spend more time solving tasks within the educational game, special attention was paid to selection of the background, which in this case consists of various forms of binary statements presented in bright colours (Figure 4).

Fig. 4. The interface of ArhiCOM

Motives of modern applications were used for representation of elements in the game, together with motives of the Aero interface in the operative systems Windows Vista and Windows 7, with effects of brightness, transparency and reflection, characteristic for new "fancy" technologies. Unary logical operations that can be selected by students are:

- COMPLEMENT,
- NEGATE,
- INCREMENT,
- DECREMENT,
- SHIFT LEFT,
- SHIFT RIGHT,
- ROTATE LEFT,
- ROTATE RIGHT.

To make working in the application more interesting, components in the game are not fixed but can move on the screen independently, which gives students comfortableness in the process of task solving. Moving and overlaping of components such as registers enables easier defining of their contents when a complex operation is applied (Figure 5).

The task of the game is to determine the contents of Register 2 (which represents Register 1 immediately after the selected operation) in relation to contents of Register 1, which are randomly generated and appear after selection of the unary operation, together with the task text. When the student selects a bit in Register 2, the falling menu enables entering of the particular bit in the virtual register through selection of one of the options 0 or 1. Text of the task constantly changes on the basis of randomly selected values presented in the very text. Attempts to solve the task with the same text once again are reduced to a minimum. Observed from the pedagogical side, the repeated task solving prevents mechanical solving, but stimulates students to show the real level of acquired knowledge through previous problem solving.

Fig. 5. Moving and overlaping of ArhiCOM components

CONCLUSION

The educational game - *ArhiCOMP* presents in this work two sides of its character – the amusing and the educational one. The way of presenting teaching material is supported by mnemotechniques from the learning psychology [12]. This type of amusing learning has given very good and encouraging results on tests taken after playing the game. The achieved results show the need for the use of modern interactive multimedia systems for learning the fields of technical sciences that are imaginary and cannot be seen with the naked eye.

The way in which learning material should first be divided and then connected is given on the example of operations performed in the

register. The BN used for that purpose are very significant. In the graphic and program sense, implementation of the created BN with the items to be learned depend to a great extent on the skills and capabilities of very authors of such applications. However, the presented interface and the implemented logic of learning terms in this game will prompt a lot of teachers to thinking. The motivation shown by the net-generation students during playing *ArhiCOMP* is another reason for the use of such applications in today's educational process.

REFERENCE

[1] Tapscott, D., "Growing Up Digital : The Rise of the Net Generation. McGraw-Hill:" New York, 1998.

[2] Bodendorf, F., "Computer in der fachlichen und universitären Ausbildung", München, Wien: Oldenbourg, 1990.

[3] Burns, H.L., Capps, C.G., "Foundations of Intelligent Tutoring Systems: An Introduction", In M.C. Polson & J.J. Richardson (Eds.), Foundations of Intelligent Tutoring Systems, Hillsdale, NJ: Lawrence Erlbaum., 1998.

[4] Bayes, T., "*An essay towards solving a problem in the doctrine of chances"*, Philosphical Transactions of the Royal Society 53, pp. 370-418., 1763.

[5] Prokin D., "Online presentation of Programmable logic devices", Electrical Engineering and Computing Science College, Belgrade, 2010.

[6] K. Kuk, D. Prokin, G. Dimic, B. Stanojevic: Interactive Tasks as a Supplement to Educational Material in the Field of Programmable Logic Devices, ISSN 1392 – 1215, Journal "Electronics and Electrical Engineering", 2010. No. 2(98)

[7] K. Kuk, D. Prokin, G. Dimic, P. Spalevic: Interactive Tasks in Support to Modern Pedagogical Approach in Implementation of Teaching in the Subject Programmable Logic Devices, UNITECH 2009, Gabrovo, Bulagria.

[8] J. Pearl, „Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference", Morgan Kaufmann, San Mateo, CA, 1988.

[9] S.K.M. Wong and C.J. Butz, "Constructing the Dependency Structure of a Multi-Agent Probabilistic Network," IEEE Transactions on Knowledge and Data Engineering, 13(3): pp. 395-415, May 2001.

[10] S.K.M. Wong, C.J. Butz, and D. Wu, "On the Implication Problem for Probabilistic Conditional Independency," *IEEE Transactions on Systems, Man, and Cybernetics, Part A: Systems and Humans*, 30(6): pp.785-805, November 2000.

[11]
http://www.ai.mit.edu/murphyk/Bayes/bnsoft.html

[12] Rossi, P., „Logic and the Art of Memory", University of Chicago Press. 2000.