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Use Game Based Interactive Multimedia Modules to Learning Basic Concepts on Courses for Computing Science

Abstract. *Interactive multimedia simulations combined with computer game elements can be successfully applied as a new type of educational resources for teaching courses for Computing Science. This works describes the examples of game based interactive modules for learning basic concepts of some teaching units chapter in the course Computer Architecture and Organization. During designing and creation of the teaching unit for game based multimedia interactive module we used one of constructivist teaching methods – concept maps.*

Streszczenie. *Multimedialny system symulacji w połączeniu z elementami gier komputerowych może być z powodzeniem stosowany jako nowy typ materiału do nauczania kursów Informatyki. Artykuł opisuje przykłady interaktywnych modułów do nauki podstawowych pojęć architektury komputerów. Do projektowania i utworzenia jednostki nauczania gry użyto jednej z metod nauczania - mapy koncepcji. (**Wykorzystanie interaktywnych modułów multimedialnych do nauczania technik informacyjnych**)*

Keywords: interactive multimedia, computer games, teaching methods, concept maps, Bayesian network.
Słowa kluczowe: interaktywne funkcje multimedialne, gry komputerowe, metody nauczania, mapy koncepcji, sieci Bayesa.

Introduction

The course Computer Architecture and Organization, is taught as the first course for Computing Science, and Electrical Engineering majors. Students with diverse backgrounds and different expectations are introduced to the basic concepts of the domain. Some of them know some coding and think computer engineering is just coding, and some do not have any idea about the domain and feel very insecure and scared. The class is not homogeneous which makes the things more difficult for the instructor.

The main objective is to teach general computer engineering and electrical engineering concepts together with structure computer organization fundamentals. At the completion of this course, students are expected to:

- Discuss computer data representation and basic computer operations
- Appreciate the use of machine language
- Describe basic components of a computer system
- Have a general knowledge on different aspects of computer engineering

Course is planned as 12 week period, 3 hours of lectures in a class environment and 2 hours of laboratory exercises each week. The basic concepts of the Computer Engineering are taught in the lectures, while basic computer literacy practices like word processing, spreadsheet usage are taught at the lab sessions. The lectures include broad coverage; simple concepts like binary numbering system, memory-based architecture, graphics primitive operations and I/O devices, and more advanced ones like machine language.

The content of the course Computer Architecture and Organization, is as follows:

- Chapter 0 - Introduction
- Chapter 1 - Data Representation
- Chapter 2 - Number Representation
- Chapter 3 - Computer Organization
- Chapter 4 - Binary Arithmetic
- Chapter 5 - Boolean Algebra
- Chapter 6 - Operation on Bits
- Chapter 7 - Data Storage
- Chapter 8 - Data Manipulation
- Chapter 9 - Machine Language Programming
- Chapter 10 - I/O Devices
- Chapter 11 - Display Systems
- Chapter 12 - Graphics Processor and Algorithms
- Chapter 13 - Graphical User Interface (GUI)

We start introducing history of computation, then continue with data storage concepts which include storage of bits, main memory, mass storage, representing different type of information in computer systems, numbering systems, Boolean algebra, gates, flip-flops, machine architecture, machine language and program execution.

Concept maps

Knowledge structure is regarded as an important component of understanding in a subject domain, especially in science. The knowledge structure of experts and successful learners is characterized by elaborate, highly integrated frameworks of related concepts [1, 2], which facilitate problem solving and other cognitive activities. A knowledge structure, then, might well be considered an important but generally unmeasured aspect of science achievement. Concept-mapping techniques are interpreted as representative of students' knowledge structures and so might provide one possible means of tapping into a student's conceptual knowledge structure [3].

During designing and creating of a teaching unit a lecturer may find concept maps very useful. Global, „macro-maps" can also be made, showing the main ideas we want to present during the entire course, or specific „micro-maps", showing the structure of knowledge for specific fields. Concept maps are graphic tools for organizing and presenting knowledge. They comprise concepts presented in regular geometric shapes, and relations among them are marked by lines that connect them [4].

Connecting words or expressions are written on the lines and they determine the relationship between the concepts. A concept is defined as a regularity discovered in phenomena or objects, or data on stated phenomena and objects. Ideas comprise two or more concepts connected by words or expressions into a sensible unit (Figure 1).

In the sense of graphics, concept maps include:

- Concept
- Connecting lines and words
- Sub-concepts (concepts which the connection is leading to)

With the use of advantages of the concept map technique, in the subject of Computer Architecture and Organization we created a concept map for the teaching units in Chapter 12, with the aim to reduce the items presented in this unit to main concepts and to connect them in the simplest possible way.

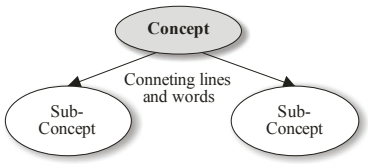

Fig.1. Concept map

The learning module named „Z-buffer" has been made on the basis of a concept map created for this teaching unit, which is shown in Figure 2. Since two main concepts are given in the concept map (the depth and color test concepts), which are to be learned by students through this module, we presented them as two levels with different solving difficulty. Solving the task that presents operating of the Depth test is shown in the module as the easier level, i.e. level 1.

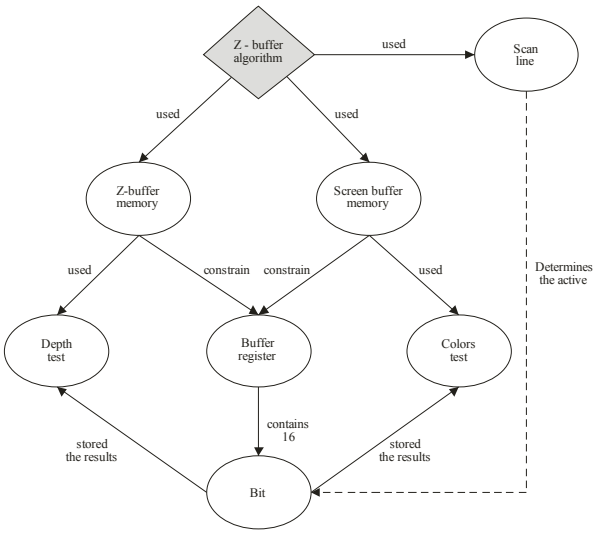

Fig. 2. A concept map for Graphic algorithm "Z-buffer"

Multimedia in education

Multimedia content, associated with human perception, including acoustic and visual effects, such as animation and graphics, as well as feedback forces, have become very attractive to learners because of the engaging human computer interactions. In recent years, multimedia research has contributed valuable ideas and techniques to improve learning, teaching and testing. State-of-the-art multimedia systems, available online or standalone, were designed to help students explore abstract concepts, keep them engaged in problem solving and improve their long term performance. The goal of multimedia education is to provide equal educational opportunities to everyone, who can access learning and testing support anywhere and at any time.

Interactive multimedia content has the capability of improving learning performance by enhancing user satisfaction and engagement. Multimedia content also provides better concept representation, which is not possible in conventional multiple-choice and fill-in-the-blank formats [5].

Authors Stuchlikova L'assassin, Gröna Michal and Csabay Otto described an e-learning project that was implemented at the Department of Microelectronic education in the Slovak University. Their project includes an interactive animation to introduce students to the work of electronic circuits [6]. Interactive animations in this project enabled students to independently change the parameters and animations based on the response of the system to learn how to operate electronic circuits. The set of all realized interactive animation students is given through the Internet portal "eLearn Central".

After performing an analysis of existing Internet simulations and applications used in the teaching process, we came to the conclusion that it is necessary to introduce some of those contemporary teaching resources for Graphics Algorithms, so that students could learn the planned material in the best possible way. We consider that the main objective of computer techniques is awaking interest in graphic algorithms through game based module (Figure 3). Thus the game concept should be based on two components:

- learners must get the course information through it's interpretation in game world;
- learners must see the result of his algorithm in a game context;

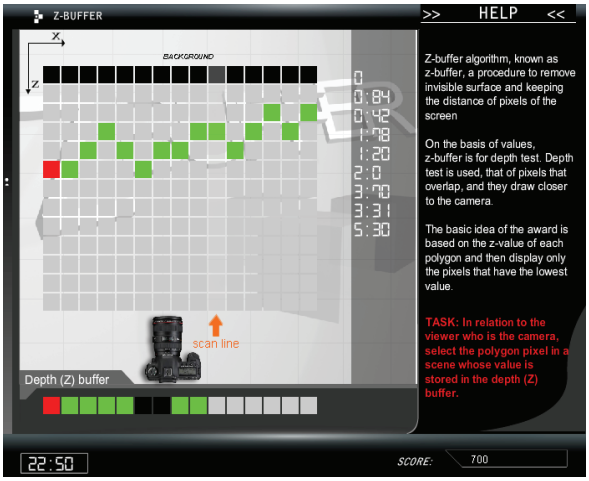

Fig. 3. Game based interactive multimedia modul "Z-buffer"

Interactive multimedia modules

Instead of computer games, animations, cartoons, and videos being used only for entertainment by kids, there is now an interest in using multimedia for "innovative testing." Rather than traditional paper-and-pencil tests, audio, video and graphics are being conceived as alternative means for more effective testing in the future [7, 8].

The innovative way of checking knowledge with multiple answer computer tests served us as the main idea for the way in which teaching material could be given to students for solving. With the use of techniques for the first class innovative testing select/recognize, we came to the idea that answers in the multimedia interactive module can be given as a series of image fields on which a student should click. Since the buffer we use in the Z-buffer algorithm uses 16 bits, the task of this module is to determine the value of each bit, i.e. contents of the registry in various situations presented in the task. The correct answer to fill the content of one bit is one of the proposed answers presented to students in the form of squares to be selected. These squares, i.e. offered answers, are presented in two ways. In the first level of the module answers are offered in the form of a 13-square column (type 1, Figure 4). Answers in the second level are also offered as an array, but in the form of a five-square row (type 2, Figure 4). This row with offered answers is not constantly visible, but is shown only when the given bit is selected as a sub-menu in the menu list.

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. 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 Computer Architecture and Organization or related courses in higher years of studies. The possibility of visual representation of the task solving method for rehearsing material in Chapter 6, enabled their implementation in the form of an game based interactive multimedia module (Figure 5.)

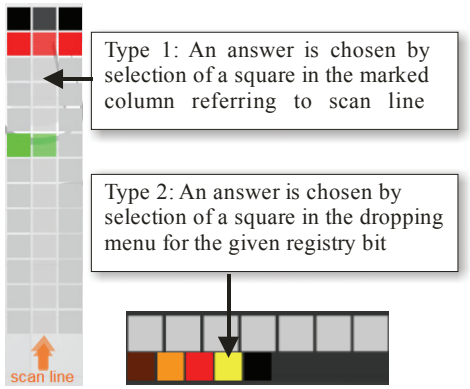

Fig.4. Possibility of answer selection in interactive multimedia module ”Z-buffer”

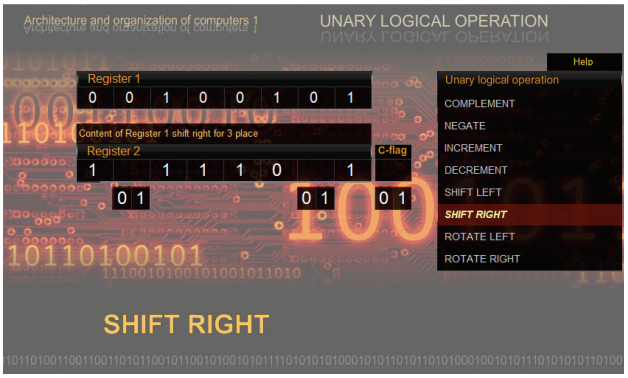

Fig.5. Game based interactive multimedia module “Unary logical operations”

This game based multimedia interactive module contains interactive tasks [9] implemented in the graphic environment, which directly associates with the field of the application use. The interactive module 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. 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

The task of the multimedia interactive module “Unary logical operations” 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.

Bayesian network - a tool for analyzing functionality of the game based multimedia interactive module

During development of an game based multimedia interactive module, it is needed to model information that is a precondition for solving a task within the module, 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.

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 directed acyclic graphs - DAG can be constructed manually with the aid of the course textbook. The next task in the construction of the Bayesian network - BN is to specify a conditional probability distribution - CPD for each node given its parents [10]. For variable a_i with parent set P_i, a CPD $p(a_i \mid P_i)$ has the property that for each configuration (instantiation) of the variables in P_i, the sum of the probabilities of a_i is 1.0.

The functionality analysis of the game based multimedia interactive module with the use of BN was carried out by defining the knot Register contents, whose parents are Unary logical operations and Binary digit system (Figure 6)

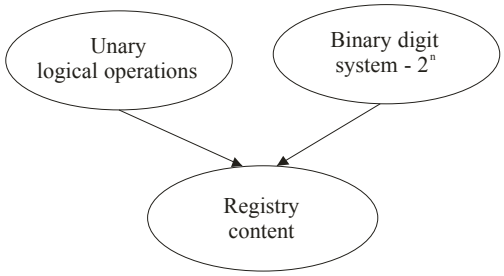

Fig.6. Sub-DAG for the Registry content construction

Conclusion

The purpose of learning through the interactive multimedia modules is to enable students to learn the rules and check them in practice on the example of some teaching units chapter in course Computer Architecture and Organization. In our system for learning, instead of the standard animation, interactive multimedia animation is used as a kind of simulation game based on theoretical principles that students need to learn. This paper describes a new approach to learning through interactive module, which is a combination of implementation strategies and game theory with concept maps for assessment of the acquired level of knowledge. 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.

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