

Interactive Flash Environments Based on Bayesian Networks to Improve Learning Electronic Engineering

Abstract. This work presents a new pedagogical approach in learning electronic engineering which includes the use of active and interactive learning techniques. Interactive tasks are developed with the basic aim to make it easier for students to acquire practical knowledge in the field of digital hardware design and design implementation in complex programmable logic circuits. The multimedia application with interactive tasks is mainly developed using Adobe Flash software. The paper describes the model and architecture of a multimedia environment for the realization of interactive tasks by Bayesian approach. The interactive tasks were designed in the academic year 2011, to support the implementation of teaching the subject Programmable logic devices in the Moodle environment. On the basis of surveys carried out at the end of the semester it can be seen that the students' first experience is very positive.

Streszczenie. W artykule przedstawiono nowy system interaktywnej nauki elektrotechniki. Wprowadzone zadania mają na celu przybliżenie studentom techniki programowania układów CPLD. Aplikacje multimedialne wykonano, korzystając z Adobe Flash. Opisane środowiska, wykonane zostały w oparciu o formułę Bayes'a. (Interaktywne środowisko Flash w nauce elektrotechniki – wykorzystanie sieci Bayes'a).

Keywords: e-learning, pedagogy, interactive learning, Bayesian networks, programmable logic devices, multimedia.

Słowa kluczowe: e-learning, pedagogika, interaktywne uczenie, sieci bayesowskie, programowalne urządzenia logiczne, multimedia.

Introduction

The use of multimedia in education demands from a teacher to actively use some of pedagogical software packages available on the Internet, as well as to be familiar with tools and techniques for creation and modeling of multimedia contents. The aim of modeling of all educational multimedia materials is to make possible for students to better understand and remember a specific teaching unit. For that purpose, all the team members taking part in preparation of educational multimedia material should also be familiar with some basic rules of cognitive learning and cognitive theory process, apart from software tools.

As a result of multimedia teaching, students are expected to be capable of using the acquired knowledge in new situations, which is checked through various tasks. Even better memorizing and understanding of the learned educational material with the use of multimedia can be accomplished if there is interactivity during solving tasks, which represents the result of students' own activity and the use of the existing knowledge.

A contemporary approach in education stimulates finding a way for modeling good multimedia contents on the basis of teaching material [1], which instigates active cognitive processes and leads to cognitive learning through creative problem solving. Using this potential offered by multimedia contents, and adding interaction with participants, we have created new pedagogical techniques – interactive tasks as a supplement to educational material for preparation of exams.

Pedagogical framework

A well modeled multimedia teaching unit is divided into several stages, such as exercises, repetition, evaluation, etc.

In the exercise stage, students apply the newly acquired knowledge or skills on their own for the first time. During the exercises, higher probability of making mistakes is expected from students. It is, therefore, necessary to provide a kind of supervision in order to perform all the needed corrections [2]. In that sense, multimedia contents that would provide additional corrective exercises for students should be made. In the case of distance learning, where there is no direct contact between a student and teacher, multimedia exercise contents should most often be prepared in the

form of interactive simulations. Interactive simulations are based on practical examples to the greatest possible extent, i.e. they are realized through interactive tasks, with implemented control mechanisms which in our examples use pedagogical feedback. For instance, with interactive Flash tasks problem solving cannot be continued unless the accurate procedure is carried out [3, 4], and in the case of badly performed procedures, there is an implemented return mechanism until the correct answer is guessed.

Modeling student knowledge with Bayesian Network

Bayesian network represents a graphic description of probability and allows efficient probability propagation combined with strict formalism [5]. If the probability of a transition state to another static state, we have Bayesian network that a particular set of states S (which is determined by events) and oriented graph marked the transition probabilities.

Figure 3 is a part of Bayesian network in which the variables B and D are independent, the variable C is dependent on D only, while the variable A is conditionally independent on D via variables B and C .

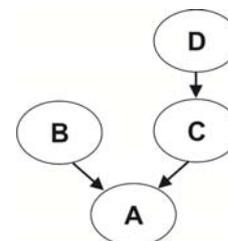


Fig. 1. Bayesian Network

Exploring conditional independence among variables, this formalism provides for a compact description of the joint distribution, especially dominant local dependence, to be explored by efficient concluding algorithms. In Bayesian network, the variable which conditions another variable on factorization becomes a parent of that variable in the network. When there are instances of all parents of the random variable A , we say that this random variable is conditionally independent on other random variables that are not A 's offsprings, and if these variables do not have the same parents as A .

The specific knowledge base within general knowledge base consists of: a group of knowledge atoms of contents (Bn) on a knowledge map which describes mutual dependence among knowledge atoms [6]. Bayesian network should connect the knowledge map with knowledge atoms and integrate them with specific characteristics of a student. Bayesian network should connect the knowledge map with knowledge atoms and integrate them with specific characteristics of a student. A simplified Bayesian network is given in Figure 2. The learned nodes represent a probability level that an atom is learned. This conclusion depends on the correct answer selected (marked with T) and the recognition of visual indicators (labeled I) [7].

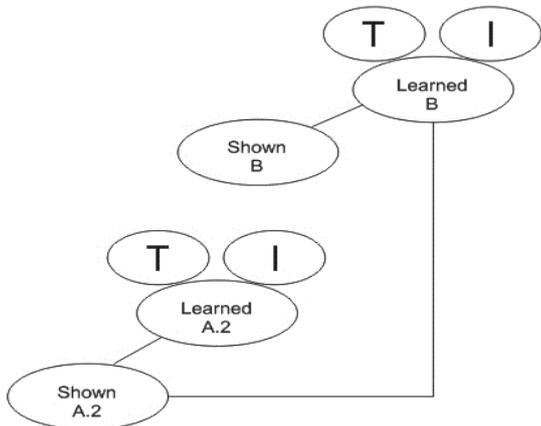


Fig. 2. Bayesian network for pedagogical actions

Interactive Flash environments

As we mentioned above, we prepared the first experimental interactive tasks for students of the third year, for preparation of colloquiums in the subject Programmable logic devices. The first step was made by a professor who gave representative tasks for specific teaching units. In cooperation with designers and programmers, we created a model of tasks with interactive elements such as: *Input text boxes*, *Combo-boxes* and *Check boxes*. An example of an interactive task is given in Figure 3.

Realizujte logičku funkciju F koja je data kao suma potpunih logičkih proizvoda u PLA kolu.
Unosite promenjive u sivo polje. $F(x,y,z,w) = \sum(1,3,4,5,10,12) = 1$

i	x	y	z	w	F	POTPUNI PROIZVOD
0	0	0	0	0	0	
1	0	0	0	1	1	<input type="checkbox"/> $x \cdot y \cdot z \cdot w$
2	0	0	1	0	0	
3	0	0	1	1	1	<input type="checkbox"/>
4	0	1	0	0	1	<input type="checkbox"/>
5	0	1	0	1	1	<input type="checkbox"/>
6	0	1	1	0	0	
7	0	1	1	1	0	
8	1	0	0	0	0	
9	1	0	0	1	0	
10	1	0	1	0	1	<input type="checkbox"/>
11	1	0	1	1	0	
12	1	1	0	0	1	<input type="checkbox"/>
13	1	1	0	1	0	
14	1	1	1	0	0	
15	1	1	1	1	0	

$F(x,y,z,w) = x \cdot y \cdot z \cdot w +$ $+ + + +$

Fig. 3. PLA interactive task with combo-boxes
The given task from the field of designing combinatorial networks and implementation in a PLA circuit demands from students to select from a combo-box one of the offered combinations of final logic products of the input signals value. In the case of guessing the right input combination, the given combination is entered into rectangular fields at

the bottom of the task, as part of the final sum of the output function F product.

The example shows the way in which static educational material transforms into multimedia material through interactive elements [8]. The very example also includes a pedagogical aspect, which is shown by the visual indicator of accurately selected combination.

To be able to accurately fill the fields that are marked with visual indicator, students need to know the logical functions of logical gates with multiple inputs.

To illustrate the application of Bayesian network as a model that describes how to realize the principle of interactive tasks, we'll give a description of an interactive task related to the implementation of the logical expression in the PLA circuit (Figure 4).

Realizujte datu funkciju F na zadatom izlazu PLA kola (F₂).
Pri selekciji promenjivih kliknite u siva polja.

$F(x,y,z,w) = F_2 = y \cdot z \cdot w + \bar{x} \cdot z \cdot \bar{w} + \bar{x} \cdot$

Fig. 4. PLA interactive task with check box

Another condition for successful solving of the given interactive task is to be familiar with the structure of programmable array in the PLA circuit, on the basis of which we define the electric junction between signal lines by which values of input signals are distributed through the programmable AND array, and input of proper AND gate by selecting appropriate intersection junctions within overshadowed rectangular fields. Selection of accurate intersection junctions creates a possibility for executing the first level of the task, i.e. creation of logic products at outputs of the AND gates. An overshadowed rectangle will appear along the output of the selected AND gate, as an indication of properly implemented logic product. In the case of making a mistake on selection of the intersection junction, i.e. if the logic product is not properly implemented, it won't be possible to continue solving the task until creation of a proper logic product in the programmable AND array, i.e. until visual indication appears in the form of an overshadowed rectangular along the output of the selected AND gate.

The second stage of the interactive task, which is completed on assumption that all logic products from the given logic expression are successfully created, is at the same time the last stage and represents creation of the sum of logic products in the programmable OR array. The presented knots determine the probability level that an atom should be learned. These knots depend on their learned knots' parents and on learned knots of the same atom. Each node in the network has added a visual indicator, which has the role of parents and is specific for a given problem.

The entire knowledge base for the given example of an interactive task is presented in Figure 5.

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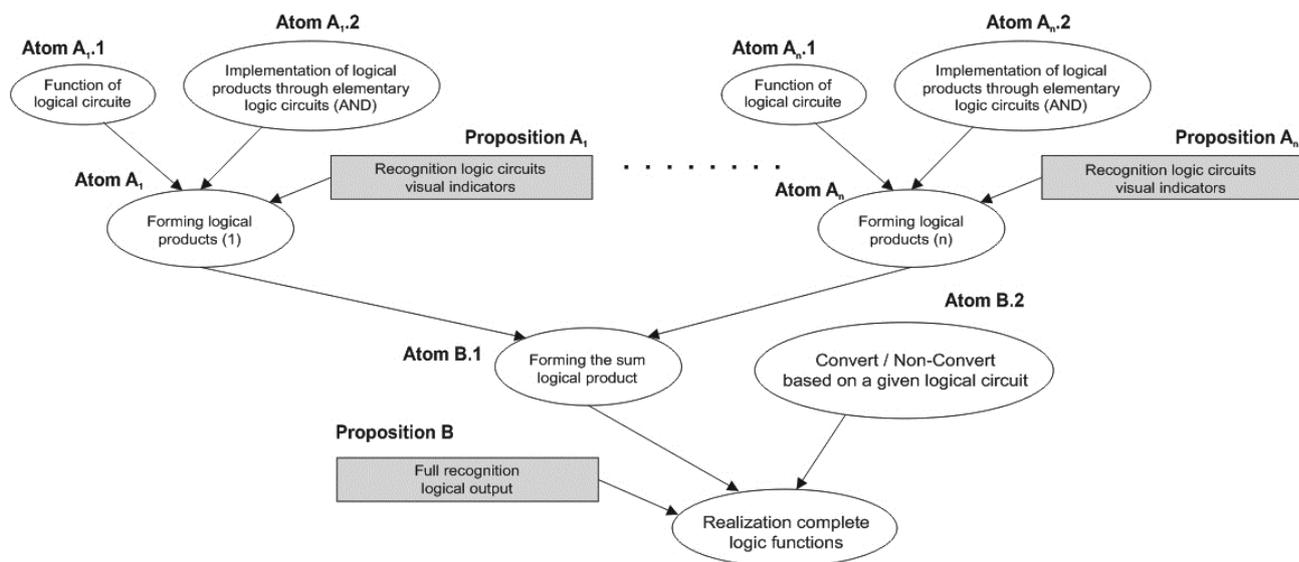


Fig. 5. Bayesian Network from an interactive task

Table 1 shows conditional probability of events for a rule with two parents, a teaching unit and a proposition. Theoretically, each atom has approximately the same importance for the success of the realization of the complete task [9]. Factors which describes the evaluation of overcoming a certain level of knowledge necessary for successful implementation of interactive tasks, are shown in Table 1.

Table 1. Conditional probability of Atom B.1

Atom X_{m-N}	Atom $X_{m+1-N+1}$	Proposition X_m	Performance
T	T	T	0.9
T	T	F	0
T	F	T	0.6
T	F	F	0
F	T	T	0.6
F	T	F	0
F	F	T	0
F	F	F	0

Parameter indication of the successful overcoming of a certain level shown value 0.9, while the parameter for the indication of partial overcoming labeled 0.6. It should be noted that the column performance is not a simple sum of the estimates, but they are empirical values based on an assessment of the actual applied knowledge in the implementation of the task. Assessing the importance of the visual element is identified with a value of assessments of knowledge of atoms, because the work on interactive tasks involve knowledge "rules of the game."

Numeric value for the assessment of factors is determined by the levels of related tasks that the user needs to solve. The value of the factors is particularly defined for each level. This means that values for atoms and propositions (rules) can vary from level to level. The maximum value of the total performance is limited to 0.9, because we assume that in some cases, the task can be successfully done even though the atoms are only partially overcome (the possibility of accidental guess).

To the user (student) could successfully solve the complete task, atom B.1. in our case must be learned. For that reason in the table are not the values of the combinations in which the atom B.1. not learned (F value). The distribution of factor values for the final realization of an interactive task that is. atom B.3. is shown in Table 2.

Table 2. Conditional probability of Atom B.3

Atom B.1	Atom B.2	Proposition B	Performance
T	T	T	0.9
T	T	F	0
T	F	T	0.6
T	F	F	0

From the given table can be assumed that success in solving the interactive task depends entirely on how it is learned each separate level of knowledge. Also, you can not progress further unless fully learned atom, which has greater weight. These are the atoms in our example on the left side in Figure 5 ($A_{n.1}$ atom and atom B.1). With interactive multimedia content, student guides through the task to the final solution.

Discussion

Exploring the impact of interactive tasks on students' success in acquiring the knowledge about complex logic devices operating principles and their implementation, at the end of the course we conducted a survey. Survey included all students who had classes in the subject Programmable logic devices in 2011. Students of various study programs were rated the content and concept of interactive tasks with marks from 1 to 5. The survey results showed that most students gave the highest rating. From this, it can be concluded that the concept and content of interactive tasks were very well accepted by students of all study programs. We also explored how many students use the interactive tasks to prepare for the exam.

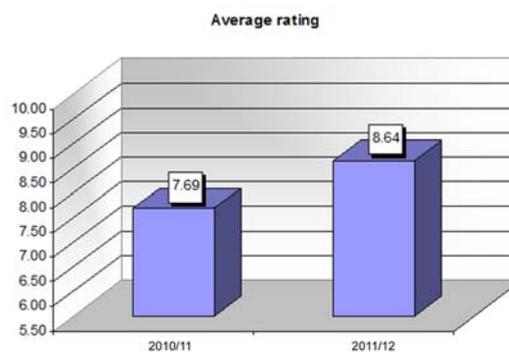


Fig. 6. Average rating of grade on exams

Analysis of the results of the exam from the programmable logic circuits showed that compared with the 2010/2011 academic year significantly increased the number of students who are due to interactive tasks in the academic 2011/2012 passed the examination (Figure 6), while at the same time increased the average mark exam.

Conclusion

Other authors that deal with designing intelligent tutoring systems, also apply Bayes network in order to assess student knowledge. Technique that we apply relies on the experience of the implementation of pedagogical elements (atoma knowledge) that the authors apply Hugo Gamboa and Ana Fred in software module for distance learning via the Internet, "the tutor of the shell" [10]. In their module used classical forms of measuring knowledge using various tests before and after the learning process, and the interface has already dobropoznate elements of e-learning systems such as navigation, html pages, suggesting paths,...

In our system for learning, instead of the standard animation, interactive animation is used as a kind of simulation game based on theoretical principles that students need to learn. 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. This project includes an interactive animation to introduce students to the work of electronic circuits [11]. 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". This paper describes a new approach to learning through interactive tasks, which is a combination of implementation strategies and game theory Bayesian networks for assessment of the acquired level of knowledge. Applying the new approach in practice has shown that in this way significantly raises the level of interest in the field of programmable logic circuits. Summarizing the results and taking into consideration a very good result in passing exams during the academic year 2011, we can conclude that interactive tasks produced very positive reactions of students.

We used Bayesian network for modeling the relation between students' activities and the results. With the efficient concluding mechanism via a graphic outline, Bayesian network helped us in modeling the interaction which we added to interactive tasks. The pedagogical aspect of solving parts of a problem before reaching the final solution gave a very good response. Interactive tasks in which knowledge is checked or acquired by guessing the correct answer with the help of visual indicators turned out to be a good teaching material. However, they are not sufficient for exam preparation, but they represent additional material modeled in a specific way.

The positive results stimulated us to continue improving the existing tasks and to give a basic concept of their creation and usage in other fields as well.

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