DESIGNING OF LEARNING CONTENT FOR A UNIVERSITY ONLINE COURSE

V. M. Lutkovski [1], P. V. Nazarov [2]

[1] Belarusian State University, Minsk, Belarus
[2] Luxembourg Institute of Health, Strassen, Luxembourg
E-mail: lutkovski@bsu.by

The paper is aimed to improve learning content for online learning. Models of neural networks are used in the paper for structuring the learning content of real educational courses. The adaptive resonance theory is applied as a tool for improving the student training process.

Key words: adaptive learning system, learning content, domain structure, neural networks, adaptive resonance theory

INTRODUCTION

Models of human learning (HL) have been studied by well-known psychologists for a very long time [1]. Unfortunately, it is very difficult to apply those models to modern educational systems based on digital platforms. The progress of science and education was greatly accelerated since the implementation of computers and information technologies (IT). Recent advances in the education were stimulated by the wide implementation of Computer Aided Learning (CAL) systems [5], learning management systems (LMS), and especially – adaptive learning systems (ALS) [4] in current practice.

Prominent achievements in the machine learning (ML) and human brain study allow making HL faster and more effective. Auditoria lectures, as one of the main forms of HL, are currently widely discussed and revised as the result of IT infrastructure growth and implementation [2], especially after COVID-19 pandemic.

The problem considered in the paper is an improving learning content for the online university course in computer sciences through the better structuring. The adaptive resonance theory [9] is used as the basis for evaluating the learning content complexity and searching compromise between learning content and limited time of online lectures. The discussed approach is illustrated by examples from the updated university course in ML called "Neural Networks Modeling" at the Belarusian State University education portal [11].

AN APPROACH TO THE LEARNING CONTENT DESIGNING

An important issue in online learning systems is structuring, reasonable simplification of text displayed on a screen and possibilities for compressing the learning content. The idea of the course content structuring is illustrated by an example in Fig. 1. The basic concepts are given in the first lecture: the neuron model [6] called a "formal neuron" (Fig. 1, *a*). It is formed on the concepts of the synaptic weights, summing block and activation function – simulating appropriate parts of a biological prototype. The topic of the second lecture is perceptron and delta-rule (Fig. 1, *b*). Both of them are formed by developing the concepts from the first lecture and so on.

In general, it is supposed that the students' memory consists of two parts – short-term and long-term memory. The model of adaptive resonance theory [9,10] may be brought for a better understanding of students' training in detail (Fig. 1, *c*). Incoming data saved in the short-term memory at each next stage of the training are compared with the basic concepts saved in long-term memory at previous steps. The saved concept in long-term memory may be improved using the new data or, alternatively, a new concept is created, if the contrast between the new data and data in long-term memory is significant. Connections between the existing basic concepts in student's memory are installed along with forming new concepts likewise connections between neurons in Hebbs' learning rule [7]. The described structuring allows step-by-step students' training from basic concepts to complex structures using a generalization.

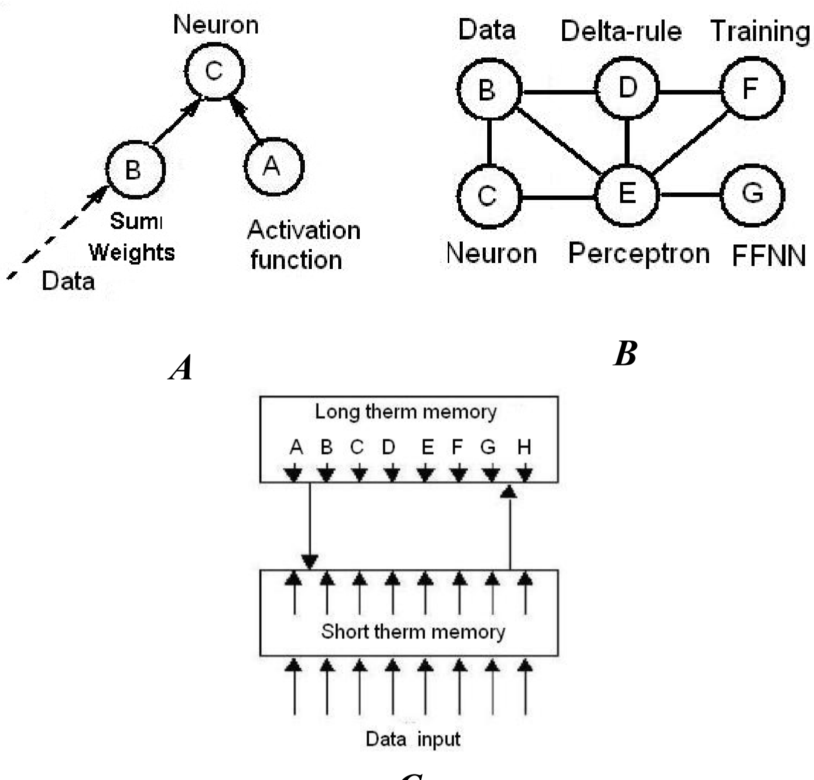

Fig 1. Domain structures (*a, b*) and the student's memory model (*c*)

THE EXAMPLE OF THE UNIVERSITY COURSE

Our updated 130-hours University course for the 4th year students at the Faculty of Radio Physics and Computer Sciences is called "Neural Networks and Deep Learning". Lecture notes based on [8] and instructions for laboratory works in PDF format (available upon request) are shared with students using Moodle LMS platform [11]. The learning content was distributed in 6 units for seven weeks as soon as the volume of human "operative memory" is limited by 7–8 units/topics. [12]. The titles of the units are: ***i***) introduction to ML, ***ii***) training of shallow neural networks, ***iii***) autoencoders and convolutional neural networks, ***iv***) recurrent and stochastic neural networks, ***v***) training and application of deep neural networks, ***vi***) hybrid and fuzzy neural networks.

Scalability is one of the remarkable properties of artificial neural networks: it allows starting to solve some real problems with the simplest architecture. Then later students could reproduce the cycle of artificial neural network designing and application using more complex architectures. It helped us in finding the efficient learning path – step-by-step from the classical shallow to modern deep neural networks. Students were stimulated to work hard and stay on schedule starting from the first lecture with the help of the next simple classification problem solved with the help of a simple neural network. Data reflecting the progress of each individual student were represented by 2-dimentional vectors (x_1, x_2) were x_1 – "theory" and x_2 – "practice" (Fig. 2).

The model of the 2-inputs perceptron was trained using a dataset prepared by a lecturer based on data of the previous year's students. The class of successful students was coded as "+", and the data for unsuccessful students were labeled with "o". In this case, passing from some level or unit of the course to the next level may be regarded as the simple classification problem using such model trained on actual dataset.

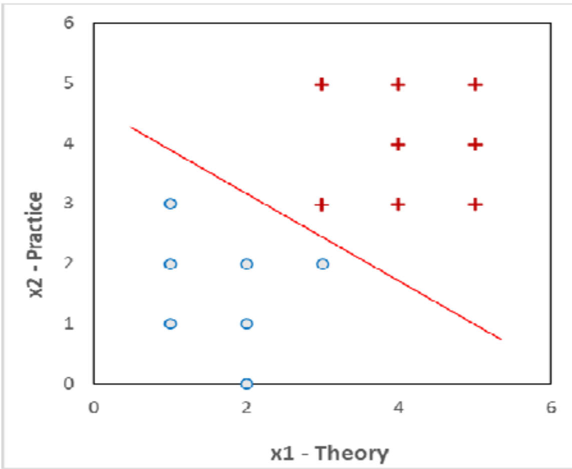

Fig 2. Mapping for classification of successful/unsuccessful students

DISCUSSION AND CONCLUSION

Models of neural networks were used here in two instances: both as a tool for educational system design and as the example of real University course in

Machine Learning. Those models were used for constructing the learning content of the real educational courses.

Based on our experience, the best educational results for the course were obtained when the learning content was limited to a few topics that are followed by an intermediate test. A similar approach is in fact, used in deep learning: models are trained iteratively on data "batches", instead of training on the entire huge dataset. The discussed structuring of learning content distributed in 3-4 lectures and one laboratory work per one-week unit allows progress in learning for students having different backgrounds and learning styles.

Usually, the domain structures of classical online courses in mathematics and statistics are fixed and stable for every student [4]. In the frame of the presented University course, we propose considering it as a developing structure during the training of students according to their progress.

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