The Use of Artificial Neural Networks in Supporting Education and Curriculum Planning*

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The proposed research describes the application of artificial neural networks in order to support curriculum planning and advance educational process at the level of higher education. The developed artificial neural network model contains three layers: input, hidden and output. The input layer includes parameters such as previous education, number of points that future student brings from high school, city in which the student finished high school and subject that the student chose for entrance exam. The predicted parameter is the number of students with specific previous education. The results could have a significant effect on curriculum planning thus supporting educational process. Teachers could adapt their courses according to the previous education of students and their knowledge. The evaluation of neural network with Root mean square error (RMSE) gave the value of 0.12 which is acceptable for predicting model. A Web based application is developed in order to enable teachers to obtain the results from the artificial neural network without specific knowledge about the methodology of neural networks. The created application was evaluated through one use case and validated with real data from last year.

Keywords: information technology; artificial neural network; web based application; curricula planning

1. Introduction

Over the last few years Information technology (IT) has become very popular among future students. In Serbia, their first encounter with the subjects within IT happens in primary school, and it continues through high school as well. In the last few years high schools introduced the possibility to form special groups interested in Information technology, with specific curriculum and opportunity to learn more and get valuable knowledge and skills in the field.

At the Faculty of Technical Sciences in Čačak, University of Kragujevac, the study program "Information technology" had been accredited for the first time in 2009 for 40 students, while in 2014 it was accredited for 80 students. In 2017, the program from 2014 was innovated, according to the special call from Government. The Faculty teachers put considerable amount of effort to provide a new curriculum with advanced subjects which are in line with industry needs (for 130 students). Moreover, the Faculty of Technical Sciences offers Master and PhD studies in Information technology. As already stated, the interest in the mentioned study program has grown significantly over the last years. As a result, the students who enrol in this program have better scores from high schools. Every year the number of interested students notably exceeds the number of available places.

Analyzing the students interested in Information technology study program and their previous education, the authors noticed that they come from very different schools and that their previous knowledge related to IT differs significantly. Some of them come from specialized groups which learn more about information technology, while others come from schools which offer some other specific knowledge and skills like economics, technical sciences, mechanical engineering, etc. According to the Information technology curriculum some subjects require previous knowledge and skills from high schools but according to some previous analyses these skills are very different depending on previous education.

The Faculty of Technical Sciences is located in West Serbia, Moravica district, and majority of future students come from the same city or from other cities in West Serbia. During the application process future students provide necessary information about their previous education. But the faculty staff can never predict the number of interested students from different schools. Furthermore, they can't predict the previous knowledge and skills or previous education of interested candidates. This type of information could be very helpful in planning the teaching process. Educational and curriculum planning could be changed significantly (up to 20%) to meet the specific needs of future students. The accreditation process in Serbia allows curriculum to be changed by 20%.

The application of data mining techniques is one of the solutions to the research question. Artificial neural network could be used in order to predict the number of interested students with specific characteristics which the end-user defines.

2. Related Research

There are many related studies regarding the implementation of data mining techniques in educational process.

The authors in [1] examine how predicting modelling can be used to analyze application behaviour. In the same research artificial neural networks are applied in order to predict which students are likely to apply to a Research Institution in the Midwest. Research described in [2] "allowed recognition of the differences and the selection of the most appropriate of the three learning paths offered". Learning paths provide the solution which gives an opportunity to students to satisfy their own needs and expectations. Also, students' possibilities and limitations are considered in defining the learning path by using artificial neural network. Similarly, artificial neural networks are used in order to help in personalizing learning interests in [3]. By using artificial neural networks users get suggestions based on their preferences. With the application of the mentioned technique users need less time and effort to choose appropriate learning materials among many resources. Multilayer perceptron was used in [4] in order to investigate the factors that affect the success of university students. The goal was to measure predictive ability of mentioned techniques applied on educational data. The study also analyzed radial basis function to compare the two methods with the aim of obtaining more accurate results. In the study presented in [5] artificial neural network was used in an educational qualitative data analysis. A cascade-forward back-propagation neural network model was developed to analyze categorical data in order to determine students' attitudes. The results described in [5] indicate that using the proposed model in analyzing educational data in order to examine attitudes could provide more detailed information and also precise characteristics of the participants involved. The authors of [6] collected data on the personnel educational training and used data mining techniques for the analysis and classification. Based on the results the authors proposed a model suitable for educational training. The research explored how to maximize the results through planning the courses and the personnel's participation in the training. In the research described in [7] the authors presented a novel model of full-path learning recommendation which is based on machine learning techniques. The collection of learners is clustered, and the model is trained in order to predict their learning paths and performance. The authors in [8] used knowledge discovery techniques to analyze student data which are related to grades. The goal was to predict whether or not the student will drop out of a course. The final goal is reducing the dropout rate from the course. Some papers give a review of published manuscripts on application of data mining techniques in education [9, 10]. Both of these studies show that there is significant interest in applying data mining techniques in education. Also, the effect of presented research shows the improvement of teaching and learning process through the mentioned techniques.

All related research is summarized in Table 1 and Table 2. Table 1 gave an overview of applied artificial neural networks and Table 2 presents review articles or other used artificial intelligence techniques.

According to the related studies presented in Tables 1 and 2 the main similarities and differences between them and the research presented here are:

- A data mining technique (artificial neural network) is used in the proposed research as well as in all presented papers.

Table 1. Summary of related research information for type of AI tool used: artificial neural networks

Reference number	Purpose	Supporting resources	Key results
[1]	Predict which students are likely to apply to a large Research institution in the Midwest.	SPSS Clementine	Information about students and their interest for applying to a large Research institution in the Midwest.
[2]	Selection of educational content on an e-learning portal using artificial neural networks.	Statistica, Moodle	Individualizing the student education process and its adaptation to the educational needs and competency gaps of participants.
[3]	Review of using neural networks in E-Learning personalization.	E-learning tools	Presented methods of personalization and summarized current applications of them with their improvements and limitations.
[4]	Investigation the factors that affect the success of university students by employing two artificial neural network methods.	21 references	The results related to the fact that the multilayer perceptron artificial neural network outperformed the radial basis artificial neural network in terms of predictive ability.
[5]	Determination of students' attitudes in order to get yield qualitative results out of a huge amount of categorical data.	22 references	The key results are getting precise knowledge about students' attitudes and beliefs.

Table 2. Summary of related research information for type of AI tool used: other than artificial neural networks

Reference number	Type of AI tool used	Purpose	Supporting resources	Key results
[6]	Review	Review paper with tasks and applications existing in the field of educational data mining and categorized them based on their purposes.	China motor corporation resources,	Results are related to compared proposed study with other existing surveys about educational data mining.
[7]	Clustering, LSTM neural networks	Discovering useful hidden patterns from learner data for online learning systems.	38 references	Results are related to making recommendations on appropriate learning paths with significantly improved learning results in terms of accuracy and efficiency.
[8]	Logistic regression model	Analyse historical student course grade data in order to predict whether or not a student will drop out of a course.	Moodle	Tool and a tutoring plan that can be used educational institution to reduce dropout rate in e-learning courses.
[9]	Review	The purpose is to provide an unexplored review of EDM research of the teaching and learning process considering the educational perspective.	102 manuscripts for review	The results show expandation into many areas and themes in educational data mining.
[10]	Review	The purpose is review of educational data mining and learning analytics in higher education.	328 references for review	Review covered the most relevant studies related to four main dimensions: computer-supported learning analytics, computer-supported predictive analytics, computer-supported behavioral analytics, and computer-supported visualization analytics.

- The target group is not related to the current, but future students, which opens up the possibility to adapt the courses from the very beginning of their study process.

The research goals are defined as strategic and professional, and also as long-term and personal. Strategic goal: Predicting the number of future students with specific previous education using data mining techniques in order to plan educational process and adapt curriculum at the Bachelor study program "Information technology". Professional goal: Developing a Web based application for predicting the number of future students. Long-term goal: Developing a Web based application with the aim of improving curriculum planning for the next accreditation cycle. Personal goal: Adapting specific subject curriculum (up to 20%) in line with students' previous education performed by teachers.

The main contributions of the research are defined in correlation with the goals: Strategic contribution: Possibility of predicting the number of future students with specific previous education using data mining technique with planning educational process and adapting the curriculum at the Bachelor study program "Information technology". Professional contribution: Developed Web based application for predicting the number of future students. The Web based application is based on artificial neural networks, but it has a very simple user interface. The application could be used by all teachers, not only the teachers of IT subjects. Long-term contribution: Possibility of improving curriculum planning for the next accreditation cycle by using the developed application. Personal contribution: Possibility of the adaptation of personal subjects and learning materials for the teaching process.

3. Methodology

In order to achieve the goals, the artificial neural network is used, together with the methodology related to this technique. The methodology includes specific research tasks which are related to data mining process:

3.1 Data Collection, Pre-Processing and Transformation

The data is collected at the Faculty of Technical Sciences, in the student services. At the Faculty of Technical sciences in Čačak a specific service is dedicated to the enrolment of students and collection of data which students provide. The service holds all data since 2009 which will be used in the research. All relevant data were collected: high school, city of previous education, number of points from high school and subject chosen for the entrance exam. Data are collected for the period of 10 years: 2009–2019. For training and testing the artificial neural network the authors used data from the period 2009–2018 (9 years).

The last year is 2019 and this year is used for the validation of the application.

Pre-processing is a phase that involves removing the entries which contain errors. In this phase, anything that is not relevant to this specific research is considered an error and it is removed. For example, the database contains the names of future students which is not relevant for the research. The date when they applied for the study program Information technology was also removed from the database. There were not empty cells so the problem with missing data did not exist. The data pre-processing is a necessary step in data mining process, but in this research the mentioned step did not require some specific subtasks.

The collected data are in the appropriate form for the research and majority of parameters do not demand further transformation. In the research transformation is done with the points from high school. The maximum number of points from high school is 40. The authors defined 4 categories:

1 category–future students who have 35–40 points; 2 category–future students who have 30–34.9 points; 3 category future students who have 25–29.9 points; 4 category–future students who have 20–24.9 points

The number of points from high schools is calculated in the following way: The average scores for every grade are summed up and then multiplied with 2. So, the best pupils have 5.00 as average score for every year. For 4 years the sum is 20 and multiplied by 2 it is 40. In the research this falls under category 1.

3.2 Neural Network Model Creation

A so-called multilayer perceptron is used in this research which can be trained by many algorithms. The training algorithm used here is back-propagation. The neural network algorithm is used to create a network that, in this study, can contain three layers of neurons: an input layer, a hidden layer (which is optional), and an output layer. Neural network model is presented in Fig. 1. The input layer contains the following parameters: high school of

Fig. 1. Neural network model.

future student, subject chosen for the entrance exam, city in which future student finished high school and number of points which future student received in high school. Those parameters are available in the moment of applying for the faculty and they are relevant to the specific research tasks. Future work includes adding more parameters through questionnaire which will students fill in.

3.3 Neural Network Evaluation

Neural network model consists of three layers:

Input layer (standardized term, 34.02.07 in ISO/IEC 2382-34:1999, 1999). Hidden layer: Neurons in the hidden layer use a hyperbolic tangent function: ($f(x) = \frac{e^{2x}-1}{e^{2x}+1}$ which converts the input in the interval ($-\infty$, $+\infty$) to interval (–1, 1)). Output layer (34.02.08 in ISO/IEC 2382–34:1999, 1999). Output neuron represents the attribute values that were predicted. In the approach used in this study, the number of students is the output from the network. Neuron in the output layer use linear activation function. For purpose of training neural network the back propagation algorithm was used. 30% of data for testing and 70% of data for training the neural network are used for model evaluation in this research. Besides that, the root mean square error is calculated.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=0}^{n-1}(t_i - o_i)^2} \;[11] \qquad (1)$$

where t_i is the calculated output given by the network, o_i is the real output for case i, and n is the number of cases in the sample. The RMSE value in this research is 0.12. The model is useful when RMSE is lower than 1. Lower RMSE is a sign of a more accurate model than unintelligent predictor. RMSE presents relation between total error of the created model and unintelligent predictor (which always predicts mean value of the output). The cross-validation methodology was used for the training and testing of the classifiers using. The data set is randomly divided into a set of K distinct sets. Training is performed on K–1 sets and the remaining set is tested. The process is repeated for all of the possible K training and test sets. The average of all K results are the classification results.

3.4 Neural Network Testing

The model based on neural networks was tested through Datamining Extension (DMX) queries [12]. DMX (data-mining extensions) were written and tested in the Microsoft SQL Server Management Studio 2010 [13] environment in order to determine the number of future students based on the parameters entered by the user. By writing
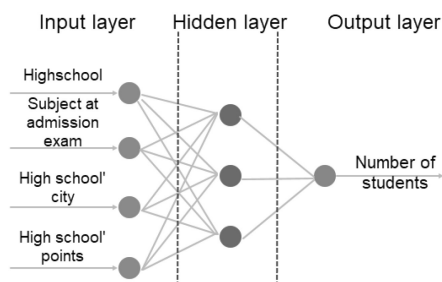
DMX queries, the user can define specific input values based on which they can predict the number of future students. Queries are written and tested to provide data not only about the created neural network and network statistics, but also about queries that are used to predict the number of students based on the entered values.

3.5 Web Based Application Developing

Taking into the consideration the graphical results, especially those obtained through the DMX query, it can be concluded that knowledge of IT is of crucial importance for writing the query. However, the target group which will use this application is not made up only of IT specialists, but also people who participate in the teaching process (other teachers, administrative staff, etc.). This was the main reason for the creation of a Web-based application that does not require specific IT knowledge. Program language C# was used for developing the application in the NET programming environment. Visual Studio 2016 [14] is an integrated development environment that has the necessary functionality. The application is connected to the Microsoft SQL service for analysis through ADOMD.NET. ADOMD.NET is an environment of Microsoft.-NET that allows communication with Microsoft SQL services for the analysis.

3.6 Application Testing and Verification

The evaluation of the created system is achieved by one use case. The system was activated and tested by entering the values for potential future students and analyzing the results. Verification in real situation is done for the last year (2019).

4. Results and Discussion

The final result is related to the Web based application which provides predictions. The target group includes teachers and all interested staff at the Faculty (Faculty management, public relation service, people who are involved in the promotion of the study program, etc.).

4.1 Architecture of Application

Fig. 2 shows the architecture of the proposed web application. The collected data is pre-processed and transformed. Then, the database is created under database server. Under Analysis services the neural network model could be browsed and queried through DMX queries. Microsoft SQL service for analysis is connected to the Web based application which is available to users through ADOMD.NET.

4.2 Testing through DMX Queries

For testing the created artificial neural networks, the authors used DMX (Data Mining Extensions Queries). The information is extracted from the data mining model through DMX queries [15, 16]. DMX queries are applied to all data mining models. Since the technique of neural networks is chosen for this research, DMX queries are created and applied to that data mining model. The aim of using DMX queries refers to the creation of queries in order to obtain desired results, i.e. the answer to the research questions. The objective in this research is to predict the number of students for the chosen input data. The prediction queries are a special kind of DMX queries. The authors have chosen a singleton prediction query as one among many examples which
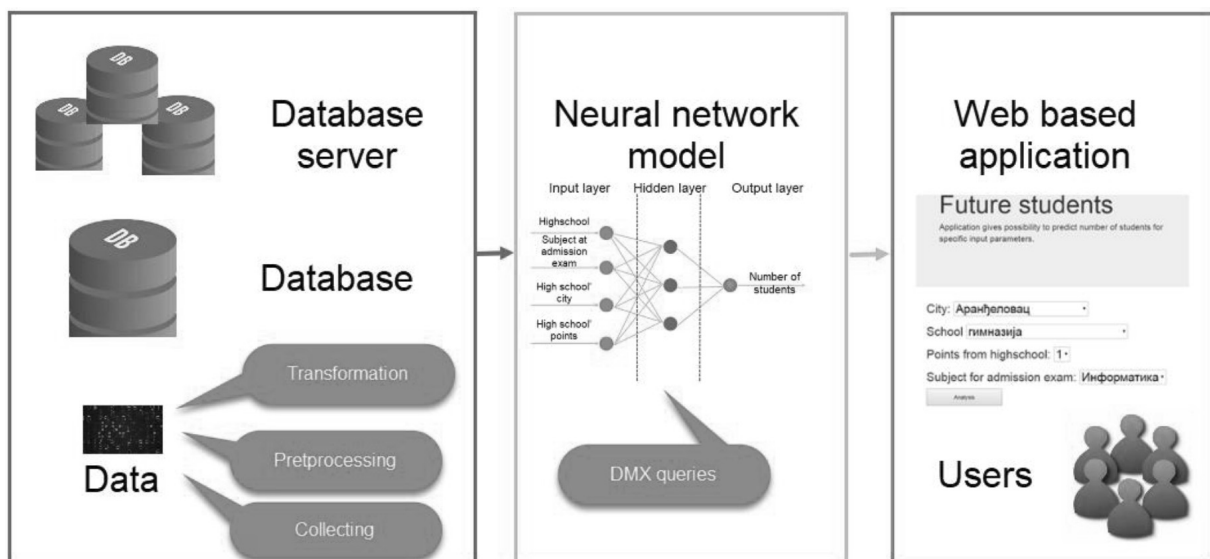

Fig. 2. System architecture.

are performed under testing. The following example shows the query in which the chosen input parameters include: the city of Arilje, Computer science as the subject chosen for entrance exam, category 1 for the points from high school (according to the classification given above it stands for 35–40 points) and Grammar school as finished high school.

After the query is processed the result presented in Fig. 3 is obtained.

As shown in Fig. 3, the result for chosen input parameters is 3. It means that for chosen input parameters we could expect 3 future students. According to the number teachers could adapt their classes and give some additional materials for those 3 students. Those 3 students have finished high school with very demanding program related to information technology and programming. Teachers could prepare for them additional materials in order to satisfy their learning needs.

4.3 Evaluation Through Use Case

The evaluation is done through one use case. The evaluation also helps determine the advantages and drawbacks of the application. The end users are all teachers and interested staff from the Faculty. Most of them do not have specific IT skills which are required. That is the main reason for developing the Web based application which is simple to use. The use case includes choosing input parameters and obtaining the results. It is not necessary to include all parameters in query. In the shown use case it is shown using of all parameters. Fig. 4 shows a graphical user interface with chosen input parameters and results (after pressing the button "Analysis"). Fig. 4 shows the graphical user interface and chosen parameters (city-Čačak, school-technical school; points from high school–1 (35–40); subject chosen for entrance exam-Computer science). The result for chosen input parameters is 6. It means that the teachers or Faculty staff could expect 6 students from Čačak who have 35–40 points from technical school and their entrance exam is in Computer science.

Given results could be significant for curriculum planning at the Faculty. Students from technical schools have valuable knowledge in information technology and they usually need some advanced lessons. The predicted number is not very high, but it includes only the territory of Čačak. Also, teachers could choose another type of school where future students did not have many subjects or classes in information technology. Those students could be also very successful, but they need different approach. The whole concept leads to personalized learning based on previous knowledge and skills in information technology. According to the national and university regulative the curriculum could be changed and adapted up to 20%, and the proposed model could be the basis for the adaptation of the curriculum. According to the presented use case the advantages and drawbacks could be discussed.
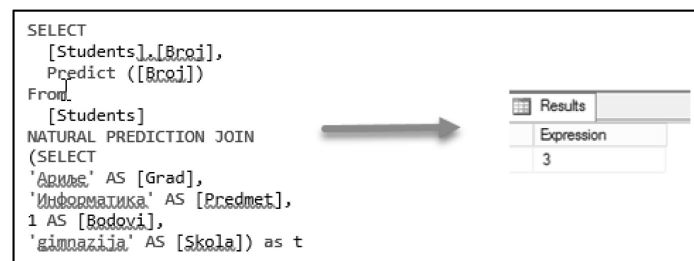

Fig. 3. Result for chosen input parameters.

Fig. 4. Graphical user interface (chosen input parameters and results).

While developing the application special attention is drawn to reduce possibilities of making errors by end users. The drop-down lists are used in order to achieve that. The application is very simple to use although it uses artificial neural network and DMX queries. Simple use is its main advantage. It is based on advanced techniques such as artificial neural networks but it could be used by people who have basic skills in Information technology. This is the advantage for the teachers at the study programmes who teach non-IT subjects (like English language, Entrepreneurship…). Drawbacks and limitations of the application are related to the fact that it can only provide the predicted number of students. Further development should include the basic tutorial on the skills that future students obtain in different schools. Also, there will be students who come from schools with small number of IT subjects but with excellent knowledge and skills which they have achieved through some informal education.

Future implementations include adding some additional input parameters about future students through filling questionnaire while applying for the faculty. Those parameters are related to specific IT skills and knowledge, previous experience in some kind of jobs and competition in IT field. The model could be adapted and applied in detecting future students at higher levels of study (for master and PhD studies) which is also part of future research.

4.4 Validation

Validation is standardized term. According to [17]: "Validation is confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled." Validation is critical to the success of software quality, according to Kitchenham and Pfleeger [18]. The definition of validation is also referential because of the phrase "compliance with specific requirements" [19]. In order to perform validation, the data from the previous year (2019) were not included in training and testing process of the model. The created artificial neural network model was tested with DMX query and the results are compared with the data from 2019. It was done through the Web based application and DMX for the school of economics.

The predicted number for that school is 15. After the execution of the query the original data from 2019 are checked and compared with the result. The real number of students from that school is 16. The result could be accepted as appropriate, with relatively small error which does not affect the curriculum planning. The error proves the fact that prediction models are not ideal, they do not predict correct all cases. In the presented example the error is relatively small and does not effect on strategy of personalization and adapting courses to the group of 16 students.

5. Conclusions

The proposed application implements artificial neural networks and gives possibility to teachers and faculty staff to provide input parameters such as: previous education, city, type of high school, number of points from high school. The output is the expected number of students for the chosen input parameters.

With the results from the application teachers could get the prediction of the number of students with specific previous education and according to the information adapt their teaching methodology and curriculum. For example, if the prediction for the next year is a large number of future students whose previous school was the school of economics teacher will start with lower level of subjects related to programming languages because future students from this school do not possess previous knowledge in programming at an advanced level, but only some basic knowledge. However, these students could successfully apply knowledge and skills form the field of economics to IT education.

Based on the presented example and use case in the section with the results it could be concluded that the application allows for the possibility to adapt learning materials according to students' previous knowledge and thus promote personalized learning.

The main contributions of the research include developed Web based application which uses artificial neural network. With the main contribution target group of users get possibility of predicting the number of students with specific previous education. According to the prediction teachers could adapt their teaching materials within the subject to fulfil the requirements of students' previous knowledge. Learning personalization is tested in subject "Introduction to programming". After prediction, the number of students without previous knowledge about programming languages teacher planned curricula with additional materials and classes for those students in order to get the same level of knowledge as other students. In the middle of semester (after the first results from mid-semester colloquium) the results have shown that students without previous knowledge but with adapting course for them passed the test in the satisfied percent of success.

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