PREGLEDNI NAUČNI RAD – REVIEW SCIENTIFIC PAPER

APPLICATION OF ARTIFICIAL NEURAL NETWORKS ACROSS VARIOUS DOMAINS: A RESEARCH OVERVIEW

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ABSTRACT

The research provides an examination of the Artificial Neural Networks (ANNs) application across diverse domains of creativity. In addition to exploring the theoretical background of machine learning and artificial intelligence, numerous practical applications of ANNs are discussed in fields such as education, agriculture, traffic, environmental protection and healthcare. The primary aim of these studies is to enhance predictive capabilities across various parameters, thereby facilitating automation of processes or generating valuable insights within specific domains. The outcomes of these applications result in user-friendly interfaces designed to disseminate useful information to individuals without advanced IT proficiency. Future work in this area is anticipated to involve the integration of additional sensors to obtain more precise results and ensure the incorporation of all relevant input parameters.

Keywords: artificial neural network, education, agriculture, traffic, environmental protection, healthcare.

INTRODUCTION

According to the independent high-level expert group of the European Commission (2018) “artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)”. The development of artificial intelligence has been continuous, characterized by periods of rapid progress and occasional setbacks. Given the expected changes that artificial intelligence brings, many countries, including the Republic of Serbia, have structured its development through strategic documents. The Republic of Serbia adopted the Strategy for the Development of Artificial Intelligence (2020), which covers the period from 2020 to 2025 (Vlada Republike Srbije, 2024). The AI Readiness Index is prepared by Oxford Insights in collaboration with the International Development Research Centre (IDRC). The 2023 AI Readiness Report shows the ranking of countries along with indexes in four different categories. Figure 1 presents the top 10 countries on the readiness ranking list for 2023. The Republic of Serbia holds the 57th position in the ranking for that year.

Global Ranking	Country	Total score	Government Pillar	Technology Sector Pillar	Data & Infrastructure Pillar
1	United States of America	84.80	86.04	81.02	87.32
2	Singapore	81.97	90.40	66.19	89.32
3	United Kingdom	78.57	82.50	68.80	84.42
4	Finland	77.37	88.34	60.36	83.39
5	Canada	77.07	85.30	64.73	81.17
6	France	76.07	84.03	60.40	83.80
7	Republic of Korea	75.65	87.55	54.36	85.02
8	Germany	75.26	80.78	63.28	81.72
9	Japan	75.08	82.76	56.85	85.61
10	Netherlands	74.47	78.90	61.96	82.55

Figure 1. AI Readiness Index for the top ten countries (Oxford Insights, 2023).

The neural network technique is a subset of artificial intelligence. This technique uses the principles and structure of the human brain to develop sophisticated data processing strategies. At its core, this approach relies on parallel data processing. The architecture of an artificial neural network consists of a specific arrangement and connection of neurons forming a network. Neural networks differ in architecture depending on the number of neuron layers. Typically, each layer receives inputs from the previous layer and sends its outputs to the next layer. The first layer is called the input layer, the last is the output layer, and the layers in between are known as hidden layers. One of the most common neural network architectures is the three-layer network. The position of artificial neural networks in relation to machine learning and artificial intelligence, as well as deep learning, is shown in Figure 2.

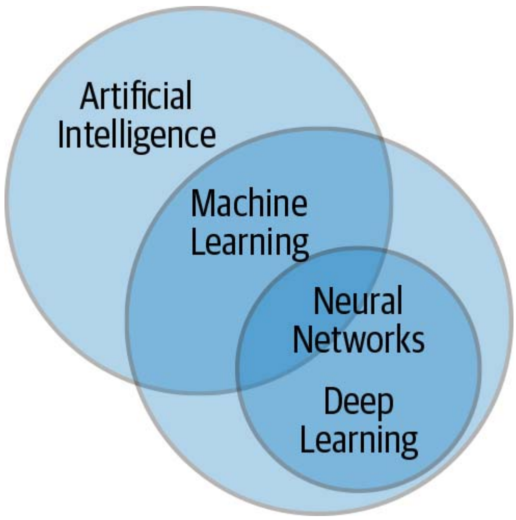

Figure 2. Position of artificial neural networks (Castrounis, 2019).

The aim of the paper is to review research involving the application of artificial neural networks in various domains of human creativity.

METHODOLOGY

The methodology encompasses standard procedures in the data mining process:

- data collection,
- data preprocessing,
- data transformation,
- model creation, testing and evaluation,
- model interpretation,
- model integration.

Every use case presented in this study follows these steps resulting in user-friendly applications that do not necessitate specialized IT skills in artificial neural networks.

In this research, various tools were employed, including Microsoft Visual Studio, Weka, and Python.

One of the potential sources of data for analysis are open data portals. According to Unicef (2019), open data refers to data that are freely accessible without copyright, patents, or other control mechanisms. This type of data originates from external sources worldwide. It can range from public data collected by government agencies to economic trend reviews from banks and financial conglomerates.

Open data are machine-readable and freely accessible for reuse. Reuse refers to the utilization of open data by individuals or entities for commercial or non-commercial purposes, different from the purposes for which they were originally collected or created. Furthermore, data must be in a format suitable for computer processing and available for use without any restrictions.

In addition to the aforementioned, open data imply authenticity, completeness, and timeliness. Open data stimulate economic growth, make public administration more efficient and cost-effective, enable better services for citizens, ensure transparency, and reduce opportunities for corruption.

The European Union was among the first to recognize the importance of opening up data held by public authorities, having adopted the Directive on the re-use of public sector information (Directive 2003/98/EC) as early as 2003. This directive was revised and improved in 2013 (Directive 2013/37/EU).

RESULTS AND DISCUSSION

The study illustrates several applications based on previous research where artificial neural networks are employed.

One notable application is in the field of education, specifically in predicting student enrollment numbers for the Information Technology study program.

By analyzing data on students interested in Information Technology and their prior education, the authors observed that students come from various schools with significantly different levels of IT knowledge. Some students come from schools specializing in information technologies, while others come from schools offering distinct knowledge and skills in areas such as economics, technical sciences, engineering, etc. During the application process, prospective students provide necessary information about their prior education. However, the faculty cannot predict the number of interested students based on the schools they come from. Moreover, it is impossible to foresee their prior knowledge, skills, or educational background. This type of information can be highly beneficial in planning the educational process. For this study, data were collected from the student services office at the Faculty of Technical Sciences. The office contains all the data from 2009 onward, which were used in this research. All relevant data were gathered: high school, city of prior education, average grade from high school, and the chosen subject for the entrance exam. Data were collected over a 10-year period from 2009 to 2019. For training and testing the artificial neural network, the authors used data from the period 2009–2018 (9 years). Figure 3 shows the neural network model used to address this issue, as well as the system architecture. Figure 4 presents the web-based application for predicting the number of students.

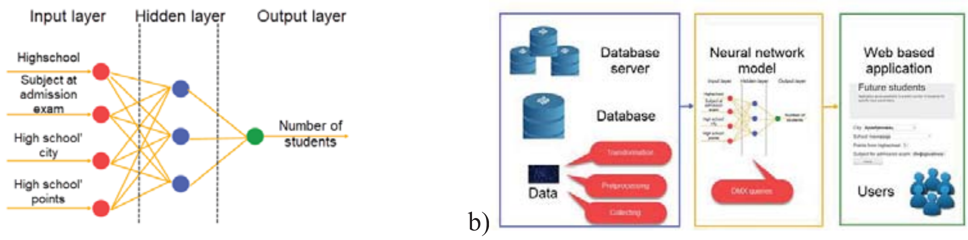

Figure 3. a) Neural network model (Blagojevic, & Micic, 2020); b) Architecture of the created system (Blagojevic, & Micic, 2020).

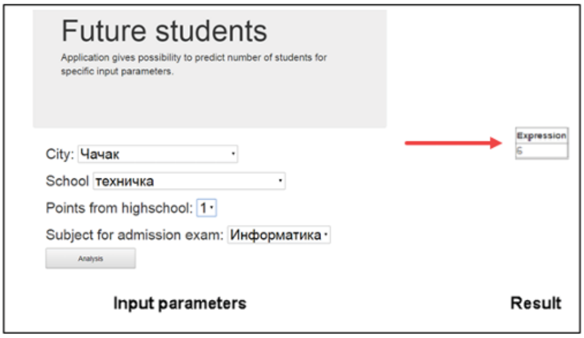

Figure 4. Web-based application (Blagojevic, & Micic, 2020).

The next application to be presented is in the domain of agriculture. Given the significance of predicting crop yield per hectare for the upcoming period, the purpose of the research by Blagojevic et al. (2016) was to provide end-users with insights into potential yield per hectare based on specified input parameters.

The research aims of this study were as follows:

Identifying the characteristics of neural networks to predict apricot/apple yields per hectare.

Enabling end-users (farmers and other stakeholders) to forecast apricot yields per hectare based on input parameters.

The dataset is randomly divided into K different subsets. Training is conducted on K-1 subsets, while the remaining subset is used for testing. This process is repeated for all possible K training and test sets. The average value of all K results represents the classification outcomes. Figure 5 depicts the neural network model, while Figure 6 shows the yield prediction calculator.

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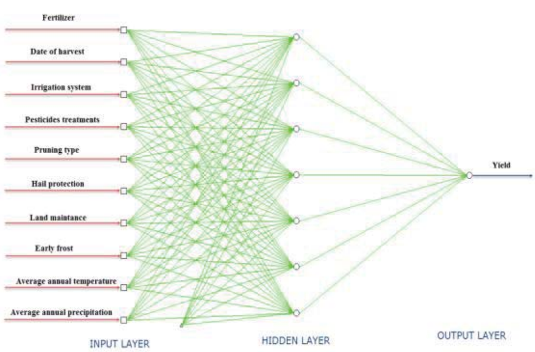

Figure 5. Artificial neural networks model (Blagojevic, 2018).

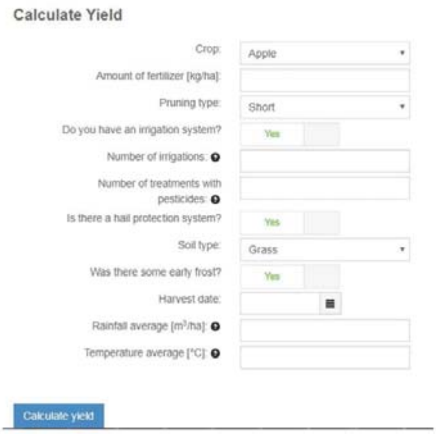

Figure 6. Yield prediction calculator (Blagojevic, 2018).

The third example focuses on the challenge of measuring passenger comfort in vehicles, particularly addressing the impact of vibrations during travel (Jovanovic et al., 2019). Passenger comfort, recognized as a crucial aspect of transportation, depends on various factors, with vibrations widely acknowledged as the most significant contributor to comfort levels. The primary factors influencing vibrations include vehicle condition, driver expertise and driving style, and road conditions. Data for the neural network were gathered through 30 measurements along the Belgrade-Cacak route. A multilayer perceptron with three layers—input, hidden, and output—was employed. Figure 7 depicts the neural network structure, highlighting selected input and output parameters.

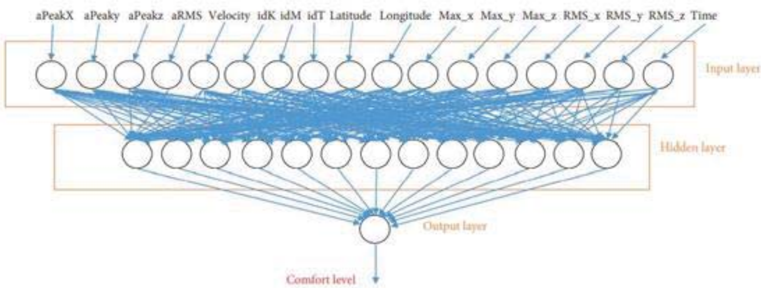

Figure 6. Architecture of artificial neural network (Jovanovic et al., 2019).

To evaluate the model in this study, 30% of the data was used for testing, while 70% of the data was used to train the neural network. Evaluation was conducted in two ways: through a confusion matrix and mean squared error. Figure 7 displays the confusion matrix and ROC curve.

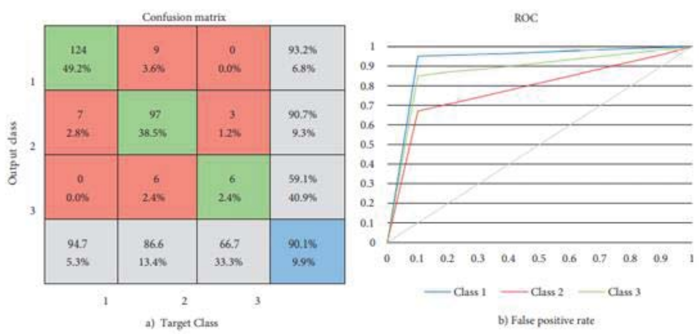

Figure 7. a) Confusion matrix b) ROC curve (Jovanovic et al., 2019).

The next application involves using neural networks to maintain optimal fluid balance in children undergoing hemodialysis for kidney failure. This is crucial for preventing both hypo- and hyper-hydration, as well as mitigating long-term cardiovascular complications. During hemodialysis (HD), excess fluid is removed from patients with compromised kidney function, typically through ultrafiltration

However, there are no standardized protocols for this procedure, and many clinicians rely on their extensive experience and personal judgment to assess the entire hemodialysis (HD) process. By leveraging artificial intelligence, machine learning, and fuzzy logic, the system establishes connections and correlations among the measured physiological parameters. These connections enable the system to predict and make decisions at specific points during the HD procedure. The entire HD treatment can be fully tailored to individual patients and remotely overseen by clinical experts. This system offers real-time, continuous, multiparameter monitoring of patients, facilitating early detection of anomalies and trend analysis of patient conditions. It ensures the precision of measurements and treatments, providing personalized feedback and guidance to patients. The application of the artificial neural network for this study is illustrated in Figure 8.

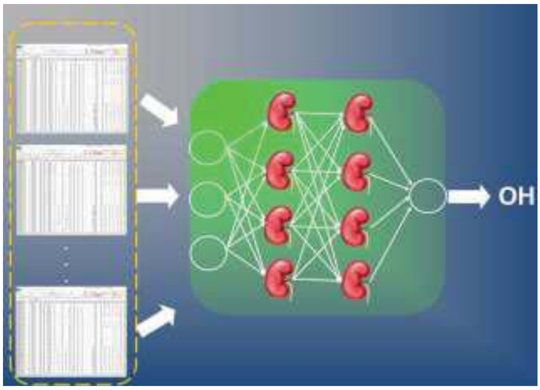

Figure 8. The application of the artificial neural network in the study conducted by Milosevic et al., (2023).

CONCLUSIONS

Based on the presented examples of the application of artificial neural networks, several conclusions can be drawn:

- Successful application of artificial neural networks is achievable across various domains of human endeavor, aimed at prediction or classification.
- The outcomes of applying this technique are tailored for use by individuals with basic knowledge and skills in information technology, without the need for expertise in artificial neural networks.
- Each application domain provides insights into future values and predictions, facilitating better planning for subsequent activities.
- Future work focuses on applying various machine learning techniques in other fields for prediction or classification purposes, aimed at enhancing business operations.

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