University “St. Kliment Ohridski”
Bitola
Faculty of Information and
Communication Technology - Bitola
Republic of North Macedonia

PROCEEDINGS

15th International Conference on APPLIED INTERNET AND INFORMATION TECHNOLOGIES

AIIT 2025

AIIT
International Conference

Bitola, November 7, 2025

University “St. Kliment Ohridski” Bitola
Faculty of Information and Communication Technology - Bitola
Republic of North Macedonia

PROCEEDINGS
15th International Conference on
APPLIED INTERNET AND INFORMATION TECHNOLOGIES

AIIT 2025

November 7, 2025 Bitola

Proceedings publisher and organizer of the conference:
University "St. Kliment Ohridski", Bitola, Faculty of Information and Communication Technology – Bitola, Republic of North Macedonia

For publisher:
Blagoj Ristevski, PhD, Full Professor, Dean of the Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia

Proceedings editors:
Kostandina Veljanovska, PhD
Željko Stojanov, PhD

Conference Chairmans:
Blagoj Ristevski, University "St. Kliment Ohridski", Faculty of Information and Communication Technologies, Bitola, Republic of N. Macedonia – chair
Kostandina Veljanovska, University "St. Kliment Ohridski", Faculty of Information and Communication Technologies, Bitola, Republic of N. Macedonia – co-chair
Željko Stojanov, University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia – co-chair

Technical preparation of the proceedings:

Kostandina Veljanovska, PhD
Marija Apostoloska Kondoska, MSc
Darko Pajkovski, MSc

Cover design:
Kostandina Veljanovska, PhD
Hristina Dimova Popovska, MSc

e-Proceedings
ISBN 978-608-5003-06-8

Disclaimer:
All rights reserved. No part of this proceeding may be reproduced in any form without written permission from the publisher. The publisher and editors are not responsible either for the statements made or for the opinion expressed in this publication. The authors solely are responsible for the content of the papers and any copyrights, which are related to the content of the papers.

CIP - Каталогизација во публикација

CIP - Каталогизација во публикација
Национална и универзитетска библиотека "Св. Климент Охридски", Скопје

004-049.8(062)

INTERNATIONAL conference on applied internet and information technologies AIIT 2025 (15 ; 2025 ; Bitola, Republic of North Macedonia)
Proceedings / 15th International conference on applied internet and information technologies AIIT 2025, November 7 2025, Bitola, Republic of North Macedonia ; [editors Kostandina Veljanovska, Zeljko Stojanov]. - Bitola : University "St. Kliment Ohridski", Bitola Faculty of information and communication technologies, 2025. - 477 стр. : илустр. ; 30 см
Библиографија кон трудовите
ISBN 978-608-5003-06-8

а) Информатичка технологија -- Примена -- Собири
COBISS.MK-ID 67608325

Introduction

As organizing partners of 15th International Conference on Applied Internet and Information Technologies AIIT 2025, we warmly welcome all participants, researchers, and colleagues joining us from various countries and universities, united by our shared commitment to advancing knowledge in the fields of computer science, applied Internet, and information technologies.

The AIIT conference has become a long-standing tradition of excellence and collaboration, co-organized by the Faculty of Information and Communication Technologies – Bitola, University "St. Kliment Ohridski," and the Technical Faculty "Mihajlo Pupin" – Zrenjanin, University of Novi Sad, Serbia. Over the past fifteen years, this partnership has fostered not only strong academic cooperation but also genuine friendship among our institutions and scholars.

This year's conference proudly continues that tradition, bringing together innovative research, diverse perspectives, and new insights into technologies that are shaping our digital future. The Scientific Program Committee once again faced the demanding task of selecting the highest-quality papers from more than sixty submissions spanning a wide range of topics—including Artificial Intelligence, Immersive Technologies, Mathematical Simulations, Data Science and Big Data Analytics, Knowledge and IT Management, Cybersecurity, Software Engineering, Data Mining, Digital Transformation, Behavioral Economics and Business, Social Engineering, Digital Humanities, Augmented Humanity, and Hybrid Intelligence. This ensures that the program reflects both scientific rigor and creative originality.

We would like to express our sincere gratitude to all reviewers for their dedicated work, as well as to the members of the Organizing Committee for their professionalism, commitment, and enthusiasm in preparing this event.

We are confident that these proceedings will provide an enriching and thought-provoking reading experience.

Conference chairs:

Blagoj Ristevski, University "St. Kliment Ohridski", Faculty of Information and Communication Technologies, Bitola, Republic of N. Macedonia (chair)
Kostandina Veljanovska, University "St. Kliment Ohridski", Faculty of Information and Communication Technologies, Bitola, Republic of N. Macedonia (co - chair)
Željko Stojanov, University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia (co – chair)

MAIN ORGANIZERS:

Faculty of Information and Communication Technologies - Bitola
University "St. Kliment Ohridski" University - Bitola
NORTH MACEDONIA
http://fikt.uklo.edu.mk/

Technical Faculty "Mihajlo Pupin" Zrenjanin
University of Novi Sad SERBIA
http://www.tfzr.uns.ac.rs/

ORGANIZATION PARTNERS:

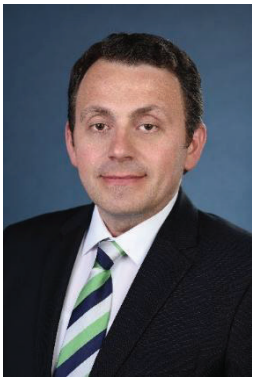
Faculty of Computer Science
Irkutsk National Research Technical University
Institute of Informational Technologies and Data Analysis
Irkutsk, RUSSIA
http://www.istu.edu/

Matrosov Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, Irkutsk, RUSSIA
http://idstu.irk.ru/

Irkutsk State Transport University (IrGUPS)
Irkutsk, RUSSIA
https://www.irgups.ru/

Faculty of Engineering South-west
University "Neophyte Rilsky"-Blagoevgrad
BULGARIA
http://www.swu.bg/

Conference Chairs



Blagoj Ristevski, University "St. Kliment Ohridski", Faculty of Information and Communication Technologies, Bitola, Republic of N. Macedonia (chair)

Prof. Dr. Blagoj Ristevski is a Full Professor at the Faculty of Information and Communication Technologies (FICT) at the University "St. Kliment Ohridski" - Bitola, where he currently serves as Dean. He holds a PhD in Technical Sciences from the Faculty of Electrical Engineering and Information Technologies, Institute of Computer Science and Informatics, at Ss. Cyril and Methodius University in Skopje. His research interests span Databases, Data Science, Data Mining, Big Data Analytics, Bioinformatics, Computer Graphics, and Cybersecurity. Prof. Ristevski has supervised numerous BSc, MSc, and PhD theses and has led several international research projects. He has served on the management committees of multiple COST actions, reviewed for numerous high-impact journals, and evaluated project proposals for the Horizon 2020 and Horizon Europe programs. Prof. Ristevski is also a senior member of IEEE.

Kostandina Veljanovska, University "St. Kliment Ohridski", Faculty of Information and Communication Technologies, Bitola, Republic of N. Macedonia (co – chair)

Kostandina Veljanovska, Ph.D. completed her education at the University "Sts. Kiril i Metodi", Skopje (BSc in Computer Science), at the University of Toronto, Toronto (MASc in Applied Engineering) and got her MSc and also her PhD in Technical Sciences at the University "St. Kliment Ohridski", Bitola, R. Macedonia. She has completed postdoc in Artificial Intelligence at the Laboratory of Informatics, Robotics and Microelectronics at the University of Montpellier, Montpellier, France. She worked as a Research assistant at the Faculty of Applied Science, University of Toronto, Canada. She also, worked at research team for Constraints, Learning and Agents at LIRMM, University of Montpellier. Currently, she works as a Full Professor in Artificial Intelligence and Systems, Computer Science and Computer Engineering at the Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" - Bitola and serves as a Vice-dean for Science and Collaboration. Her research work is focused on artificial intelligence, machine learning techniques, intelligent systems and human - computer interaction. She participated in several international and domestic scientific projects. She has published numerous scientific papers in the area of interest, as well as several monographic items. She is a reviewing referee for well-known publishing house, journals with significant impact factor in science and also, member of editorial board of several international conferences.

Željko Stojanov, University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia (co – chair)

Željko Stojanov, Ph.D. received PhD degree in Computer science and applied informatics at University of Novi Sad, Serbia. He works as a full professor at University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia. His research interests are in the fields of software engineering, software architecture, software life cycle, business informatics, learning and knowledge management, engineering education, and human aspects of software engineering. He is author of scientific papers published in refereed journals and in the proceedings of international conferences. He participated in several research and industrial projects at national and international levels. He has over fifteen years of experience working with small software companies as a consultant in the fields of software development, software maintenance and software process improvement.

Organizing Committee

Chairs

Kostandina Veljanovska (President), Faculty of Information and Communication Technologies - Bitola, N. Macedonia
Željko Stojanov, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia (vice-president)

Members

Blagoj Ristevski, Faculty of Information and Communication Technologies - Bitola, N. Macedonia
Ivana Berković, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Višnja Ognjenović, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia
Eleonora Brtka, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia
Dalibor Dobrilovic, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia
Dragica Radosav, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Biljana Radulovic, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia
Božidar Milenkovski, Faculty of Information and Communication Technologies - Bitola, N. Macedonia
Ljubica Kazi, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Snežana Savoska, Faculty of Information and Communication Technologies - Bitola,N. Macedonia
Vladimir Brtka, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Zoltan Kazi, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Siniša Mihajlović, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Velibor Premčevski, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Nikola Rendevski , Faculty of Information and Communication Technologies - Bitola, N. Macedonia
Aleksandra Stojkov, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Maja Gaborov, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Milica Mazalica, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Igor Vecštejn, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Marko Blažić, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Vuk Amižić, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Natasa Blazeska-Tabakovska, Faculty of Information and Communication Technologies - Bitola, N. Macedonia
Jovana Borovina, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Dalibor Šeljmeši, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Mimoza Bogdanoska Jovanovska, Faculty of Information and Communication Technologies - Bitola, N. Macedonia
Vladimir Šinik, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Nadežda Ljubojev, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Marina Blažeković Toshevski, Faculty of Information and Communication Technologies - Bitola, N. Macedonia
Hristina Dimova Popovska, Faculty of Information and Communication Technologies, University "St.Kliment Ohridski" - Bitola, N. Macedonia
Darko Pajkovski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" - Bitola, N. Macedonia
Marija Apostoloska Kondoska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" - Bitola, N. Macedonia
Milcho Prisagjanec, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" - Bitola, N. Macedonia
Ilche Dimovski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" - Bitola, N. Macedonia
Zoran Pavlovski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" - Bitola, N. Macedonia
Vladimir Karuović, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Evgeny Cherkashin, Institute of System Dynamic and Control Theory SB RAS, Russia
Anastasia Popova, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences, Russia
Filip Tsvetanov, South-west University "Neophyte Rilsky", Faculty of Engineering, Blagoevgrad, Bulgaria

Program Committee

Blagoj Ristevski (president), Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia,

Željko Stojanov, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia (vice-president)

Kostandina Veljanovska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia (vice-president)
Eleonora Brtka, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Višnja Ognjenović, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Dalibor Dobrilović, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Ljubica Kazi, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Dragica Radosav, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Dragana Glušac, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Borislav Odadžić, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Miodrag Ivković, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Biljana Radulović, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Ivana Berković, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Vladimir Brtka, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Zoltan Kazi, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Jelena Stojanov, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Vesna Makitan, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Nadežda Ljubojev, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Vladimir Šinik, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
Igor Nedelkovski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Aleksandar Markoski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Violeta Manevska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Pece Mitrevski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Ilija Jolevski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Dragan Grueski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Monika Markovska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Snežana Savoska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Sonja Mančevska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Mimoza Bogdanoska Jovanovska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Nataša Blažeska Tabakovska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Božidar Milenkovski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Zoran Kotevski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Nikola Rendevski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski",

Bitola, North Macedonia
Andrijana Bocevska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Tome Dimovski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Marina Blažeković Toševski, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Lela Ivanovska, Faculty of Information and Communication Technologies, University "St. Kliment Ohridski", Bitola, North Macedonia
Ilija Hristoski, Faculty of Economics - Prilep, North Macedonia
Elena Vlahu-Gjorgievska, Univerisity of Wollongong, Australia
Mimoza Mijoska, Internatonal Slavic University GAVRILA ROMANOVICH DERZHAVIN, Faculty of Technical Sciences and Informatics
Blagoj Nenovski, University "St. Kliment Ohridski", Bitola, North Macedonia
Nora Pireci Sejdiu, University "St. Kliment Ohridski", Bitola, North Macedonia
Saso Nikolovski, AUE University, Faculty of Informatics-Skopje, North Macedonia
Aybeyan Selim, International Vision University, Gostivar, North Macedonia
İlker Ali, International Vision University, Gostivar, North Macedonia
Fehmi Skender, International Vision University, Gostivar, North Macedonia
Ming Chen, Zhejiang University, China
Alexander Feoktistov, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia
Alexander Yurin, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia
Igor Bychkov, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia
Andrey Gachenko, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences. Irkutsk, Russia
Andrey Mikhailov, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences. Irkutsk, Russia
Anastasia Popova, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences. Irkutsk, Russia
Alexey Daneev, Irkutsk State Transport University, Irkutsk, Russia
Denis Sidorov, Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia
Viacheslav Paramonov, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia
Andrey Dorofeev, Institute of High Technologies, Irkutsk National Research Technical University, Irkutsk, Russia
Gogolák László, Subotica Tech - College of Applied Sciences, Subotica, Serbia
Zlatko Čović, Subotica Tech - College of Applied Sciences, Department of Informatics, Subotica, Serbia
Zora Konjović, University Singidunum, Centar Novi Sad, Serbia
Siniša Nešković, Faculty of organizational sciences, University of Belgrade, Serbia
Nataša Gospić, Faculty of transport and traffic engineering, Belgrade, Serbia
Branko Markoski, Faculty of technical Sciences, Novi Sad, Serbia
Željen Trpovski, Faculty of technical Sciences, Novi Sad, Serbia
Branimir Đorđević, Megatrend University, Belgrade, Serbia
Slobodan Jovanović, Faculty of Information Technology, Belgrade, Serbia
Željko Eremić, College of Technical Sciences - Zrenjanin, Serbia
Rajnai Zoltán, Obuda University, Budapest, Hungary
Tünde Anna Kovács, PhD, Óbuda University, Hungary
Zoltán Nyikes, PhD, Milton Friedman University, Hungary
Mirjana Pejic Bach, University of Zagreb, Croatia
Androklis Mavridis, Aristotel University of Thessaloniki, Greece

Madhusudan Bhatt, R.D. National College, University of Mumbai, India
Amar Kansara, Parth Systems LTD, Navsari, Gujarat, India
Narendra Chotaliya, H. & H.B. Kotak Institute of Science, Rajkot, Gujarat, India
Zeljko Jungic, ETF, University of Banja Luka, Bosnia and Herzegovina
Saso Tamazic, Univerisity of Ljubljana, Slovenia
Marijana Brtka, Centro de Matemática, Computação e Cognição, Universidade Federal do ABC, São Paulo, Brazil
Zoran Cosic, Statheros, Split, Croatia
Istvan Matijevics, Institute of Informatics, University of Szeged, Hungary
Slobodan Lubura, Faculty of electrical engineering, University of East Sarajevo, Bosnia and Herzegovina
Edit Boral, ASA College, New York, NY, USA
Dana Petcu, West University of Timisoara, Romania
Marius Marcu, "Politehnica" University of Timisoara, Romania
Aleksej Stevanov, South-west University "Neophyte Rilsky", Faculty of Engineering, Blagoevgrad, Bulgaria
Petar Apostolov, South-west University "Neophyte Rilsky", Faculty of Engineering, Blagoevgrad, Bulgaria
Filip Tsvetanov, South-west University "Neophyte Rilsky", Faculty of Engineering, Blagoevgrad, Bulgaria
Francesco Flammini, School of Innovation, Design and Engineering, Division of Product Realisation, Mälardalen University, Eskilstuna, Sweden
Deepak Chahal, Jagan Institute of Management Studies (JIMS, Rohini Sector-5), New Delhi, India
Abdel-Badeeh M. Salem, Faculty of Computer and Information Sciences, Ain Shams University, Cairo, Egypt
Dragan Peraković, University of Zagreb, Faculty of Transport and Traffic Sciences, Zagreb, Croatia
Gordana Jotanović, University of East Sarajevo, Faculty of Transport and Traffic Engineering, Doboj, Bosnia and Herzegovina
Goran Jauševac, University of East Sarajevo, Faculty of Transport and Traffic Engineering, Doboj, Bosnia and Herzegovina
Dinu Dragan, Faculty of technical Sciences, University of Novi Sad, Serbia
Gururaj Harinahalli Lokesh, Department of IT, Manipal Institute of Technology, Bengaluru, India
Ertuğrul AKBAŞ, Esenyurt University, Istanbul, Turkiye

CONTENT

Integrating XGBoost and Neural Networks for Accurate Student Performance Prediction in Higher Education

Buen Bajrami[1], Blagoj Ristevski[2], Kostandina Veljanovska[3]

[1,2,3] *Faculty of Information and Communication Technologies, University St. Kliment Ohridski – Bitola, Ul. Partizanska bb., 7000 Bitola, Macedonia*

[1]*bajrami.buen@uklo.edu.mk,* [2]*blagoj.ristevski@uklo.edu.mk,* [3]*kostandina.veljanovska@uklo.edu.mk*

Abstract:
This paper is dedicated to predict student performance as a persistent challenge in the academic world. One of the main reasons why institutions deal with these issues is to help students who are at risk of learning and lack successful results through personalized lessons. We have used and analyzed a hybrid approach consisting of XGBoost (eXtreme Gradient Boosting) and neural networks, which provide quite accurate predictions. This combination through XGBoost and deep learning, offers a higher reliability for building intelligent learning management systems (LMS), helping institutions make decisions in order to increase quality and positive results. We have also developed a platform that integrates both of these models and facilitates the practical usage of these cases. We have developed the platform through web technologies, with PHP used for the logical part of the platform and MySQL for data storage and structuring student data.

Keywords:
Student performance prediction, XGBoost, neural networks, educational data mining, interpretability in AI

1. Introduction

One of the main challenges in higher education remains the prediction of student performance that involves the use of analytical techniques and artificial intelligence to forecast outcomes in future courses, track progress across semesters, and identify difficulties in specific topics. Universities often face the need to understand why some students show higher success and others show poor success. Therefore, through accurate predictions, these institutions help to intervene earlier, offering additional lessons to students who have poor success and improving the learning process. Therefore, the use of educational data and modern artificial intelligence techniques is constantly increasing its impact. Traditional methods, for example, linear statistical models, enable easy interpretation by teachers. They show that the average grade and class attendance predict high academic results. However, student behavior is inherently complex, and often there are no linear relationships, which these traditional models cannot predict. Therefore, in similar situations, new machine learning models such as XGBoost or neural networks are being used, which can reveal hidden patterns and provide more accurate results. We have proposed in our study a hybrid approach, where a weighted linear formula is used as an initial step to provide transparency and understanding of the main factors, but then the results are passed to more powerful models such as XGBoost and neural networks to improve the prediction accuracy. Through this hybrid model we aim to balance interpretability, in terms of providing clear insights into the factors that influence student outcomes, and performance, in terms of achieving high prediction accuracy, thereby offering a practical and reliable tool for universities. Through the obtained results we have seen that this approach achieves a higher level of prediction accuracy, enabling institutions to design personalized policies for students.

The rest of the paper is structured as follows. Section 2 provides a review of recent literature and related work. Section 3 outlines the research methodology and the approaches employed for the project implementation. Section 4 presents and analyzes the obtained results, along with a logical part of the code, while the remaining implementation details are made available on GitHub. Section 5 is dedicated to discussion, and Section 6 concludes the paper with key findings and directions for future work.

2. Related work

In recent times, student performance prediction has become one of the most important areas within learning analytics. Our research has focused mainly on deep learning (DL) models and careful feature engineering based on data from universities as well as publicly available datasets from open repositories. Studies show that DL has an advantage over traditional models, as these are able to capture non-linear dependencies and different dynamics over time [1] [2]. Usually, the process of building such a system goes through several steps: as a first step, the source of the data to be used is determined (such as grades, demographics, and LMS data), which are then cleaned and transformed into features that better represent student behavior and progress. After this process, predictive models are trained using different algorithms, including Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks, a transformer, or even combined. Finally, the results obtained are interpreted with the aim of supporting academic decision-making [3] [4]. One of the new trends in prediction is hybrid models. These approaches offer a combination of knowledge gained from domain expertise and the power of machine learning (ML) algorithms. A simple example is the use of a weighted formula to combine indicators such as grade point average, demographic factors, and subject difficulty, before subjecting this data to an advanced model such as XGBoost or an artificial neural network [5] [6]. Studies show that when integrating data from different sources such as demographic, academic, and LMS activity, hybrid models offer higher robustness than single DL or ML models [7] [8]. This is especially important in cases where data changes over time or when models need to be applied to other situations [9]. The inclusion of confidence intervals and reliability measures has been evaluated as a practice that increases certainty and transparency for decisions made based on model results [10] [11]. Building on recent developments, our approach starts with a formula that we have designed from the expertise of our research domain, and then we have used the XGBoost model and artificial neural network for more advanced processing, which is aligned with the new trends that we have identified in the literature. Our research suggests that this type of combination improves the accuracy of the prediction, offering good opportunities for real-time future interventions and for providing reliable results in the development of educational policies [12] [13].

3. Methodology

This study uses a hybrid approach to predict academic performance, aiming to improve accuracy and provide more practical insights for academic use. The formula integrates previous grade point averages (GPAs), progress trends, demographic factors, and subject difficulty coefficients, providing high interpretability based on domain expertise [13]. This formula serves as input to an Ensemble Learning model, which uses XGBoost to capture nonlinear relationships and efficiently process structured data [14], as well as a neural network to identify complex and hidden patterns [15]. The use of such hybrid approaches in educational data mining has demonstrated high accuracy and improved prediction reliability [16] [17], while the combination of interpretive and complex models ensures an optimal balance between transparency and performance [8]. In this study, we used this model since the same one in another scientific project was tested on a sample of 12 subjects, achieving a confidence interval of 97.5% and an average reliability of 97.8%, confirming the validity of the proposed approach [18]. To adapt it to our dataset of student records, the prediction was structured in two stages. By combining a hybrid model between XGBoost and neural networks.

Stage I, involves a basic prediction with a neural map, where grades for future courses are estimated by calculating a weighted average of related course results using the correlation map.

Missing values are ignored rather than treated as zero, and if no prior records exist (e.g., first- year students), the prediction defaults to the current GPA.

Stage II, then combines this result with the GPA and adjusts it with demographic factors, making sure both interpretive and contextual variables are considered. This two-stage design allows the model to balance interpretability in the first stage with predictive power in the second stage. This combination can be regarded as a metamodel—similar to a second network layer or the regularization model of XGBoost.

4. Results

In this section, we present a practical implementation of the proposed hybrid model and the results obtained during testing. We have evaluated the model using real student data, and combining demographic and academic indicators to ensure a realistic prediction process. In addition, we describe the platform structure, the technology used, and the steps taken to integrate XGBoost with neural networks. The following subsections provide details on the data, system architecture, and analytical results of the prediction model.

4.1. Data and Platform

As for the dataset we used, it covers both the academic aspect of the students—namely their grades and overall academic performance—and the demographic aspect. A complete list of attributes is provided in the table below.

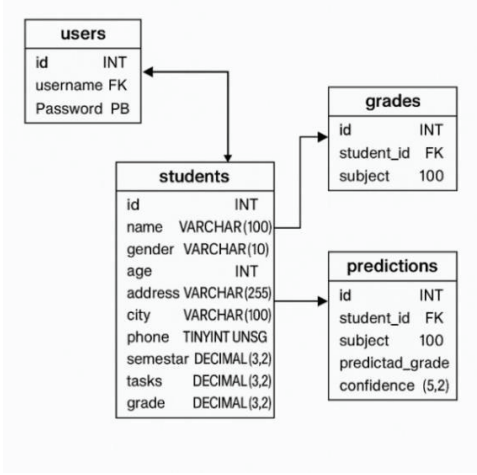


Figure 1. Entity-Relationship (ER) diagram of the database

At this stage, we have displayed another table which presents the name of the platform, the web languages used and their role in the development of our platform, as well as the database which served us to store data for students.

Table 1:
Student performance prediction platform

Field	Specification
Platform	Integrating XGBoost & Neural Networks for Student Performance Prediction
Front-End	HTML, CSS, JavaScript
Back-End	PHP
Database	MySQL

A. Block diagram of the platform

In this section, we present our project as a flowchart, illustrating the workflow of the proposed hybrid model for predicting student performance. The complete implementation,

including the full code, is available as open-source on the GitHub platform [19].

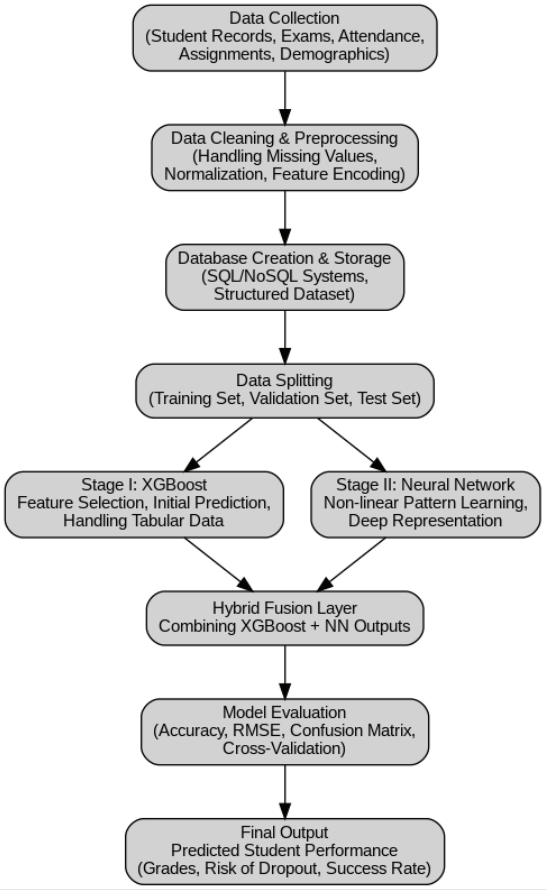


Figure 2. Block diagram of the proposed hybrid model

4.2. Results and Analysis

In this section, we present the results of the hybrid model consisting of XGBoost and neural networks. The results showed a high degree of accuracy in predicting performance by combining ML techniques, namely XGBoost and deep learning techniques. Feature analysis showed that GPA and attendance were the two determining factors in the prediction, followed by completion of assignments and other academic factors. Overall, our hybrid model demonstrated the ability to extract hidden patterns from the data and, at the same time to provide more reliable results, making the model quite suitable for its integration into intelligent systems in learning management.

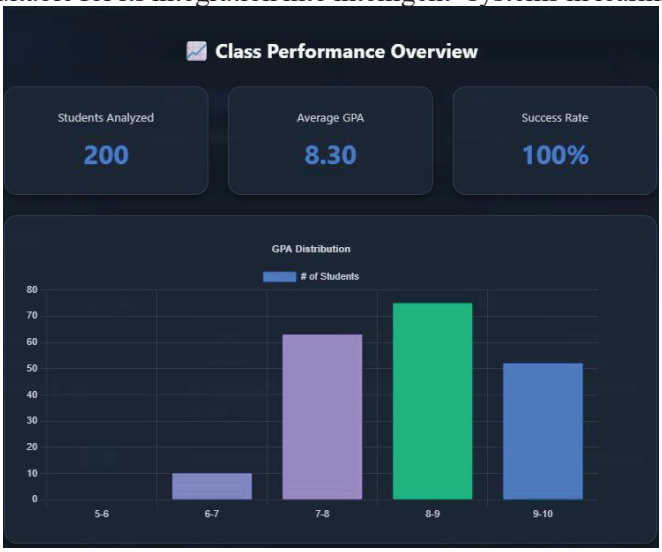


Figure 3. Student performance prediction platform statistics

In the two figures below we have presented the appearance of our platform, Figure 3, and we have presented the main page with the data of all students. Also the menus such as adding students, such as age, gender, residence, faculty, elected subjects, completed and incomplete exams, etc. Overview and Methodology are used for prediction. In Figure 4, we have made the general presentation of the statistics of a respective student after clicking on the View Full Analysis button.

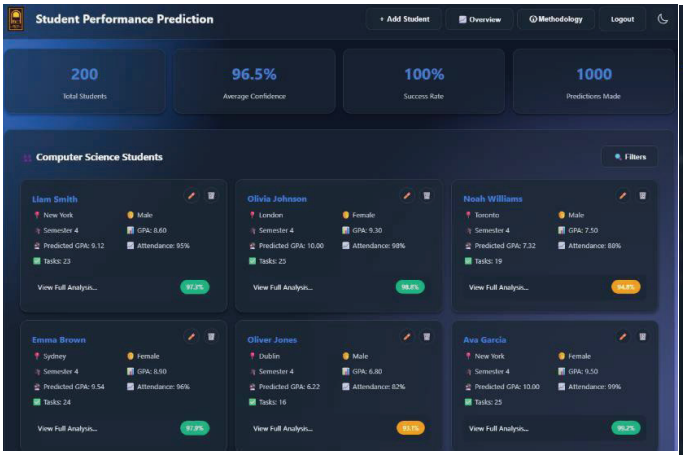


Figure 4. Platform Homepage

Figure 5. Dashboard general analysis for student

In the two figures below, we have presented all the subjects and grades. On the left side, we have listed the completed subjects, while on the right side, we have shown the predicted results for the subjects. The completed semesters, while below are the predicted semesters that remain to be completed are shown. Are shown in the Figures 5 and 6.

Figure 6. Grade details prediction

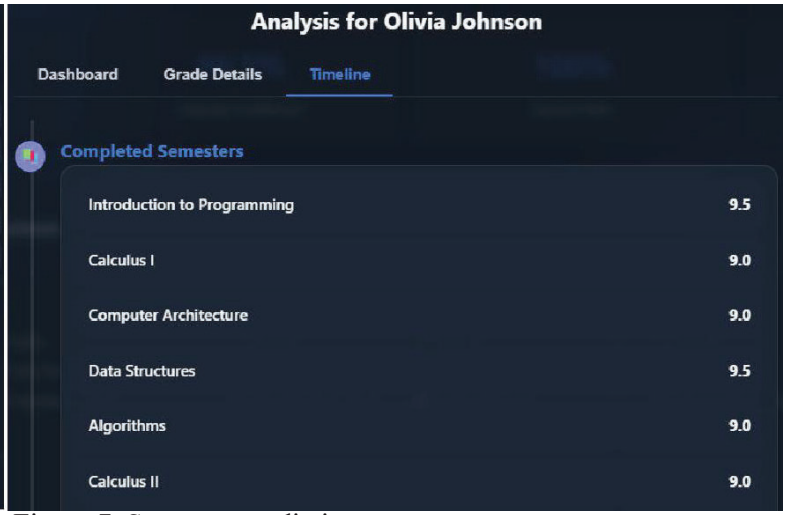


Figure 7. Semester prediction

These visualizations not only show academic progress, but also highlight how the system adjusts predictions based on student performance patterns. By identifying subjects where a student may be struggling, the platform can serve as a supportive tool for academic advising. This makes the prediction model useful not only for analysis, but also for proactive guidance and improvement of learning outcomes.

5. Discussion

The hybrid (ensemble) approach proposed in this paper combines the best of both models: we leverage XGBoost to incorporate global aspects of student performance and demographic

factors, while using an integrated neural network (in the form of a weight map between subjects) to capture connections between different subjects. The key idea is that a student's performance in certain core subjects (e.g., mathematics, algorithms, programming) influences his or her future performance in more advanced subjects (e.g., artificial intelligence, machine learning, computer graphics). This model has the potential for early warning systems by identifying students with deficiencies in specific subjects. However, this approach can be a bit challenging in terms of data, which we believe may be difficult to generalize across universities. We believe that expanding the data set to include socio-economic aspects could have a positive impact, especially in those universities where such data is available.

6. Conclusion

This study shows the importance of using hybrid approaches in predicting students' academic performance, through the combination of two models XGBoost and neural networks. In our case, the results have shown that the integration of a powerful algorithm such as XGBoost, for handling structured data, by adding the ability of neural networks to capture complex and nonlinear patterns, provides a significant increase in accuracy compared to traditional models. This model can help universities predict high-risk students by presenting their shortcomings and enabling institutions to offer personalized lessons. The hybrid approach, in addition to improving the prediction performance, creates a balance between computational efficiency and analytical flexibility. Based on the performance of our SPP platform, and the tests we have done, we assess that it has achieved our expectations by being the first project based on world research in recent years. This study analyzed the key requirements, challenges, and future perspectives of academic performance prediction. For future work, we could extend the hybrid model with broader data sources and advanced feature engineering, and test it across universities to assess its robustness and scalability.

References:

[1] Muhammad Gul et al., "Data-driven decisions in education," *Information Retrieval Journal,* vol. 28, p. art. 86, 2025.

[2] M. Fazil, "A Novel Deep Learning Model (ASIST)," *Journal of Learning Analytics,* Vols. 11, no. 2, p. 23–41, 2024.

[3] E. Howard, "OuladFormat R Package: Preparing the Open University Learning Analytics Dataset for Analysis," *arXiv,* vol. arXiv:2501.08366, 2025.

[4] Z. Pan, "A Systematic Review of Learning Analytics," *Journal of Learning Analytics,* Vols. 11, no. 2, p. 1–21, 2024.

[5] C. Molla-Esparza, "Applications of Learning Analytics," *Computers & Education: X Reality,* vol. online first, p. PII: S2666374024001146, 2025.

[6] T. Althaqafi, "Enhancing student performance prediction," *Discover Computing,* vol. 28, p. art. 79, 2025.

[7] T. K. V. B. a. M. K. Harleen Kaur, "“An ensemble deep learning model for classification of students as weak and strong learners via multiparametric analysis,”," *Discover Applied Sciences,* vol. 6, p. art. 595, 2024.

[8] W. Ahmed, "“Machine learning-based academic performance prediction with explainability for enhanced decision-making in educational institutions,”," *Scientific Reports,* vol. 15, p. art. 26879, 2025.

[9] Y. R. a. X. Yu, "“Long-term student performance prediction using learning ability self-adaptive algorithm,”," *Complex & Intelligent Systems,* vol. 10, p. 6379–6408, 2024.

[10] R. K. Veluri, "“Learning analytics using deep learning techniques for efficiently managing educational institutes,”," *Materials Today: Proceedings,* vol. 51, p. 2317–2320, 2022.

[11] D. P. a. G. V. Ahmed Al-Zawqari, "“A flexible feature selection approach for predicting students’ academic performance in online courses,”," *Computers and Education: Artificial*

Intelligence,, vol. 3, p. art. 100103, 2022.

[12] Y. Lin, "A Comprehensive Survey on Deep Learning Techniques in Educational Data Mining," *Data Science and Engineering,* 2025.

[13] W. H. a. N. A. A. R. Amirah M. Shahiri, "A Review on Predicting Student's Performance Using Data Mining Techniques," *Procedia Computer Science,* vol. 72, p. 414–422, 2015.

[14] T. C. a. C. Guestrin, "XGBoost: A Scalable Tree Boosting System," *Proc. 22nd ACM SIGKDD Int. Conf. on Knowledge Discovery and Data Mining (KDD'16),* p. 785–794, 2016.

[15] H. A.-R. S. Al-Barrak, "Predicting Students Final GPA Using Decision Trees: A Case Study," *International Journal of Information and Education Technology,* Vols. 6, no. 7, p. 528–533, 2016.

[16] C. R. S. V. F. Márquez-Vera, "Predicting School Failure and Dropout by Using Data Mining Techniques," *IEEE Journal of Latin-American Learning Technologies,* Vols. 8, no. 1, p. 7–14, 2013.

[17] A. Adefemi, "Deep Learning Models for Academic Performance Prediction: A Systematic Review," *Mathematics,* Vols. 12, no. 3, p. 59, 2024.

[18] H. Kaur, "An Empirical Study of Ensemble Techniques for Predicting Student Performance," *Journal of Big Data,* Vols. 12, no. 4, 2025.

[19] B. Bajrami, "Student Performance Prediction Platform, Source code," *Link [Aviable]: https://github.com/Buen-Bajrami/spp-platform.*