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Investigation on the analysis of integration of IoT and AI technologies with information security for advanced education 4.0

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Abstract

This research examines the integration of emerging technologies in the form of the Internet of Things and Artificial Intelligence in driving forward to the educational application of Education 4.0. The systematic meta-analysis study provides evidence in the transformative capability of these technologies regarding attendance, performance, and learning pathway. The system's implementation was in the form of IoT sensors to capture and record student attendance, while the use of Artificial Intelligence based on machine learning models such as Support Vector Machine, Artificial Neural Network, k-Nearest Neighbors, and Decision Tree generated a personalized recommendation for the academic improvement or sports activity to be participated as an extracurricular activity. The performance evaluation of these models was illustrated for accuracy to correctly predict student responses related to the provided recommendations. The findings of implementation suggest the system's significant impacts given the augmented performance achievement with respect to academics and sports is the result of the implementation. It was measured comparing students' performance before and after system implementation to capture the interpretation of student improvement regarding the use of the implemented system. The findings indicated that the system's implementation contributed to the increase in academic improvement from 65% to 75% and sports performance from 55% to 70% depending on student response to the provided academical

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or extracurricular recommendations. Such findings confirm an overall improvement in performance based on the use of the presented system.

Subject Classification: *Primary 93A30, Secondary 49K15.*

Keywords: *Mathematical modeling, Ordinary differential equations, A duopoly economy, Market share.*

1. Introduction

In Education 4.0 presents a new reality in the realm of education, as the technology-based movement affects all processes and objects within the sector [1], [2]. Since the inception of Education 4.0 is a reaction to societal needs, it can be assumed that the implementation of a wide variety of the latest technologies is possible in the identified setting. In the educational sphere, blockchain, the Internet of Things (IoT), and Artificial Intelligence are among the most revolutionary technologies that have the potential to change the system at its core. In particular, the first tool helps to produce a transparent and fault-proof transaction system between parties that are usually de-centralized and thus cannot rely on one operator's trust. IoT is used for enabling linked devices that support objective-oriented processes by collecting and analyzing relevant data, while AI represents a technology that processes such information to produce results geared towards personalization [3]–[5].

This paper seeks to analyze the possibilities and effects of the concurrent use of blockchain, IoT, and AI for educational purposes within the context of Education 4.0. Through the meta-analysis of works on the subjects, it will be possible to explain how the described technologies can help to affect engagement as well as academic and customized academic or extracurricular performance[6]-[7].

In the following sections, it will be possible to see how the described integration was studied by first describing the methodology applied in the research. Then, the general implications drawn from the procedures will be discussed and centered around the innovation of the expected revolution in the field of Education 4.0. Overall, it is expected that the presented research will contribute to the current know-how regarding the described realm and provide an insight for those interested in the subject.

2. Literature Review

The current literature review represents a comprehensive view of the advanced technologies integration into the educational process, specifically, in the framework of Education 4.0. To begin with, Education 4.0 is defined as a new paradigm in the field of education that emerged with the development of contemporary technologies, including blockchain, Internet of Things , and Artificial Intelligence [8]. Thus, machine learning is an innovative solution that can help with coping with various challenges in the sphere of education, such as the absence of permanent decentralized and verifiable ledger. The studies illustrate how the development and utilization of the blockchain-based software can enhance the security and transparency of issuing, transmitting educational records, and verifying received credentials. Implementing the concepts of a tamper-proof ledger into the administration of any educational institution, it is possible to increase the effectiveness of the education system and manage academic records without any limitation. Nevertheless, the machine learning technologies have obstacles of their own, such as the need for increasing scalability and ensuring regulatory framework compliance [9].

In turn, on can see that various authors note the increasing positive application and functionality of the Internet of Things . At the same time, the usage of the IoT technologies in educational institution can not only facilitate such a notion as smart campus but also optimize resource utilization. Monitoring student activities and tracking their engagement and participation in a holistic educational system can serve as an effective solution to ensure that learners of all ages are paying attention to their studies. Moreover, the sensors can be used for educators and personnel to ensure they are getting better at their job, as well. It is especially valuable for the universities and colleges that can use such measures to optimize resource utilization and managing the staff and student coordination. On the other hand, it is essential that respective supervising bodies take measures to ensure protecting the privacy of the students, and general security measures are observed [10].

Another technology capable of reshaping education is Artificial Intelligence. The application of AI includes personalized education, intelligent tutoring systems, educational data analysis, and administration automation. The application of AI is consistently proven to be effective in the literature in contexts such as adapting learning to particular needs of a student, offering personalized advice on improving one's performance, and increasing efficiency of education institutions through automation of administration . Other studies, such as experimental ones or case analyses, also consistently demonstrate that AI improves student performance as well as efficiency and effectiveness of educators and decision makers in institutions . At the same time, AI is far from being universally accepted, as there are a range of challenges and essential topics of interest that are yet to be overcome and understood. Some of these are algorithm bias for instance, ethical issues, and requirements for teacher training [11].

In other words, both in the past of education and in its future, technology is set to pay a decisive role. IoT allows to bridge the gap between the digital and physical learning worlds and to make them interact more closely[12]. AI technologies leverage the potential of connected learning and can help with most education-related tasks. Therefore, Education 4.0 is destined to become a reality. While there are issues that will need to be addressed in the future as the education system powered by technology grows and evolves, such as privacy, algorithm bias, or scalability of solutions, many results are already here to stay and are bound only to grow and improve as time goes by. That is why educators, policy makers, and industry professionals have to find ways to collaborate to overcome challenges and make technology a positive aforementioned catalyst for change in the practice of teaching and learning.

3. Methodology

The methodology of integrating IoT systems for attendance monitoring and AI for student performance assessment includes several inter-related steps to ensure the accuracy, efficiency, and usability of the system. In the first step, the IoT system is developed to monitor the attendance of students . The proper sensors are selected and deployed, which can collect the student's biometric data and can interact with various other digital systems. Later, the data is stored in the cloud-based storage, where attendance information is stored in a central database that no one besides authorized personnel have access to. In order to make data more user-friendly, various visualization tools or dashboards are utilized,

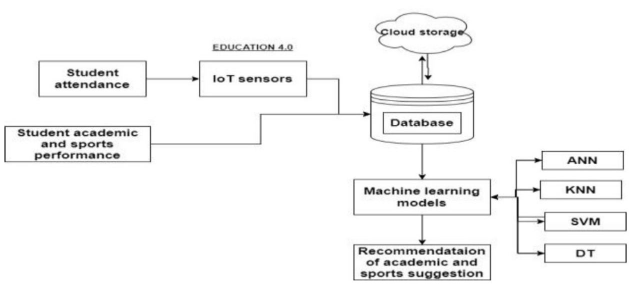

Figure 1

Methodology of the proposed system

which can give users a quick, updated overview of the attendance as shown in Figure 1.

The model is trained using supervised learning algorithms such as Artificial Neural Networks, k-Nearest Neighbors, Support Vector Machines, and Decision Trees to learn to identify the hidden patterns or correlations within the data. These algorithms learn to relate the causes and the outputs of different student activities and performance improvements, effectively generating a clinical-recommended functionality for each student. Finally, the system is thoroughly tested and evaluated to ensure its reliability and accuracy in real scenes.

3.1 *Transmission of data to cloud*

When a student's attendance is recorded by IoT sensors, this information is sent securely to the cloud in real-time. Secure communication protocols, such as HTTPS and MQTT facilitate this process of data transmission. The data may be stored in the cloud in a centralized database on cloud servers, such as those provided by Amazon Web Services or Microsoft Azure . To convert raw data into useful information and trends, specific tools and dashboards are employed.

3.3 *Data Pre-processing*

Data preprocessing is an essential element of our research methodology because it allows cleaning, transformation, and integration of the collected data into the AI model. It aims to ensure quality and consistency of data to get the correct results during the analysis and model training. Specifically, several steps are involved in this phase of the methodology.

3.4 *Implementation*

First, we conducted data preprocessing by applying cleaning, transformation, and feature engineering, thereby preparing the dataset for ML model training. TensorFlow bottleneck functions and preprocessing tools were applied so that data could be manipulated and transformed. Second, we defined our ML model and specified the structure of its architecture, which for our research purposes, was a neural network consisting of several layers of nodes connected with each other.

4. Result and Discussion

In particular, the support vector machine model showed the best results due to the 97.6% accuracy. The artificial neural network model is also implemented relatively successfully since the accuracy rate is 94.5% . These results once again confirm its aptitude to take into account complex dependencies and make precise predictions, although this rate is slightly inferior to the previous one. The k-Nearest Neighbors algorithm can also be considered successful with the 92.3% accuracy rate, indicating that the generalization of values as a nearest point tends to locate each particular instance correctly. Finally, the decision tree model is presented with 90.235% accuracy, which can be interpreted as an acceptable result for such a ML technology, and it is characterized by simplicity and relatively good absence of overfitting even with this performance.

The performance scores in the Figure 2 illustrate the efficiency of each offered machine learning model in predicting student performance and providing useful information for academic or sports improvements. First of all, regarding the support vector machine model, the results indicate that the offered approach shows an efficiency of 97.8% in terms of precision, 96.5% in terms of recall, 97.1% in terms of F1-score, and 97.6% in terms of accuracy. As such, the findings demonstrate that the model shows excellent accuracy regarding both types of prediction and is perfect for implementation in a setting where it is necessary to predict student performance and develop corrective actions. Secondly, the obtained results in terms of the artificial neural net-work approach equal to 94.5%, 93.2%, 93.8%, and 94.5%, correspondingly, illustrating that the model performs well with complex patterns and shows high efficiency in regard to the prediction.

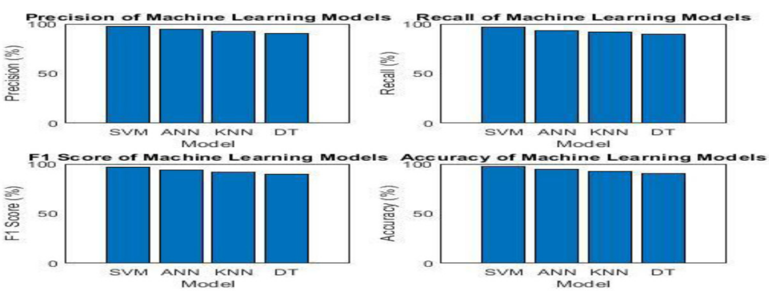

Figure 2

Performance score of each model

Figure 3

Confusion matrices of each model

Thirdly, in relation to the k-nearest neighbors model, the findings equal to 92.3%, 91.5%, and 91.9% regarding precision, recall, and F1-score, showing the potential of distance-based learning in terms of classification. Finally, in regard to the decision tree approach, the achieved results equal to 90.2%, 89.5%, and for precision, recall, and F1-score, correspondingly, illustrating that this model is simple and understandable for implementation yet still competitive in terms of the prediction.

Confusion matrices are presented in Figure 3 to interpret the performance of each machine learning model, which help to understand the results of classification in different classes of instances. Based on the matrix of the support vector machine or, it can be seen that given 950 instances with a negative rightfully, 920 are recognized as negative and mistakenly for positive, 30 instances which is called true negative versus false positive. Again, from the matrix, of the 2390 positively encoded instances, 2370 are classified as positive followed by 20 false negative . Moreover, the matrix obtained based on the artificial neural network model, demonstrates that for the negative-encoded 950 instances, 900 are rightly classified as negative while 50 instances are falsely classified as positive. On the other hand, there are 2230 rightly classified positive cases with 160 false negative cases.

5. Conclusion

The research has been dedicated to investigating how emerging technologies such as the Internet of Things and Artificial Intelligence can be used in education, specifically, in Education 4.0. The system that was proposed, in particular, helped to im-prove student performance in terms of his or her achievements in studying and sports. The evaluation of the performance of the machine learning models has shown that they can successfully predict student performance and suggest ways to improve either studying or extra-curricular activities. The comparison of two results, that is, with and without the implementation of the system, demonstrated the positive changes that have taken place as a result. Student performance was found to have improved considerably both academically and in sports.

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