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Machine Learning, Neural Networks, Internet of Things, Blockchain Technologies in Education

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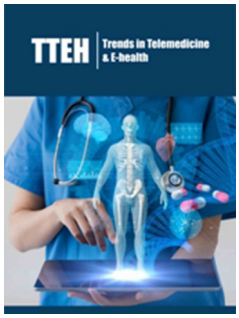

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Abstract

The purpose of the article is to study the using of technologies: Machine Learning (ML), Neural Networks (NN), Internet of Things (IoT) and Block Chain (BC) to improve the effectiveness of education. The study examines the limitations of traditional education and the impact of digitalization. The advantages and systems from the separate use of machine learning and neural networks are presented: predicting academic performance, analyzing student behaviour, and verifying knowledge. The IoT architecture in education is considered, consisting of three levels: perception, network and applications. The process of integrating ML, NN, IoT, and BC technologies has been developed, including data collection using IoT devices, analytical data processing using ML and NN, and reliable data storage using blockchain. Based on this scheme, the structure of the integration system is proposed, consisting of modules for data collection, intelligent analysis and storage, confirmation, and data protection.

Keywords: Machine learning; Neural networks; Internet of things; Blockchain; Education

Introduction

With the development of IT technologies, Massive Open Online Courses (MOOCs) [1] and distance learning have become powerful tools to expand access to education. Platforms such as Coursera [2], edX, and Khan Academy [3] provide students with access to courses from the world's leading universities. Advantages: accessibility of education for students from remote regions; the opportunity to study at a convenient pace and choose suitable courses. Limitations: There is no direct interaction between students and teachers. Learning Management Systems [4] such as Moodle, Blackboard, and Google Classroom play a key role in modernizing the educational process. These platforms integrate learning materials, assignments, assessments, and communication, providing centralized access to educational resources. Advantages: simplification of the organization of the educational process; an opportunity for teachers to analyze student activity and adjust the learning process in real time. Limitations: The need for technical literacy among users; the risk of data leakage and the possibility of cyber-attacks. The main problems that new technologies are trying to solve. Modern technologies allow us to record the results of each student, monitor his activity and identify weaknesses. The use of ML and Learning Analytics methods helps teachers build predictive models for early identification of students at risk of poor academic performance. An example is the use of Early Warning Systems. The data on the preferences, level of preparation and speed of assimilation of the material by the student are analyzed in order to automatically adjust the educational content and assignments. Example: Adaptive platforms ALEKS [5] and Dream Box [6].

Simplified document management and confirmation of qualifications

Blockchain technologies allow you to create secure databases for storing educational documents. Application examples: Verification of diplomas and certificates through

blockchain networks (MIT Digital Diplomats project [7]). Creation of decentralized repositories for storing academic performance data. Combining LMS with analytical systems for automatic recommendation generation. IoT integration for monitoring students' physical activity (via wearable devices) and learning conditions in real time. Creating ecosystems in which student data is transferred between platforms in a secure format, supporting their educational path at all levels of learning.

Machine Learning, Neural Networks, AI and Blockchain in the Educational Process

Predicting academic performance

Approaches to predicting academic performance include the use of Random Forest and Gradient Boosting methods. Factors are processed: Personal data of students, academic history, patterns of behavior on the platform. Duolingo platforms [8], uses algorithms to personalize recommendations; dynamically adapts the complexity of exercises based on real user results. In more advanced scenarios, machine learning models analyze data and neural networks are used to analyze user behavioral patterns in real time.

Analysis of students' behavior

Educational platforms like moodle [9] accumulate data on student activity, including the number of course visits, the duration of work on the platform and the frequency of assignments. Based on these data, behavioral models are formed that allow analyzing the dynamics of the educational process. The use of time series algorithms in NN, such as LSTM, provides an opportunity to predict a decrease in student engagement in educational activities in the short term.

Automatic knowledge verification

The use of GPT models in the educational field opens up opportunities for automatic verification of written papers and providing feedback in natural language. OpenAI models are able to analyze texts, highlighting their strengths and weaknesses, which helps students improve their work and at the same time reduces the burden on teachers. The architecture of the IoT network in education consists of three levels.

a. Perception Layer: Devices for data collection, such as temperature sensors, lighting sensors, and biometric analysis devices.

b. Network Layer: Communication protocols that provide real-time data transmission. For example, in smart classrooms, Wi-Fi and LoRaWAN networks are used to transfer data to servers.

c. Application Layer: Analytical platforms and user interfaces that interpret data for decision-making. Dashboards for administrators of academic buildings can show which classrooms are underutilized.

A key feature of IoT in education is the ability to integrate with existing LMS systems and provide a personalized approach to the organization of the educational process. Presence sensors can automatically detect student attendance using RFID or infrared scanning technologies, which simplifies monitoring attendance at lectures and seminars [10]. Devices like fitness trackers and smart watches can record students' physical activity in real time during class.

The use of blockchain to verify educational documents [11]

Blockchain technology provides a reliable and transparent tool for storing and verifying the authenticity of educational documents, solving the problem of their forgery. The School of Programmers has implemented a blockchain to publish graduation certificates. The system includes a smart contract, an Ethereum node for sending and verifying transactions, an EduApp platform for publishing data, and a page for verifying the authenticity of certificates. Access to the data is provided with the consent of the graduate through a private key. The blockchain does not store personal data, but encrypted records in the form of a hash, which provides additional security. Such solutions simplify the document verification process for employers and universities, reducing administrative costs and saving time. Graduates can instantly confirm their achievements, which makes the system convenient and efficient.

Creation of secure databases on student academic performance

Blockchain allows you to securely store student data, including their grades, projects, and certificates. Such databases guarantee the privacy and accessibility of information, as well as provide the opportunity for its transfer between institutions. The European EBSI (European Blockchain Services Infrastructure) project includes the development of blockchain solutions to simplify the exchange of educational data between EU universities [12].

a. Micropayments and tokenization: blockchain is actively used to automate financial transactions, such as payment for courses, remuneration for completing training assignments or participating in projects. An example is the Bit Degree platform [13], where students receive tokens for successful completion of courses, which they can use to pay for other courses or cash out.

Decentralized management of educational processes

Blockchain-based smart contracts can be used to automate administrative tasks such as enrolling in courses, managing student finances and issuing certificates. An example is the use of smart contracts in the Blockchain for Education system [14].

The Structure of Integration of ML, NN, IoT and Blockchain for Education System

The integration of ML, NN, IoT and blockchain opens up new opportunities for the transformation of the educational process. These technologies have complementary advantages: ML and NN provide data mining, the IoT is responsible for the rapid collection and transmission of data, and the blockchain provides reliable storage and protection against forgery. This combination of technologies makes it possible to create systems that can adapt to

the individual needs of students, while ensuring transparency and reliability of all processes. The integration scheme may include the following steps. Data Collection (IoT): Sensors, wearable devices, and LMS (Learning Management Systems) platforms collect data on students' behavior, activity, and academic performance.

Intelligent analysis (ML/NN)

Machine learning algorithms analyze data to identify patterns, predict student success and create personalized recommendations. Data storage: blockchain guarantees the immutability of data, which is important when storing academic performance information, certificates, and other documents. It based on the proposed scheme, we will define the integration structure, which consists of three modules. Data acquisition modules include sensors and IoT devices. Devices placed in smart classrooms will monitor parameters such as attendance, noise level, lighting, and temperature. Wearable devices collect data on students' physical activity and their interaction with educational materials. The integration of LMS with IoT allows you to record students' progress, track their activity in courses and analyze their progress. The Moodle platform can interact with IoT devices to monitor the time spent studying certain materials.

The module of intellectual analysis

Cloud computing provides opportunities for large-scale data analysis, while local servers can process sensitive data, eliminating the risk of leakage. ML/NN algorithms will predict academic performance based on attendance data, task completion time and student engagement level. More complex algorithms based on neural networks will analyze the emotional state of students, identify their preferences and form personalized recommendations.

The module for storing, verifying and protecting data

A blockchain network is used to save academic performance and attendance data, which guarantees their immutability and transparency. For example, each successfully completed course can be recorded in the blockchain, which eliminates the possibility of falsifying the results. Smart contracts can provide automatic points to students for completing assignments, tests, etc.

The usage process

In smart buildings, the integration of IoT, ML and blockchain makes it possible to optimize the management of buildings and educational processes. IoT sensors can monitor lecture attendance, monitor classroom conditions (lighting, temperature) and adapt them to the current needs of students. Attendance data is recorded on the blockchain, providing transparency and the possibility of further analysis. IoT and blockchain-based authentication systems can identify students using wearable devices, simplifying the process of entering a building or online platform.

Support for individual educational programs

The integration of IoT, ML and blockchain allows you to create unique training programs for each student. For example, homework data collected through the LMS platform can be analyzed using ML to identify student strengths and weaknesses. Based on this analysis, the system offers personalized recommendations such as additional materials or changes to the training schedule. Student's achievements are recorded in the blockchain, which makes it possible to use this data to receive scholarships, certificates, or employment opportunities.

Automated assessment systems

The combination of ML and blockchain makes it possible to automate the knowledge assessment process. For example, deep learning algorithms can check texts or calculated assignments, providing detailed feedback from the teacher. The results are automatically saved in the blockchain, which eliminates the possibility of manipulation. Blockchain smart contracts can be used to automatically transfer students to the next level of education after meeting all the necessary requirements.

Hybrid educational environments

Technology integration allows you to combine online and offline learning, providing maximum flexibility. For example, in a hybrid model, students can participate in online courses by completing assignments on the LMS platform, and then attend offline sessions where IoT is used to analyze their engagement and progress. All data is synchronized via the blockchain to provide a single source of information.

Protecting IoT devices from hacking

IoT systems used in educational institutions, such as smart classrooms or sensors for monitoring student activity, are becoming key elements of the digital educational infrastructure. However, IoT devices connected to open networks are vulnerable to cyber-attacks such as data interception, device identity substitution, and Distributed Denial of Service (DDoS) attacks. To protect such devices, it is necessary to implement comprehensive measures, including the use of encryption protocols (TLS or IPsec), firmware updates, and the development of user authentication mechanisms [15].

Secure data storage using the blockchain

The blockchain provides a high level of security due to its immutability and decentralized architecture [11]. An example is the MIT Digital Credentials system, which allows students to store and share their diplomas with employers via a secure blockchain. However, the introduction of blockchain is also associated with problems such as high energy consumption (in public networks) and scaling complexity.

Conclusion

a. The integration of ML, NN, IoT and blockchain is a new tool for creating adaptive, transparent and effective educational systems. After their solution, technology integration is one of the most promising areas for further research and development in the implementation of the University 4.0 project.

An integration scheme has been developed, including the stages of data collection using IoT, analytical data processing with ML and NN, and data storage using blockchain. Based on the scheme, the structure of the integration system is proposed, consisting of modules for data collection, intelligent analysis and storage, confirmation and data protection.

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