METHODS AND ALGORITHMS FOR THE FORMATION OF DISTANCE EDUCATION SYSTEMS BASED ON BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE DIGITAL ECONOMY

Rakhimberdiev Kuvonchbek1
1Department of information security, National University of Uzbekistan,
qquuvvoonn94@gmail.com
Ishnazarov Akram*
*Department of Mathematical Methods in Economics, Tashkent State University of Economics, Tashkent, Uzbekistan
a.ishnazarov@tsue.uz

Khayitova Oydinoy3
[3]Urgench State University, Urgench 220100. Khorezm region, Uzbekistan
komiljon0444@gmail.com

Abdullayev O.4
[4]Tashkent University of Information Technologies, Tashkent, Uzbekistan
o_k_a623@mail.ru

Jorabekov T.K.5
[5]Karakalpak state university, Nukus, Uzbekistan
timurjorabekov@gmail.com

ABSTRACT

Currently, artificial intelligence technologies are rapidly entering many areas of our society. It should be said that currently several reforms are being implemented in the Republic of Uzbekistan for the development of artificial intelligence technologies. In particular, the decision of the President of the Republic of Uzbekistan "On measures to create conditions for the rapid introduction of artificial intelligence technologies" dated February 17, 2021, No. PQ-4996 defines the main tasks in this regard. One of the most pressing issues studied by modern researchers is the issues related to the topic of digitalization of the educational process. In this article, the stages of development of artificial intelligence, and its application in the field of modern education are presented. The potential of artificial intelligence in education is also considered. At the same time, the processes of intellectual education are modeled mathematically. Algorithms of intellectual educational processes are proposed using CCN, and SHAP algorithms for organizing intellectual educational processes.Also, issues of ensuring the immutability and confidentiality of student evaluation results on distance education platforms, a strategy for ensuring the security of student test and control data using blockchain technology are presented.

CCS CONCEPTS

• **Blockchain, decentralization, immutability, anonymity, verification, block Version, time stamp, nonce, Merkl tree, artificial intelligence, education, Netex Learning, Smart capsules, Carnegie Learning Thinker Math, Personalization of education using AI.**;

ACM Reference Format:
Rakhimberdiev Kuvonchbek1, 1Department of information security, National University of Uzbekistan, qquuvvoonn94@gmail.com, Ishnazarov Akram*, Khayitova Oydinoy3, Abdullayev O.4, and Jorabekov T.K.5. 2022. METHODS AND ALGORITHMS FOR THE FORMATION OF DISTANCE EDUCATION SYSTEMS BASED ON BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE DIGITAL ECONOMY. In *The 6th International Conference on Future Networks & Distributed Systems (ICFNDS '22), December 15, 2022, Tashkent, TAS, Uzbekistan.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3584202.3584287

ICFNDS '22, December 15, 2022, Tashkent, TAS, Uzbekistan

ACM ISBN 978-1-4503-9905-0/22/12…$15.00
https://doi.org/10.1145/3584202.3584287

1 INTRODUCTION

It should be noted that currently several reforms are being carried out in the Republic of Uzbekistan on the development of artificial intelligence technologies. In particular, the decision of the President of the Republic of Uzbekistan "On measures to create conditions for the rapid introduction of artificial intelligence technologies" dated February 17, 2021, No. PQ-4996 defines the main tasks in this regard [1]. Therefore, there is a need to develop artificial intelligence technologies in our republic. Currently, consistent research is being conducted in our country on the introduction of artificial intelligence and blockchain technologies. In particular, the application of these technologies to science and education systems serves as a basis for the development of the fields.

Artificial intelligence is a technology that studies ways to train a computer, robotic equipment, and analytical system to think intelligently, just like a person. Since the mid-1950s, mankind has been amazed by the ability of computers that perform several tasks simultaneously. In the same period, the first technologies and research in the field of artificial intelligence begin to emerge. Research in this area was based on the study of human intelligence, after which the results were applied to the activities of computers. Information for research on artificial intelligence is taken from various sources and disciplines such as mathematics, computer science, psychology, linguistics, biology, mechanical engineering, etc. Based on this data, using machine learning technologies, computers try to imitate the operations of human mental actions [2].

Currently, there are the following distance learning platforms based on artificial intelligence technologies:

- Third Space Leaning
- Carnegie Learning
- Thinker Math Learning
- Netex Learning
- Supercharge Learning

In addition, the development of distance education systems based on blockchain technology leads to effective results. Blockchain technologies fit into the components of innovative development in education: the development of the educational process, technical and technological development, and also have the characteristics of innovative educational models: the use of modern information and communication technologies.

Blockchain is an immutable public distributed ledger of data that allows transactions to be carried out without a single central intermediary (decentralized network or peer-to-peer network consisting of nodes - individual users). If we consider in more detail - a built sequential chain of blocks containing encrypted or open information. Each block stores, in addition to information, its own hash sum and the hash sum of the previous block in the chain [3].

To form the most complete picture, several additional definitions of this technology can be given [4]:

- A decentralized peer-to-peer ledger of all transactions where participants can validate transactions without a certificate authority (Price Waterhouse Coopers, 2016).
- A technology that provides secure and resilient distributed data management combined with data analysis techniques that add scalability and flexibility (Wilson, 2017).
- A distributed digital ledger of cryptographically signed transactions that are grouped into blocks. Each block is cryptographically linked to the previous one after verification and consensus decision is made (see further in the block "Block" and "Consensus"). As new blocks are added, older blocks become more difficult to modify. New blocks are replicated across all copies of the registry on the network, and any conflicts are resolved automatically using the established rules.

Thus, the blockchain technology is based on the concepts of a decentralized network architecture and uses a distributed data ledger controlled by the established rules of the chosen consensus algorithm. Based on this, the blockchain has a number of the following properties [5]:

- Decentralization. In a decentralized network, there is no need for a third controlling party due to the equality of each of the participants and the functioning of the consensus algorithm, decentralization leads to complete consistency of operations (see below in the "Consensus" subsection).
- Immutability. Blockchain is supposed to be an immutable ledger of data due to its architecture. Each action of a participant (for example, a transaction) is recorded in the registry forever and cannot be changed.
- Anonymity. Each participant is assigned an address, which is used in the identity verification process. It is worth paying attention to the fact that the blockchain cannot guarantee perfect privacy due to certain internal limitations.
- Verification. The consensus algorithm also allows an independent audit of the entire blockchain at a certain frequency and /or depending on certain conditions.

LITERATURE REVIEW

Let's delve into the history of the creation of artificial intelligence. Back in 1924, the famous writer and science fiction writer Karel Capek staged a play called "Uni-versal Robots" in the London theater, the performance discouraged the audience, and the words "robot", and "artificial intelligence" became firmly established in the everyday life of mankind. In 1956, the founder of programming, John McCarthy, demonstrated a prototype of an artificial intelligence program at Carnegie Mellon University and won the Turing Award. Note that he is also credited with the authorship of the term "artificial intelligence".

Research on the possibilities of using artificial intelligence in education, conducted by UNESCO experts, provides an analysis of data on the possibilities of using AI to improve learning outcomes, as well as the risks and consequences of using AI in education around the world [5].

The positive aspects of the use of AI in education primarily include AI technology to ensure inclusive access to education. Regardless of the existing intellectual, social, physical, linguistic, and other characteristics, a person is provided with training in educational institutions. With the introduction of AI in the educational environment and the use of AI, students with special needs in emergencies can attend classes from home or the hospital. In this way, learning can be personalized in a variety of ways, and AI technologies support inclusiveness and access to education everywhere. It should be borne in mind that when working with artificial intelligence in education, the following difficulties may arise: preparing high-quality data systems, training future teachers based on artificial intelligence, and developing AI to understand learning technologies [6].

Matthew Lynch, Doctor of Psychology, owner of Lynch Consulting Group, LLC, in his article "Artificial Intelligence in Education: Seven Applications", identifies 7 aspects of the effective use of artificial intelligence in education: adaptive learning, personalized learning, automatic assessment, interval learning, teacher assessment students, smart capsules, control of the examination process [7].

Researchers V.A. Chulyukov and V.M. Dubov in the scientific article "Artificial Intelligence and the Future of Education", note that artificial intelligence has limited opportunities in education. The developers were able to teach the computer to independently carry out quite complex tasks. An algorithm was created that was based

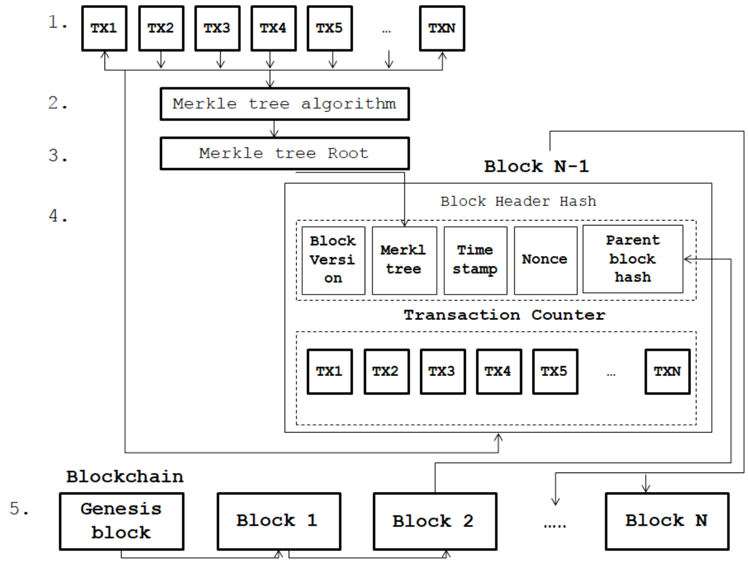

Figure 1: Blockchain infrastructure

on self-learning. The authors draw attention to the fact that artificial intelligence will not replace professionals, but it can improve the educational process and develop the skills of teachers.

In addition, using artificial intelligence technologies, it is possible to improve students' speech and solve their problems in the process of listening to words. In the process of understanding the words in the text presented during the teaching process, students may not understand to a certain extent. In this case, using neural networks or other artificial intelligence systems, converting the sounds of the read text into texts allows the students to fully understand the subject.

2 DATA AND METHODOLOGY

Empirical and classification methods are used in teaching. Artificial intelligence technologies, neural networks, data classification, and machine learning methods were also used. Cryptographic and blockchain technology methods are used to ensure the confidentiality of student test and control results.

3 BLOCKCHAIN TECHNOLOGY STRUCTURE AND EXPECTED RESULTS OF APPLICATION IN HIGHER EDUCATION

3.1 Blockchain technology structure

The blockchain infrastructure with incoming structural elements is shown in Figure 1

1. Tests of students of higher education institutions, control work and their grades.

2. A Merkle tree is formed when storing the data of higher education organizations in blockchain blocks. The nodes of this tree are transactions. Each transaction is hashed using the SHA-256 hash function algorithm.

3. The Merkle Root value of the incoming transaction data.

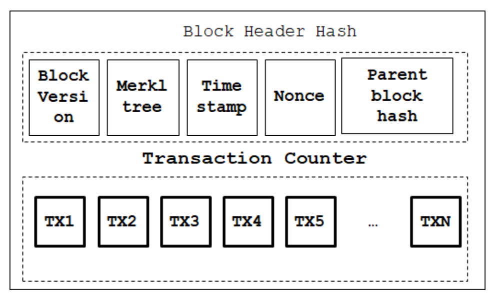

Figure 2: Diagram of the internal structure of the block

4. Block structure. A block is the main structural element of a blockchain, serving as a container for transactions or other types of data (depending on the implementation). Each block has a connection with the previous block through the hash sum of the data of this block, obtained using one of the hash functions: SHA1, SHA256 or other hash functions. The scheme of the internal structure of the block is shown in Fig. 2. below with a description of the elements from the Block Header in Table. 1.

5. Higher education student data blockchain.

The technologies used at this level are:

- Function of hashing the state of the current block to create a chain of blocks that refer to each other (immutability). The hash function, in this case, is used to create a string of 256 bits (when using SHA256) in order to further confirm the validity of the contents of the block [8].
- The hash tree (eng. Merkle Tree). This algorithm is used to create a hash tree from a given number of inputs (such as transactions). In blockchain, an algorithm is often used to validate the content of a block, as a hash sum of the current block [11].

Table 1: The meaning of the block elements in the Block Header

Name	Description
Block Version	Current version of block field structure
Merkle Tree Root Hash	The hash sum of the state of the block by applying the hash tree of the transactions included in the block.
Timestamp	Block creation time (Unix format)
nBits	Block state length in bits
Nonce	The length of the generated hash sum after running the Proof-Of-Work consensus algorithm.
Parent Block Hash (or Previous Block Hash)	Hash sum of the state of the previous block in the chain

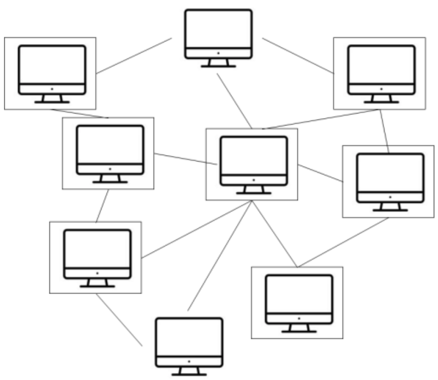

Figure 3: Decentralized network scheme

- A transaction is a record of the movement of tangible or intangible assets between interacting parties. Also, a transaction can be interpreted as an element in the context of checking an account. Each transaction that claims to be placed in a block must contain certain fields (depending on the implementation of the blockchain and the version of the structure of its transactions) [12].

Transactions to send and receive information use an electronic signature to verify identity. In the context of blockchain technologies, an electronic signature is formed on the basis of public and private keys (ECDSA or RSA) and is an encrypted string of arbitrary length [18].

The entire blockchain is built on a decentralized network as a tool for a more efficient distribution of resources (no central verification center). Using DHT (distributed hash table) capabilities decentralized networks are extended to routing and managing a list of known nodes. Figure. 3 shows the view of a network of this type (in a somewhat simplified version) [19]:

Each connected device is called a node. The network consists of many peer nodes interconnected by some communication protocol, most often it is GRPC or similar protocols based on TCP/IP [17]. Blockchain is an effective technology in the development of the higher education system and can lead to the following results:

- Ensuring confidentiality of student assessment data through distance learning systems;
- Acceptance and evaluation of supervision work of students studying in the form of distance education;
- Conducting tests for distance learning students. In this case, the protection of test results through blockchain technology;
- Secure data sharing by creating a decentralized network;
- Ensuring that the grades of test and control work are not changed;

Currently, using the architecture of the UzBCS (Uzbekistan Blockchain Credit System) platform, created on the basis of blockchain technology, work is being carried out to safely store the results of student evaluations in higher education systems.

4 MATHEMATICAL MODELING OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES

4.1 Convolutional Neural Network

Convolutional Neural Networks (CNN) consist of neurons with trainable weights and shifts. Each neuron receives input data, then the scalar product is performed and, if necessary, adds nonlinear optimization. The entire network expresses one differentiable evaluation function. There is also a loss feature enabled on the last layer, such as Softmax. Adamas was chosen as the optimization algorithm. Using it, the inertial moment of the distribution of gradients of an arbitrary degree is calculated.

$$u_t = \beta_2^p v_{t-1} + \left(1 - \beta_2^p\right) |g_t|^p \tag{1}$$

To use the value from formula (1), it is required to extract the root $u_t = v_t^{\frac{1}{p}}$, derive the decision rule, as $p \to \infty$ and expand under the root using formula (1):

$$\begin{aligned} u_t &= \lim_{p\to\infty} \left[\beta_2^p v_{t-1} + \left(1 - \beta_2^p\right) |g_t|^p\right]^{\frac{1}{p}} = \\ &= \lim_{p\to\infty} \left[\left(1 - \beta_2^p\right) \left(\sum_{i=1}^{t} \beta_2^{p(t-i)}\right) |g_t|^p\right]^{\frac{1}{p}} = \\ &= \lim_{p\to\infty} \left[\left(\sum_{i=1}^{t} \beta_2^{p(t-i)}\right) |g_t|^p\right]^{\frac{1}{p}} = \\ &= \max\left(\beta_2^{t-1} |g_1|, \beta_2^{t-2} |g_2|, \ldots, \beta_2 |g_{t-1}|, |g_t|\right) \end{aligned} \tag{2}$$

Putting u_t in the updated equation:

Good default values:

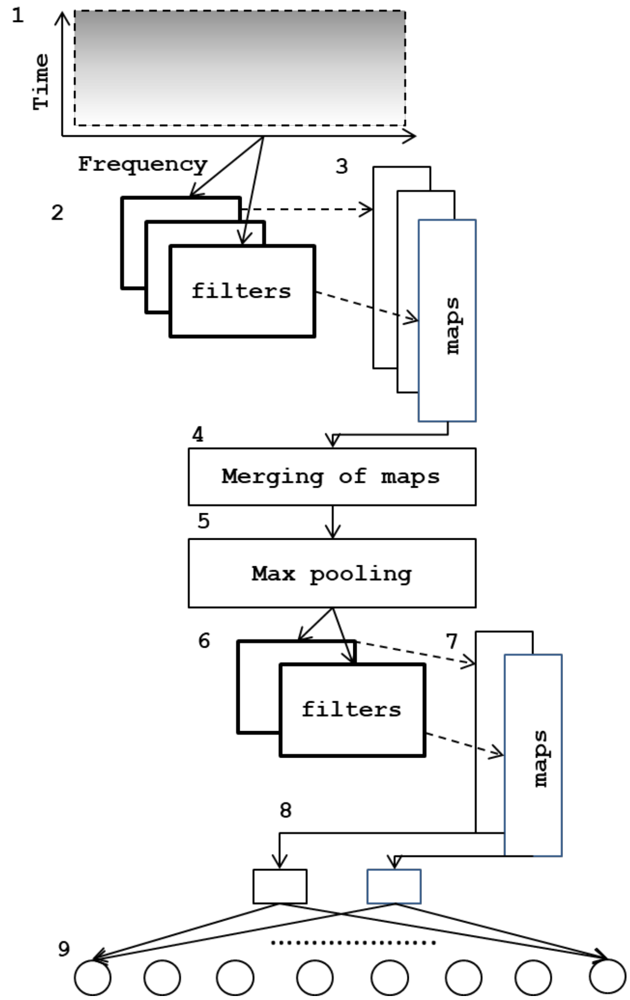

Figure 4: Scheme of the CNN architecture

$\eta = 0,002$, $\beta_1 = 0,9$ and $\beta_2 = 0,999$

Let's move on to building a neural network (see Figure. 4.). The architecture of a convolutional network accepts data as a one-dimensional array as input. The implementation of our network will take place in Google Colab.

Algorithm 1 Algorithm 1.

Input spectrogram
N filters each having a width of 3
1d convolution maps between input and filters
Concatenate Nconvolved feature maps
Max pooling of concatenated maps with factor 2
filters each having a width of 3
1d convolution maps between output and filters
Global max pooling
Fully connected layer for classification

For further work, the sklearn and Keras libraries will be used. With the train test split of the sklearn library, 90% of the data will be used for training, and 10% for testing. We also perform data augmentation before training. Data augmentation is the process by which we create new synthetic data samples by adding small perturbations to the initial training set. To generate syntactic data for audio, we can apply noise injection, shift time, pitch change, and speed. The goal is to make our model invariant to these perturbations and increase its generalization ability. For this to work, the addition of perturbations must keep the same label as the original training sample.

4.2 SHAP algorithm

Additive Shapley Explanations (SHAP): This is a game theoretic approach to explain the results of any machine learning model using Shapley values.

It was proposed by Lundberg and his colleagues [8]. SHAP explains input predictions by computing the contribution of individual features to that output prediction. By formulating the functions of the data as players in a coalition game, one can compute Shapley values to learn how to distribute payoffs fairly.

In the SHAP method, the data can be separated into categories. in tabular data, or groups of superpixels in images like LIME. SHAP then outputs the problem as a set of linear functions, where the explanation is also a linear function [16].

If we consider g as the explanatory model of the machine learning model f, $z' \in \{0,1\}^M$, Mas the coalition vector,$M$is the maximum size of the coalition, and $\phi_j \in R$ is the attribution of the feature j, $g(z')$ is the sum of the bias and contributions of individual features such, from this.

$$g\left(z'\right) = \phi_0 + \sum_{j=1}^{M} \phi_j z'_j \tag{3}$$

Algorithm 2 Algorithm 2. KernelSHAP algorithm for Local Explanations

Input: Classifier$f$, the input sample x
Output: Explainable coefficient from the linear model
$z_k \leftarrow SampleByRemovingFeature(x)$
$z_k \leftarrow h_x(z_k)$ ▷ h_x is a feature transformation to reshape to x
$y_{k \leftarrow} f(z_k)$
$W_x \leftarrow SHAP(f, z_k, y_k)$
$LinearModel(W_x).fit()$
Return:$LinearModel.coefficients()$

SHAP has also been widely used by the research community and has been directly applied and improved in many ways. Consider some examples of the use of SHAP in the medical field to explain clinical decision-making and some recent work that is of great importance:

- Anavar and colleagues [9] developed an extended SHAP method to explain autoencoders used for anomaly detection. The authors classify anomalies using an autoencoder by comparing actual data instances with the reconstructed output. Since the final result is a reconstruction, the authors suggest that explanations should be based on reconstruction errors. SHAP values are found for the most efficient functions and are divided into contributing and compensating anomalies.

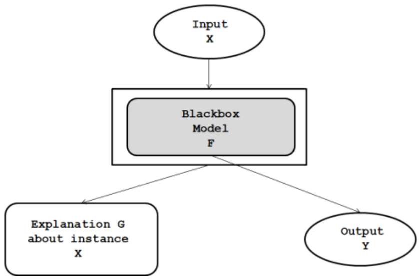

Figure 5: General illustration of locally explainable models.

- Sundararajan and colleagues [10] have expressed various shortcomings of the SHAP method, such as generating illogical explanations for cases where certain features are not important. This "uniqueness" property of the attribution method is enhanced using the basic Shapley method (BShap). The authors further extend the method by using integrated gradients for continuous regions.
- Aac and colleagues [11] explored the relationship between SHAP values by extending the KernelSHAP method to handle dependent features. The authors also presented a Shapley cluster value method corresponding to dependent features. A thorough study of the KernelSHAP method was carried out with four proposed methods to replace the conditional distributions of the KernelSHAP method using an empirical approach and either a Gaussian one.
- Lundberg and colleagues [12], described an extension of the SHAP method for trees in a framework called TreeExplainer, where the structure of the global model is explained using local explanations. The authors described an algorithm for calculating the local explanation of trees in polynomial time based on exact Shapley values.

Vega Garcia and colleagues [13] described a SHAP-based method for explaining time series signal predictions involving long short-term memory (LSTM) networks. The authors used the DeepSHAP algorithm to explain individual cases in the test set based on the most important features from the training set. However, no changes were made to the SHAP method, and explanations were generated for each input instance.

4.3 LIME algorithm.

LIME belongs to the category of locally explainable algorithms. Typically, this method focuses on a single instance of data to generate explanations using different data. Here we are interested in the generation to explain the decisions made for a single input instance (see Figure 5).

Typically, a single input instance is used for the explanation. Groundbreaking research in the field of local explanations uses Bayesian methods and highlights the importance of matrix features in understanding model output predictions. Explanations for the output data were always positive real matrices or vectors. New researches in local explanatory models improve old methods based on graphs and game theory in which we get a functional estimate of positive and negative correlations in the output classification. Here, a positive value causes the particular function to improve the probability of the output class, while a negative value means that the function has reduced the probability of the output class.

In 2016, Ribeiro et al. introduced Local Interpretable Model Agnostic Explanations (LIME) [14]. To get a human-readable representation, LIME tries to find the importance of adjacent superpixels (pixel fragments) in the source image in the output class. Therefore, LIME finds a binary vector to indicate the presence or a sense of a continuous path, or the superpixel that provides the highest representation of the class output. This works at the patch level for a single data entry. Therefore, the method falls under local explanations. There is also a global explanatory model based on LIME called SP-LIME, described in the global explanatory model subsection. Here we focus on local explanations.

Algorithm 3 Algorithm 3. LIME algorithm for local explanations

Input: classifier$f$, input sample$x$, number of superpixels$n$, number of features to pick$m$.
Output: Explainable coefficients from the linear model
$\bar{y} \leftarrow f.predict(x)$
for I inn do
end for
end for
end for
end for
$simscore \leftarrow SimilarityScore(dist)$
$x_{pick} \leftarrow Pick(p, simscore, m)$
$L \leftarrow LinearModel.fit(m, p, simscore)$
return L weights

Consider $g \in G$, an explanation, as an example from the class of potentially interpretable models G. Here g can be solved using trees, a linear model, or other models of varying interpretability. Let the explanation complexity be measured by$\Omega(g)$. It $\pi_x(z)$ is a measure of proximity between two instances x and z around x and $L(f, g, \pi_x)$represents the accuracy of g in the approximation of f in the locality defined by π_x, then explains ξ for the input data sample x is determined by the LIME equation:

$$\xi(x) = \arg\min_{g \in G} L(f, g, \pi_x) + \Omega(g) \tag{4}$$

Now in equation 4, the goal of LIME optimization is to minimize the loss, taking into account the locality of $L(f, g, \pi_x)$ the model agnostic method used.

An example visualization of the LIME algorithm for a single instance is shown in Algorithm 3. Algorithm 3 shows the steps for explaining the model for a single input sample and the general LIME procedure. Here, for the input instance, we permute the data by finding the superpixel. We then calculate the distance (similarity score) between the permutations and the original observations. Now we get different class scores for the original input and the new "fake" data. We can then make predictions based on the new "fake" data using the f model [15, 17]. It depends on the number of superpixels selected from the original data. The most important feature one can choose is to improve the prediction of permuted data. If we fit a simple model, often a locally weighted permuted regression with m features and similarity scores as weights, we can use the feature weights or coefficients from the simple model to explain the local behavior of the complex model [19].

5 CONCLUSION

Thus, it can be concluded that artificial intelligence, like all innovations in technology, has its advantages and disadvantages, however, it is assumed that the introduction of AI in the learning process may become more active as technologies develop. These technologies are being improved following the demands of society and are aimed at the effectiveness of the learning process according to the "teacher-student" scheme. It is problematic for one teacher to meet the needs of a class of a large number of modern students. In modern realities, it is no longer a fantasy to introduce AI-based applications into the education process. This approach solves the problem of the low quality of education, the problem of inaccessibility of education, and also, if possible, minimizes the shortcomings of the existing education system.

REFERENCES

[1] The decision of the President of the Republic of Uzbekistan "On measures to create conditions for the rapid introduction of artificial intelligence technologies" dated February 17, 2021, No. PQ-4996.

[2] G. Juraev and K. Rakhimberdiev, Mathematical Modeling of Credit Scoring System Based on the Monge-Kantorovich Problem, 2022 IEEE International IoT, Electronics and Mechatronics Conference, IEMTRONICS 2022 Proceedings.

[3] G. Juraev and K. Rakhimberdiev, Modeling the decision-making process of lenders based on blockchain technology, International Conference on Information Science and Communications Technologies: Applications, Trends, and Opportunities, ICISCT 2021, pp. 1-5.

[4] Alejandro Barredo Arrieta, Natalia Diaz-Rodriguez идр. Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges toward Responsible AI . arXiv:1910.10045, 2019.

[5] Katharina Weitz, Dominik Schiller, Ruben Schlagowski, Tobias Huber, Elisabeth Andre "Let me explain!": exploring the potential of virtual agents in explainable AI interaction design. Journal on Multimodal User Interfaces volume 15, pages 87–98 (2021)

[6] Alejandro Barredo Arrieta, Natalia Diaz-Rodriguez идр. Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges toward Responsible AI . arXiv:1910.10045, 2019.

[7] S. M. Lundberg and S. I. Lee A unified approach to interpreting model predictions in Advances in Neural Information Processing Systems, 2017, pp. 4765–4774

[8] L. Antwarg, B. Shapira, and L. Rokach Explaining anomalies detected by autoencoders us-ing shap arXiv:1903.02407, 2019.

[9] M. Sundararajan and A. Najmi The many Shapley values for model explanation arXiv:1908.08474, 2019.

[10] K. Aas, M. Jullum, and A. L øland Explaining individual predictions when features are dependent: More accurate approximations to Shapley values arXiv:1903.10464, 2019.

[11] M. Vega Garcia and J. L. Aznarte Shapley additive explanations for NO2 forecasting Ecol. Inform., vol. 56, p. 101039, Mar 2020.

[12] T.Abdullaev, G. Juraev, "Application three-valued logic in symmetric block encryption algorithms," Journal of Physics: Conference Series, 2021, 2131(2), 022082, pp. 1-9.

[13] T.Abdullaev, G. Juraev, "Selection of the optimal type of the gaming function for symmetric encryption algorithms," AIP Conference Proceedings, 2021, 2365, 020004, pp. 1-7.

[14] T. Abdullaev, G. Juraev, "Development of a method for generating substitution tables for binary and ternary number systems," AIP Conference Proceedings, 2021, 2365, 020003, pp. 1-10.

[15] Juraev, G., Musurmonova, M., "An Algorithm for Solving the Problem of Radial Expansion of a Spherical Cavity Supported by a Thin Spherical Shell in an Elastic-Porous Fluid-Saturated Medium", AIP Conference Proceedings this link is disabled, 2022, 2432, 030109.

[16] Ikramov, A., Juraev, G., "The Complexity of Testing Cryptographic Devices on Input Faults" Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2021, 13041 LNCS, стр. 202–209. Author, F.: Article title. Journal 2(5), 99–110 (2016).

[17] G. Juraev and K. Rakhimberdiev, Prospects of application of blockchain technology in the banking, International Conference on Information Science and Communications Technologies: Applications, Trends, and Opportunities, ICISCT 2022, pp. 1-5.

[18] M. Karimov, J.Arzieva and K. Rakhimberdiev, Development of Approaches and Schemes for Proactive Information Protection in Computer Networks, International Conference on Information Science and Communications Technologies: Applications, Trends, and Opportunities, ICISCT 2022, pp. 1-5.

[19] K.Tashev, J. Arzieva, A. Arziev, and K. Rakhimberdiev, Method authentication of objects information communication systems, International Conference on Information Science and Communications Technologies: Applications, Trends, and Opportunities, ICISCT 2022, pp. 1-5.

[20] J. Arzieva, A. Arziev, and K. Rakhimberdiev, Application of random number generators in solving the problem of user authentication in blockchain systems, International Conference on Information Science and Communications Technologies: Applications, Trends, and Opportunities, ICISCT 2022, pp. 1-5.

[21] Sobti, Rajeev & Ganesan, Geetha. (2012). Cryptographic Hash Functions: A Review. International Journal of Computer Science Issues, ISSN (Online): 1694-0814. Vol 9. pp. 461– 479.