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CREATION AND ANALYSIS OF MATHEMATICAL MODELS USING ARTIFICIAL INTELLIGENCE

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Abstract. This study investigates methods for creating and analyzing mathematical models using artificial intelligence (AI) algorithms. Machine learning, deep learning, and optimization techniques were applied to model economic, transportation, and educational systems. The practical implementation of these models in the context of Uzbekistan confirmed their stability, accuracy, and ability to optimize system parameters. The results demonstrate the effectiveness of AI algorithms in simulating complex systems, facilitating decision-making, and advancing both scientific research and practical applications.

Keywords: Artificial Intelligence, Mathematical Modeling, Machine Learning, Deep Learning, Optimization, Republic of Uzbekistan.

1. Introduction

In recent years, artificial intelligence (AI) technologies have experienced rapid development across scientific and industrial domains. In particular, AI algorithms have significantly enhanced the process of mathematical modeling by enabling the analysis of complex systems, optimization of parameters, and automated evaluation of results. Mathematical models developed using AI not only allow faster and more accurate simulation of complex processes but also enable forecasting of various scenarios.

The Republic of Uzbekistan has also been actively promoting the implementation of digital technologies and the development of scientific research. Numerous projects related to AI-based mathematical modeling are being carried out in higher education institutions and research centers. These projects focus on analyzing and optimizing complex systems in areas such as energy, transportation, economics, and education.

In this context, the present study aims to explore methods for creating and analyzing mathematical models using AI algorithms and to evaluate their applicability in the conditions of Uzbekistan. The findings are expected to contribute to system simulation, optimal decision-making, and the development of future scientific and practical projects.

2. Methods

In this study, the process of creating and analyzing mathematical models using AI algorithms was carried out through a systematic approach. The research focused on economic processes, transportation systems, and educational environments, as these domains involve complex systems requiring parameter optimization. Data sources included official statistical reports, real-time data from digital monitoring systems, and scientific publications.

2.1 Data Preparation and Preprocessing

The first stage involved data cleaning, normalization, and structuring. Incomplete or inconsistent data were identified and removed using algorithmic filtering techniques. Due to the heterogeneity of datasets in Uzbekistan (different formats and sources), all data were standardized into a unified format.

2.2 Model Development

Python was selected as the primary programming environment due to:

- its extensive libraries (NumPy, Pandas, SciPy, TensorFlow, PyTorch);
- ease of integrating machine learning and deep learning algorithms;
- powerful tools for visualization and analysis.

The following AI algorithms were employed:

- **Random Forest and Support Vector Machines (SVM):** for parameter prediction and classification tasks;
- **Multi-Layer Perceptron (MLP) and LSTM neural networks:** for time-series analysis and dynamic system modeling;
- **Optimization algorithms (Gradient Descent, Genetic Algorithms):** for fine-tuning model parameters.

2.3 Model Testing and Validation

The developed models were tested using real-world data from Uzbekistan. Performance metrics included Accuracy, Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and parameter sensitivity. The results indicated that deep learning models provided stable performance even under uncertain conditions.

2.4 Result Analysis

The analysis focused on:

- model accuracy and reliability;
- parameter optimization;
- applicability in Uzbekistan;
- potential use in education, transportation, and economics.

This methodological framework ensures that the modeling process is systematic, reliable, and reproducible, while also providing a scientific and methodological basis for applying AI algorithms in Uzbekistan's academic institutions.

3. Results

The study resulted in the development of mathematical models across multiple domains using AI algorithms implemented in Python and MATLAB. Key findings include:

3.1 Accuracy and Stability

- Random Forest models achieved an average accuracy of **92%**.
- SVM models demonstrated **89–91%** accuracy in classification tasks.
- Deep learning models (MLP, LSTM) provided stable results in time-series analysis, with RMSE ranging between **0.07–0.12**.

3.2 Parameter Optimization

- Optimization algorithms significantly improved prediction performance.
- Scenario-based analysis enabled evaluation of system sensitivity and robustness.

3.3 Application in Uzbekistan

- **Education:** prediction of student performance and generation of personalized recommendations.
- **Economics:** optimization of production processes and resource allocation.

- **Transportation:** identification of optimal routes and logistics strategies.

3.4 Visualization and Analysis

- Python libraries (Matplotlib, Seaborn) were used for graphical representation of results.
- MATLAB enabled interactive simulation and parameter analysis.

Overall, the developed models demonstrated high accuracy and stability, providing a reliable basis for practical applications in Uzbekistan.

4. Discussion

The findings confirm that AI-based mathematical models are highly effective in analyzing and optimizing complex systems. Random Forest and SVM algorithms achieved high classification accuracy, while deep learning models showed strong performance in dynamic and time-series tasks. These results are consistent with previous studies (Goodfellow et al., 2016; Géron, 2019).

In Uzbekistan, these findings are particularly significant due to ongoing digital transformation initiatives. The implementation of AI models supports:

- personalized education systems;
- optimized resource allocation in economic systems;
- improved logistics and transportation management.

Additionally, sensitivity analysis of model parameters enhances decision-making accuracy and resource efficiency.

However, several limitations were identified:

- insufficient and heterogeneous data in some systems;
- lack of real-time data updates;
- challenges in data standardization.

Future research should focus on improving data infrastructure, expanding real-time monitoring systems, and enhancing AI algorithms.

5. Conclusion

The study demonstrates that mathematical models created using artificial intelligence algorithms are highly effective in analyzing, optimizing, and forecasting complex systems. Random Forest, SVM, and deep learning models provided accurate and stable results, confirming their practical applicability.

In the context of Uzbekistan, AI-based mathematical modeling enables:

- personalized learning and student performance prediction;
- efficient resource allocation in economic systems;
- optimization of transportation and logistics systems;
- advanced simulation and sensitivity analysis in scientific research.

Future work should focus on:

1. developing data infrastructure and real-time monitoring systems;
2. expanding AI education and training programs in universities;
3. applying models in additional domains such as energy, agriculture, and healthcare;
4. improving model performance through hybrid AI and optimization techniques.

Overall, this study highlights the scientific and practical significance of AI-based mathematical modeling and its potential to support strategic planning and decision-making in Uzbekistan.

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