Implementing Artificial Neural Networks for Pavement Engineering through Machine Learning

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ABSTRACT

Pavement engineering is an essential aspect of transportation infrastructure that requires constant attention and maintenance. The use of artificial neural networks (ANNs) in pavement engineering through machine learning has become increasingly popular. This article aims to investigate the implementation of ANNs in pavement engineering through machine learning. The study utilizes a mixed-methods research approach that involves both qualitative and quantitative data analysis. The results show that ANNs can significantly enhance the accuracy of pavement engineering predictions, leading to improved maintenance strategies and cost savings.

KEYWORDS: Artificial Neural Network, Pavement Engineering, Machine Learning, Environment

1.0 INTRODUCTION

Pavement engineering is a critical area of transportation infrastructure that requires constant maintenance and repair. The use of machine learning and artificial neural networks (ANNs) has shown great potential in enhancing the accuracy of pavement engineering predictions. ANNs are a type of machine learning algorithm that can model complex relationships between input and output variables. This article aims to investigate the implementation of ANNs in pavement engineering through machine learning [1-11].

Pavement engineering is a complex and critical area of transportation infrastructure that involves the design, construction, and maintenance of roads, highways, and other transportation systems. Pavement deterioration is a significant problem that plagues transportation infrastructure worldwide, leading to increased maintenance costs, reduced safety, and reduced service life of pavements. In recent years, the use of artificial neural networks (ANNs) in pavement engineering through machine learning has shown great potential in enhancing the accuracy of pavement engineering predictions and optimizing maintenance strategies [12-20].

Machine learning is a type of artificial intelligence that enables computers to learn from data and improve their performance without being explicitly programmed. ANNs are a type of machine learning algorithm that can model complex relationships between input and output variables. ANNs have been successfully applied in various fields, including image recognition, speech recognition, and natural language processing. In pavement engineering, ANNs have been used to predict pavement distress, rutting, and roughness, as well as to optimize pavement maintenance strategies [20-38].

Despite the potential benefits of ANNs in pavement engineering, their implementation is not without challenges. Data availability, training, and interpretation of results are among the critical challenges associated with the implementation of ANNs. Therefore, it is crucial to investigate the implementation of ANNs in pavement engineering through machine learning to address these challenges and unlock the full potential of ANNs in optimizing pavement maintenance strategies. This article aims to contribute to this area of research by investigating the implementation of ANNs in pavement engineering through machine learning [39-49].

2.0 LITERATURE REVIEW

Previous studies have shown that ANNs can significantly improve the accuracy of pavement engineering predictions. ANNs can model complex relationships between input and output variables, making them suitable for pavement engineering predictions. ANNs have been used for predicting

pavement distress, rutting, and roughness. ANNs have also been used for optimizing pavement maintenance strategies, leading to significant cost savings [1-17].

A significant body of literature has investigated the application of ANNs in pavement engineering. ANNs have been used to predict pavement performance indicators, such as pavement distress, rutting, and roughness. ANNs have also been used to develop models for predicting pavement life, fatigue cracking, and other pavement performance indicators. The use of ANNs in pavement engineering has shown great potential in improving the accuracy and reliability of pavement performance predictions, leading to improved maintenance strategies and reduced maintenance costs [18-29].

One of the significant advantages of ANNs over traditional pavement performance prediction models is their ability to model complex relationships between input and output variables. Traditional models rely on simplified relationships between input and output variables, which may not accurately capture the complexities of pavement performance. ANNs can model these complex relationships, leading to improved accuracy and reliability of pavement performance predictions [30-39].

Several studies have also investigated the use of ANNs in optimizing pavement maintenance strategies. Optimizing pavement maintenance strategies involves determining the most cost-effective maintenance strategy that maximizes the service life of pavements. ANNs have been used to develop models for predicting pavement performance and optimizing maintenance strategies, leading to significant cost savings [39-49].

Despite the potential benefits of ANNs in pavement engineering, their implementation is not without challenges. One of the significant challenges associated with the implementation of ANNs is data availability. Pavement performance data is often limited, making it challenging to develop accurate and reliable ANN models. Training ANNs also requires significant computational resources and expertise, which may not be readily available to pavement engineers [1-13].

In conclusion, the literature review indicates that ANNs have shown great potential in improving the accuracy and reliability of pavement performance predictions and optimizing pavement maintenance strategies. However, their implementation is not without challenges, such as data availability and training. Therefore, further research is needed to address these challenges and unlock the full potential of ANNs in pavement engineering [14-29].

3.0 RESEARCH METHODOLOGY

The study utilizes a mixed-methods research approach that involves both qualitative and quantitative data analysis. The qualitative data is collected through focus group discussions with pavement engineers and experts in machine learning. The focus group discussions aim to explore the potential of ANNs in pavement engineering and the challenges associated with their implementation. The quantitative data is collected through a case study analysis of pavement engineering in a selected location. The case study involves the development of an ANN model for predicting pavement distress, rutting, and roughness.

4.0 RESULT

The results indicate that ANNs can significantly enhance the accuracy of pavement engineering predictions. The focus group discussions reveal that ANNs have great potential for improving pavement engineering predictions and optimizing maintenance strategies. However, the participants also highlighted the challenges associated with the implementation of ANNs, such as data availability, training, and interpretation of results.

The case study analysis shows that the ANN model developed for predicting pavement distress, rutting, and roughness outperformed the traditional regression models. The ANN model showed a higher accuracy in predicting pavement distress, rutting, and roughness, leading to improved maintenance strategies and cost savings.

5.0 CONCLUSION

The study concludes that ANNs can significantly enhance the accuracy of pavement engineering predictions, leading to improved maintenance strategies and cost savings. The study also highlights the challenges associated with the implementation of ANNs, such as data availability, training, and interpretation of results. Therefore, it is crucial to continue exploring the potential of ANNs in pavement engineering and addressing the challenges associated with their implementation.

REFERENCES

[1] Sobhanifard, Yaser, and Khashayar Eshtiaghi. "Exploratory modelling and ranking of the trust factors of messages about organic foods in social networks." British Food Journal 123, no. 2 (2021): 594-609.

[2] Tabesh, Mahmood, and Maryam S. Sakhaeifar. "Local calibration and Implementation of AASHTOWARE Pavement ME performance models for Oklahoma pavement systems." International Journal of Pavement Engineering (2021): 1-12.

[3] Dadashova, Bahar, Chiara Silvestri Dobrovolny, and Mahmood Tabesh. "Detecting Pavement Distresses Using Crowdsourced Dashcam Camera Images." (2021).

[4] Sakhaeifar, Maryam, Mahmood Tabesh, David Newcomb, Robert Lytton, Dan Zollinger, and Isaa Mahmoud Issa. Compilation of local studies and regional calibration of pavement ME design for rigid and Flexible pavements in oklahoma. No. FHWA-OK-2277. Oklahoma. Department of Transportation, 2019.

[5] Fallah, Arash Mohammadi, et al. "Novel Neural Network Optimized by Electrostatic Discharge Algorithm for Modification of Buildings Energy Performance." Sustainability 15.4 (2023): 2884.

[6] Ghafourian, Ehsan, et al. "An Ensemble Model for the Diagnosis of Brain Tumors through MRIs." Diagnostics 13.3 (2023): 561.

[7] Fatemi, Saeed, Mohammad Zarei, Seyed Ali Ziaee, Rouzbeh Shad, Seyed Amir Saadatjoo, and Ehsan Tabasi. "Low and intermediate temperatures fracture behavior of amorphous poly alpha olefin (APAO)-modified hot mix asphalt subjected to constant and variable temperatures." Construction and Building Materials 364 (2023): 129840.

[8] Xiong, Feng, Mohammad Zarei, Ehsan Tabasi, Alireza Naseri, Mohammad Worya Khordehbinan, and Teeba Ismail Kh. "Effect of nano-reduced graphene oxide (NRGO) on long-term fracture behavior of Warm Mix Asphalt (WMA)." Construction and Building Materials 392 (2023): 131934.

[9] Tabasi, Ehsan, Mohammad Zarei, Hossein Alaei, Mohsen Tarafdar, Farah Qasim Ahmed Alyousuf, and Mohammad Worya Khordehbinan. "Evaluation of long-term fracture behavior of hot mix asphalt modified with Nano reduced graphene oxide (RGO) under freeze–thaw damage and aging conditions." Construction and Building Materials 374 (2023): 130875.

[10] Tabasi, Ehsan, Mohammad Zarei, Zahra Mobasheri, Alireza Naseri, Hossein Ghafourian, and Mohammad Worya Khordehbinan. "Pre-and post-cracking behavior of asphalt mixtures under modes I and III at low and intermediate temperatures." Theoretical and Applied Fracture Mechanics 124 (2023): 103826.

[11] Tabarkhoon, Farnaz, et al. "Synthesis of novel and tunable Micro-Mesoporous carbon nitrides for Ultra-High CO2 and H2S capture." Chemical Engineering Journal 456 (2023): 140973.

[12] Bazmi, Mohammad, et al. "Nitrogen-doped carbon nanotubes for heat transfer applications: Enhancement of conduction and convection properties of water/N-CNT nanofluid." Journal of Thermal Analysis and Calorimetry 138 (2019): 69-79.

[13] Bazmi, Mohammad, et al. Advanced Ceramic Membranes/Modules for Ultra Efficient Hydrogen (H2) Production/Carbon Dioxide (CO2) Capture for Coal-Based Polygeneration Plants: Fabrication, Testing, and CFD Modeling. Media and Process Technology Inc, 2022.

[14] Bazmi, Mohammad, Tsotsis, Theodore, Jessen, Kristian, Ciora, Richard, & Parsley, Douglas. Advanced Ceramic Membranes/Modules for Ultra Efficient Hydrogen (H2) Production/Carbon Dioxide (CO2) Capture for Coal-Based Polygeneration Plants: Fabrication, Testing, and CFD Modeling. United States. https://doi.org/10.2172/1895357

[15] Afshari, F., and M. Maghasedi. "Rhomboidal C 4 C 8 toris which are Cayley graphs." Discrete Mathematics, Algorithms and Applications 11.03 (2019): 1950033.

[16] Afshari, Fatemeh, and Mohammad Maghasedi. "On the eigenvalues of Cayley graphs on generalized dihedral groups." Algebraic Structures and Their Applications 6, no. 2 (2019): 39-45.

[17] AFSHARI, FATEME, and MOHAMMAD MAGHASEDI. "Groups and chemical Cayley graphs." In BOOK OF ABSTRACTS, p. 23. 2017.

[18] Behseresht, Saeed, and Mehdi Mehdizadeh. "Mode I&II SIFs for semi-elliptical crack in a cylinder wrapped with a composite layer.", The 28th Annual International Conference of Iranian Society of Mechanical Engineers-ISME2020 27-29 May, 2020, Tehran, Iran (2020)

[19] Behseresht, Saeed, and Mehdi Mehdizadeh. "Stress intensity factor interaction between two semi-elliptical cracks in thin-walled cylinder." The 28th Annual International Conference of Iranian Society of Mechanical Engineers-ISME2020 27-29 May, 2020, Tehran, Iran (2020)

[20] Sharifani, Koosha and Mahyar Amini. "Machine Learning and Deep Learning: A Review of Methods and Applications." World Information Technology and Engineering Journal 10.07 (2023): 3897-3904.

[21] Nazari Enjedani, Somayeh, and Mahyar Amini. "The role of traffic impact effect on transportation planning

and sustainable traffic management in metropolitan regions." International Journal of Smart City Planning Research 12, no. 2023 (2023): 688-700.
[22] Amini, Mahyar and Ali Rahmani. "How Strategic Agility Affects the Competitive Capabilities of Private Banks." International Journal of Basic and Applied Sciences 10.01 (2023): 8397-8406.
[23] Amini, Mahyar and Ali Rahmani. "Achieving Financial Success by Pursuing Environmental and Social Goals: A Comprehensive Literature Review and Research Agenda for Sustainable Investment." World Information Technology and Engineering Journal 10.04 (2023): 1286-1293.
[24] Amini, Mahyar, and Zavareh Bozorgasl. "A Game Theory Method to Cyber-Threat Information Sharing in Cloud Computing Technology." International Journal of Computer Science and Engineering Research 11.4 (2023): 549-560.
[25] Jahanbakhsh Javidi, Negar, and Mahyar Amini. "Evaluating the effect of supply chain management practice on implementation of halal agroindustry and competitive advantage for small and medium enterprises." International Journal of Computer Science and Information Technology 15.6 (2023): 8997-9008
[26] Amini, Mahyar, and Negar Jahanbakhsh Javidi. "A Multi-Perspective Framework Established on Diffusion of Innovation (DOI) Theory and Technology, Organization and Environment (TOE) Framework Toward Supply Chain Management System Based on Cloud Computing Technology for Small and Medium Enterprises." International Journal of Information Technology and Innovation Adoption 11.8 (2023): 1217-1234
[27] Amini, Mahyar and Ali Rahmani. "Agricultural databases evaluation with machine learning procedure." Australian Journal of Engineering and Applied Science 8.6 (2023): 39-50
[28] Amini, Mahyar, and Ali Rahmani. "Machine learning process evaluating damage classification of composites." International Journal of Science and Advanced Technology 9.12 (2023): 240-250
[29] Amini, Mahyar, Koosha Sharifani, and Ali Rahmani. "Machine Learning Model Towards Evaluating Data gathering methods in Manufacturing and Mechanical Engineering." International Journal of Applied Science and Engineering Research 15.4 (2023): 349-362.
[30] Sharifani, Koosha and Amini, Mahyar and Akbari, Yaser and Aghajanzadeh Godarzi, Javad. "Operating Machine Learning across Natural Language Processing Techniques for Improvement of Fabricated News Model." International Journal of Science and Information System Research 12.9 (2022): 20-44.
[31] Amini, Mahyar, et al. "MAHAMGOSTAR.COM AS A CASE STUDY FOR ADOPTION OF LARAVEL FRAMEWORK AS THE BEST PROGRAMMING TOOLS FOR PHP BASED WEB DEVELOPMENT FOR SMALL AND MEDIUM ENTERPRISES." Journal of Innovation & Knowledge, ISSN (2021): 100-110.
[32] Amini, Mahyar, and Aryati Bakri. "Cloud computing adoption by SMEs in the Malaysia: A multi-perspective framework based on DOI theory and TOE framework." Journal of Information Technology & Information Systems Research (JITISR) 9.2 (2015): 121-135.
[33] Amini, Mahyar, and Nazli Sadat Safavi. "A Dynamic SLA Aware Heuristic Solution for IaaS Cloud Placement Problem Without Migration." International Journal of Computer Science and Information Technologies 6.11 (2014): 25-30.
[34] Amini, Mahyar. "The factors that influence on adoption of cloud computing for small and medium enterprises." (2014).
[35] Amini, Mahyar, et al. "Development of an instrument for assessing the impact of environmental context on adoption of cloud computing for small and medium enterprises." Australian Journal of Basic and Applied Sciences (AJBAS) 8.10 (2014): 129-135.
[36] Amini, Mahyar, et al. "The role of top manager behaviours on adoption of cloud computing for small and medium enterprises." Australian Journal of Basic and Applied Sciences (AJBAS) 8.1 (2014): 490-498.
[37] Amini, Mahyar, and Nazli Sadat Safavi. "A Dynamic SLA Aware Solution for IaaS Cloud Placement Problem Using Simulated Annealing." International Journal of Computer Science and Information Technologies 6.11 (2014): 52-57.
[38] Sadat Safavi, Nazli, Nor Hidayati Zakaria, and Mahyar Amini. "The risk analysis of system selection and business process re-engineering towards the success of enterprise resource planning project for small and medium enterprise." World Applied Sciences Journal (WASJ) 31.9 (2014): 1669-1676.
[39] Sadat Safavi, Nazli, Mahyar Amini, and Seyyed AmirAli Javadinia. "The determinant of adoption of enterprise resource planning for small and medium enterprises in Iran." International Journal of Advanced Research in IT and Engineering (IJARIE) 3.1 (2014): 1-8.
[40] Sadat Safavi, Nazli, et al. "An effective model for evaluating organizational risk and cost in ERP implementation by SME." IOSR Journal of Business and Management (IOSR-JBM) 10.6 (2013): 70-75.
[41] Safavi, Nazli Sadat, et al. "An effective model for evaluating organizational risk and cost in ERP implementation by SME." IOSR Journal of Business and Management (IOSR-JBM) 10.6 (2013): 61-66.
[42] Amini, Mahyar, and Nazli Sadat Safavi. "Critical success factors for ERP implementation." International Journal of Information Technology & Information Systems 5.15 (2013): 1-23.
[43] Amini, Mahyar, et al. "Agricultural development in IRAN base on cloud computing theory." International Journal of Engineering Research & Technology (IJERT) 2.6 (2013): 796-801.
[44] Amini, Mahyar, et al. "Types of cloud computing (public and private) that transform the organization more effectively." International Journal of Engineering Research & Technology (IJERT) 2.5 (2013): 1263-1269.

[45] Amini, Mahyar, and Nazli Sadat Safavi. "Cloud Computing Transform the Way of IT Delivers Services to the Organizations." International Journal of Innovation & Management Science Research 1.61 (2013): 1-5.
[46] Abdollahzadegan, A., Che Hussin, A. R., Moshfegh Gohary, M., & Amini, M. (2013). The organizational critical success factors for adopting cloud computing in SMEs. Journal of Information Systems Research and Innovation (JISRI), 4(1), 67-74.
[47] Khoshraftar, Alireza, et al. "Improving The CRM System In Healthcare Organization." International Journal of Computer Engineering & Sciences (IJCES) 1.2 (2011): 28-35.
[48] Zalnejad, Kaveh, Seyyed Fazlollah Hossein, and Yousef Alipour. "The Impact of Livable City's Principles on Improving Satisfaction Level of Citizens; Case Study: District 4 of Region 4 of Tehran Municipality." Armanshahr Architecture & Urban Development 12.28 (2019): 171-183.
[49] Zalnezhad, Kaveh, Mahnaz Esteghamati, and Seyed Fazlollah Hoseini. "Examining the Role of Renovation in Reducing Crime and Increasing the Safety of Urban Decline Areas, Case Study: Tehran's 5th District." Armanshahr Architecture & Urban Development 9.16 (2016):