Journal of Information Systems Engineering and Management
2025, 10(35s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Ai-Based Traffic Congestion Prediction for Smart Cities Using Artificial Neural Network

Komal Patel[1] , Dr. Manish Patel[2] ,
PhD Scholar, Sankalchand Patel College of Engineering ,SPU, Visnagar, India [1]
Professor, Information Technology, Sankalchand Patel College of Engineering ,SPU, Visnagar, India [2]
komalcpatel1993@gmail.com[1] ,mmpatel.it_spce@spu.ac.in[2]

ARTICLE INFO

Received: 18 Dec 2024

Revised: 10 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

As urbanization accelerates, efficient traffic management has become a critical challenge for smart cities. Traditional traffic prediction methods often struggle with the complexity and dynamic nature of city-wide congestion patterns. This study explores deep learning-based approaches for accurate and real-time traffic congestion forecasting. Using historical and real-time traffic data, we develop and evaluate neural network models (ANN) to capture spatiotemporal traffic dynamics. The proposed AI-driven framework integrates diverse urban data sources, such as road sensors, GPS trajectories, and weather conditions, to enhance predictive accuracy. Experimental results demonstrate that deep learning models outperform conventional statistical approaches in congestion prediction, offering valuable insights for traffic control, route optimization, and urban mobility planning. The findings highlight the potential of AI-powered traffic intelligence in developing smarter, more efficient, and sustainable urban transportation systems. When we evaluate using Kaggle datasets, we see that ANN model does better than other methods for precision, recall, F1-score as well as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). Moreover the ANN model outperforms other methods in various time ranges. This comparison provides more evidence to support the effectiveness of this method for improving prediction accuracy in traffic congestion. It shows promise for a future where urban transport systems are smarter and more efficient

Keywords: Traffic Congestion Prediction, Smart City, Deep Learning, Artificial Intelligence (AI), Traffic Management, And Optimization

I. INTRODUCTION

The economy is growing, cities are developing fast and people want to travel privately [1]. This has led to a big increase in traffic congestion level for many large or rapidly expanding cities all over the world. The problem of traffic jam directly impacts the growth rate, development speed and environment quality in these places. As economic growth takes place and cities become more attractive for people to live there, it also brings an increasing demand on transportation infrastructure—needed both by those who work in these areas as well as those wanting goods moved or travelling for leisure purposes—to keep up with this urban expansion [2, 3]. But often times building new infrastructures does not happen at same speed like how quickly urban areas grow causing problems such as congestion which can affect city life greatly. The growing wish to have personal cars, pushed by more money for spending and cheaper vehicles, is also making the problem worse. As a result, when there are more private cars on the street it causes increased traffic volume especially at busy times of day.

The unbalanced increase in population and lack of growth in infrastructure significantly adds to congestion that results in many negative impacts. Traffic congestion [4]not only slows down transportation but also causes serious environmental problems. The fumes from vehicles that are not moving add to air pollution and greenhouse gases, which makes air worse and increases global warming [5, 6]. Also, when the streets are crowded with cars and trucks, it will take more time to travel. This impacts every person and different parts of our economy. For workers, an increase in travel duration means they have less time for actual

Journal of Information Systems Engineering and Management
2025, 10(35s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

work or enjoying life beyond their job's official hours. This also reduces their ability to produce output and impacts the overall quality of life. The irritation of being caught in traffic may result in road fury and intense driving manners, increasing the chances for accidents. Moreover, crowded traffic situations might lead to disorderly driving circumstances that enhance probabilities of accidents [7].

The stopping and starting of vehicles in heavy traffic, together with the high number of cars on the road, can create a situation where unpredicted accidents happen. The total effect of traffic congestion is a big problem that needs systematic solutions like putting money into public transport; enhancing infrastructure quality such as roads and bridges; planning land use properly along with promoting other means for traveling apart from using private automobiles. Working on these aspects can assist cities in lessening issues related to excessive traffic, as well as render living arrangements inside the cities more sustainable and agreeable for all parties involved. Hence, traffic management study [8]is very important for researchers in present times. We can reduce high congestion by two ways: one way is to add more transportation infrastructure which costs a lot of money; second way includes using possible traffic strategies like analyzing congestion pattern or making short-term traffic information prediction that can be applied quickly on existing road networks and it's just a small part of the total cost. When compare it to pattern analysis, which finds out about road networks that have repeated problems with too much traffic, predicting exact short-term information related to traffic like speed, volume and level of congestion becomes more useful for people who are traveling as well as those managing the flow of vehicles [9].

From these metrics, one parameter that is especially wanted and beneficial for short-term traffic forecasting has to be the traffic congestion level. This shows the condition of road network (like Jam, Slow or Free) which allows drivers to select routes better by avoiding congested roads. It also aids in enhancing efficiency of traffic managers who can react systematically towards variations in transport network's supply-demand balance. In this way, precise short-term predictions about traffic serve as a useful instrument for improving flow of cars on roads and lessening issues related with congestion in city environments. The beginning forecasting models [10, 11]mainly concentrated on estimating traffic characteristics like speed, volume and flow of vehicles in solitary roads, sets of roads or minor road networks. These models had a restriction because the complete data necessary was not easily accessible, so it limited their extent. Thus, these initial models only gave incomplete prediction abilities that were not very helpful for people who travel to work or organizations managing traffic looking for more detailed and useful understandings. Hence, these models did not receive extensive use and could not successfully tackle the larger requirements of city traffic management. In this first type of model, the data usually came from sensors that are fixed on roads [12].

These could be road sensors, inductive loops or traffic cameras. Some models also used data from networks of vehicles like Vehicular Ad Hoc Networks (VANETs) and Floating Car Data. In these cases, the cars themselves become a source for information as they move along various routes. The provided data was useful but it was not easy to gather consistently and required considerable effort to process into useful form for modeling purposes [13, 14]. These were some difficulties: Fixed sensors are costly in terms of installation, running and keeping them well-maintained. This kind of expense could make it hard to set up many fixed sensors throughout an area. Additionally, the continuing costs for maintaining these sensors so that they continue giving precise and dependable data over time are also taken into account. Getting data from these sources is not easy because of privacy and regulation issues. For example, to gather data from traffic cameras and other fixed sensors often needs special permissions that can be quite bureaucratic -it takes time to get these licenses. It make complexity to acquire the complete data needed for accurate and prompt traffic forecasts. Moreover, the difference in data quality and uniformity among sensors contributes to a fluctuation in accuracy of traffic predictions.

These limitations showed that there was a demand for better and broader ways of gathering data, along with more complex predictive models which could offer insights about traffic throughout the whole city. The dependence on fixed sensor information had scaling problems, pushing researchers to look at other sources of data and new ways to enhance forecasting. This change aimed at handling the flaws

Journal of Information Systems Engineering and Management
2025, 10(35s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

in initial models and providing more efficient methods for controlling urban traffic jam situations, benefiting both people who travel daily as well as those who manage traffic from their work perspective. The issue of traffic jam prediction has become very important as cities grow and face complex transportation problems. The old ways to forecast traffic, using fixed sensors along with limited data suppliers, cannot give total real-time understanding throughout the whole city. Web services like Google Traffic, Bing, Seoul Transportation Operation and Information Service (TOPIS) [15]are now bringing new perspectives in this field by giving precise city-wide real-time traffic information. Data from many places is gathered and studied. For instance, data from GPS that comes out of people's smartphones, information coming in from road sensors or traffic cameras -all these are combined to give an instant picture of how the traffic situation looks like. These kind of web services can provide abundant data and high-quality standards, factors that can enhance precision and dependability in traffic forecasts. The up-to-date traffic particulars from these services assist in developing better predictive models for foreseeing congestions without much lag time. This active information about traffic aids the creation of flexible management plans before congestion turns into a problem [16].

Also, these web services are simpler to use and less costly compared to the old ways of collecting data. This lowers the demand for expensive building and upkeep of infrastructure. However, even with their potential advantages, deep learning models for traffic congestion prediction also come with some significant limitations [17]. These models need a lot of good quality data sets to train on. It might be hard to gather and keep these data sets, especially in real-time and across big city areas. Also, deep learning models are very demanding on computer power and memory resources. This makes live prediction complicated and requires a big investment in high-performance computing infrastructure. So, the proposed work could be related to developing a particular and intelligent system for recognizing traffic jams in networks of smart cities by utilizing images from traffic [18].

This approach takes advantage of the common existence of traffic cameras and image information to offer immediate accurate forecast about crowded regions. The structure uses sophisticated methods for image processing and deep learning [19, 20]. It can examine the traffic images, locate congested patterns and provide prompt information to people who travel as well as traffic management agencies. The addition of traffic images also improves model interpretability because visual data is easier to understand and can be verified by human operators. The idea of this creative system is to enhance city movement, reduce crowding, and contribute in constructing more intelligent city transport systems.

The main research objectives of this work are given below:

- This develop a new structure that uses sophisticated methods to improve the precision of forecasting traffic jams on smart city networks
- To implement ANN as an important part of the framework, created to adeptly capture spatial-temporal characteristics from traffic data

The paper is organized as follows: Section 2, a thorough review of literature about traffic jam prediction models. This area deeply examines different methods ranging from old statistical ways to complex deep learning techniques and their advantages as well as disadvantages. Section 3, an understandable explanation of the suggested model. This part gives a detailed path for the process and algorithmic explanations which show how traffic images are used to detect congestion. In section 4, we discuss about performance outcomes of this proposed work that include results compared with existing models to show its effectiveness and enhancements. To end, Section 5 gives a wrap-up of the paper's results and offers ideas for upcoming studies to improve traffic congestion prediction in smart city networks.

II. STUDY OF LITERATURE

In this section, we examine the current research on anticipating traffic congestion in smart city settings. There is a special emphasis placed on typical machine learning and deep learning methods. Through study of appropriate literature, we intend to give an all-encompassing view of the ways, algorithms and approaches used for predicting traffic jams. This review acts as groundwork for comprehending how models for

Journal of Information Systems Engineering and Management
2025, 10(35s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

prediction have changed over time within this area and recognizing important patterns and obstacles that influence present study tasks.Bai, et al [21]introduced a new method for predicting traffic jam using Relative Position Congestion Tensor and Predictor for Position Congestion Tensor. The goal of the authors is to solve the difficulty in accurately guessing traffic congestion on city road networks by using spatio-temporal data and deep learning methods. This technique works with relative places of road nodes, which is different from usual ways that often concentrate only on absolute locations or basic traffic details such as speed and amount. These matrices get changed to three-dimensional spatio-temporal tensors, which offer an extensive representation of traffic data across time and area. The model's need for large and good traffic data is a big difficulty, because it can take much effort to get and keep these sets of information. Also, the complexity of computational work in ConvLSTM networks could restrict how easy it is to increase the size of model and use it in real time. This situation may be more difficult for traffic management groups that do not have much access to strong computing facilities. Lastly, not being able to interpret the predictions from this model might slow down its acceptance by professionals who manage traffic situations.

Akhtar, et al [22]orderly wraps up previous research that has been done by using different methods of artificial intelligence, especially various machine learning models. It neatly classifies these models into branches of AI and gives a complete view on their strong points and drawbacks. This way of arranging information helpsreaders to get a straightforward grasp on the wide-ranging field of AI-centered solutions for certain problems. In this way, the paper combines what literature already exists to give important understandings about the present situation of AI research and to show where more study is needed or enhancements are possible. The mention of artificial intelligence development and availability of big data points towards a shift in traffic management, where researchers are using modern modeling methods to deal with this.

Khan, et al [23]talks about a very important missing part in the field. It suggests an effective scheme for predicting traffic flow using group techniques, like bagging, combined with air pollution data. This method is especially useful because it helps to make precise traffic flow prediction systems in smart cities more accurate. These systems need advanced methods to handle growing congestion problems efficiently. The goal of the research is to predict traffic flow and it has two parts: first compare various simple regression techniques to find best model performing; second use bagging and stacking ensemble methods for improving prediction accuracy afterwards. However, the model's usefulness could be restricted by the necessity for pollution data, which might not be easy to get in some places. Also, the computational difficulty of ensemble techniques such as bagging might make it difficult to apply them immediately in environments with limited resources. Furthermore, this study mainly concentrates on regression models and could overlook other sophisticated machine learning methods thatcould boost prediction precision.

III. MODELING AND ANALYSIS

In this part, the clear explanation for the proposed Artificial Neural Network (ANN) model is provided in detail. We will explain how it works and what methods it uses. This work's main goal is to present an original framework called ANN that is designed for predicting traffic congestion in smart city networks. For reaching this aim, we use advanced image processing methods ANN. The ANN methodology is an approach to examining and foreseeing traffic jams in city areas, using input data that comes as pictures. These pictures are like quick views of different parts of the city's traffic situation, showing important details such as how many vehicles there are on a road or what kind of condition it's in along with patterns for how much movement is happening at any given time. The power of the ANN structure, which includes separable convolution layers based on depth wise convolutions assists ANN in efficiently extracting spatial features from these images without excessive computational requirements. Next, the spatial features are taken and put into the recurrent layers of ANN. This lets the model understand time-based relationships and moving patterns found in traffic data. The inclusion of recurrent connections helps ANN to examine data sequences across time, thus boosting its prediction abilities. ANN provides a special and strong answer for predicting traffic jams within smart city networks. This prediction is very helpful for those who plan cities and manage traffic because it allows them to take action before congestion starts. They can put in place measures that lessen congestion or enhance transport efficiency when they know about it beforehand from reliable

Journal of Information Systems Engineering and Management
2025, 10(35s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/ **Research Article**

predictions made by ANN. In the end, the creation of ANN makes a big step forward in traffic management area which could change how we deal with difficult issues related to urban movement during current time period. The proposed ANN is bringing a fresh framework that changes the way we predict traffic jams in smart city networks. It essentially uses advanced methods for processing images, especially ANN, to get complex spatial traits from traffic pictures. In contrast with old ways of looking at images as fixed things, ANN uses the recurrent connections in ANN to understand times-based relationships and moving patterns present in traffic data. This merging creates the ability for ANN to inspect sequential details across time, providing better understanding about how traffic moves and congestions growing.

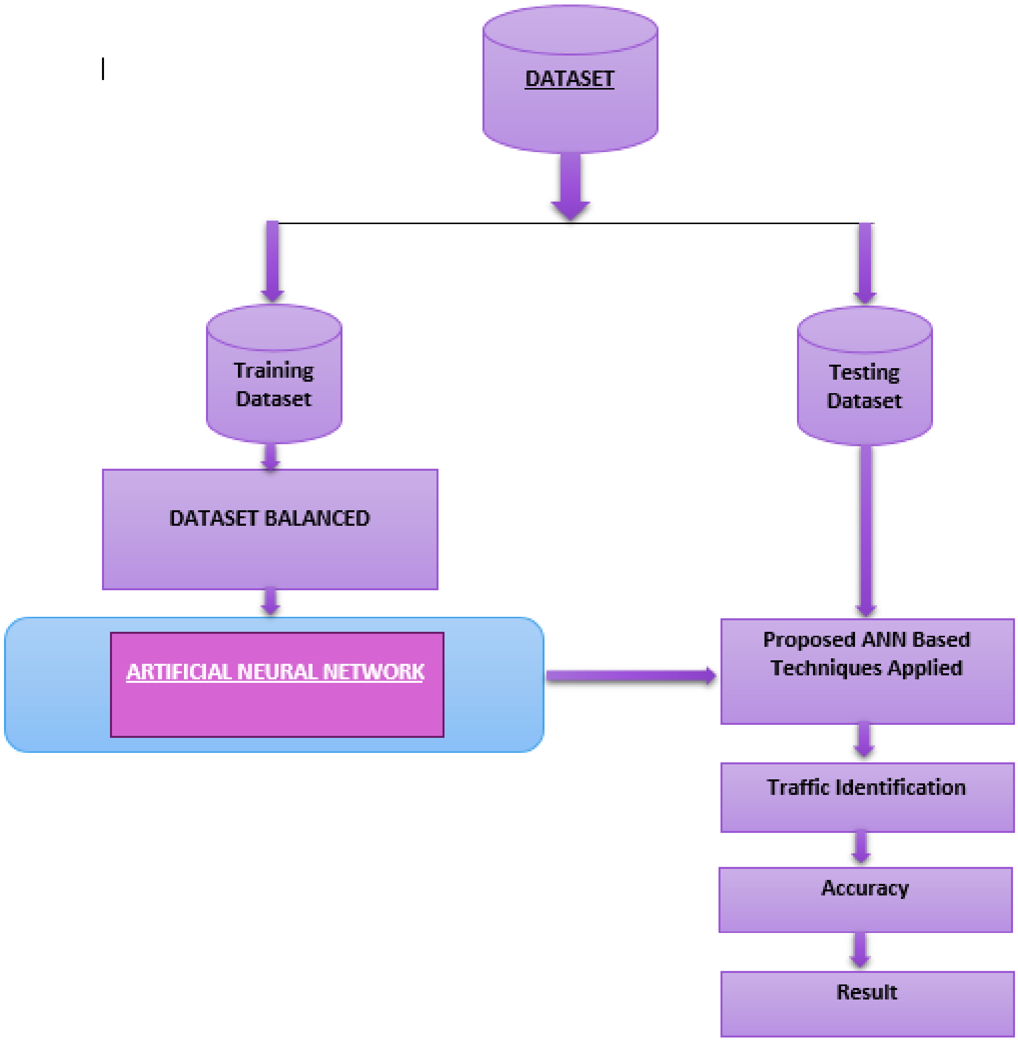

Fig 1: Proposed model

The flow of the ANN model can be seen in Fig 1, which gives a graphical display of how the ANN structure works to anticipate traffic congestion amounts within smart city networks.

Acquiring Input Data: The first step is to acquire input data. This usually involves gathering different kinds of traffic-related information from smart city sensors, cameras or other monitoring devices. The input data contains images that show the present situation of traffic like vehicle quantity, condition of roads and patterns in how traffic is flowing.

- Preprocessing: The input data that we have collected goes through preprocessing steps to make it ready for more analysis. This can include actions like cleaning the data, normalizing it, and adding more to improve quality and uniformity of input data.

Journal of Information Systems Engineering and Management
2025, 10(35s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

- Feature Extraction: The data that has been preprocessed is given to the module for feature extraction. Here, important spatial and temporal features are taken out. This part uses complex methods like ANNs to get useful attributes from the input data.

- Training and validation: After feature extraction, the ANN model is trained. In this phase, the model learns to match input data with appropriate levels of traffic congestion. It does so by using a mix of supervised learning methods and optimization techniques on the features gathered from previous stage. After the model is trained, it can be used to make predictions on fresh data that hasn't been seen before. The ANN model which has been trained takes in input as the features extracted from incoming data and gives out predictions on traffic jam levels for a specific smart city network.

- Evaluation: At last, the performance of ANN model is assessed by using suitable standard and yardstick to measure how precise, dependable and successful it can be in predicting traffic jam. This evaluation step helps in understanding the strong points as well as restrictions of this model and directs possible enhancements or adjustments.

IV. RESULTS AND DISCUSSION

This section shows that the suggested model, the ANN, has been validated and is considered strong. Validation is an important phase in creating any forecasting model. It makes sure the model works well on data it hasn't seen before, not just on the training set. We are using open source datasets, which provide traffic information from different smart city locations and cover a wide range of traffic scenarios. The chosen open source datasets for validation, Kaggle and GoogleMap, are quite varied in their traffic scenarios. They include city traffic congestion, movement on highways and even seasonal patterns within traffic conditions. These datasets provide extensive and data to test the model's ability to handle different kinds oftraffic situations. Once these sets have been chosen, we do preprocessing steps before they go into our model. Standard preprocessing steps involve cleaning the data, normalizing it or feature extraction as required by our input pipeline setup stage. This aids in ensuring that the data is well-structured which enhances learning of model by assisting it to comprehend and utilize information efficiently. To understand more clearly how well the ANN model performs, we use a variety of evaluation measures. These measures give us number-based results that can be used for comparison with other methods available now.

```
Epoch 1/10
1202/1202 [==============================] - 54s 42ms/step - loss: 0.2126 - accuracy: 0.9112
Epoch 2/10
1202/1202 [==============================] - 53s 44ms/step - loss: 0.1291 - accuracy: 0.9498
Epoch 3/10
1202/1202 [==============================] - 48s 40ms/step - loss: 0.1205 - accuracy: 0.9557
Epoch 4/10
1202/1202 [==============================] - 50s 41ms/step - loss: 0.1141 - accuracy: 0.9563
Epoch 5/10
1202/1202 [==============================] - 49s 41ms/step - loss: 0.1098 - accuracy: 0.9586
Epoch 6/10
1202/1202 [==============================] - 49s 40ms/step - loss: 0.1102 - accuracy: 0.9584
Epoch 7/10
1202/1202 [==============================] - 50s 42ms/step - loss: 0.1101 - accuracy: 0.9576
Epoch 8/10
1202/1202 [==============================] - 48s 40ms/step - loss: 0.1059 - accuracy: 0.9599
Epoch 9/10
1202/1202 [==============================] - 53s 44ms/step - loss: 0.1043 - accuracy: 0.9593
Epoch 10/10
1202/1202 [==============================] - 49s 41ms/step - loss: 0.1045 - accuracy: 0.9602
Training Loss: [0.09117908030748367, 0.9626586437225342]
Testing Loss: [0.10993289947509766, 0.9573538303375244]
```

Fig 2: ANN Accuracy

Journal of Information Systems Engineering and Management
2025, 10(35s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

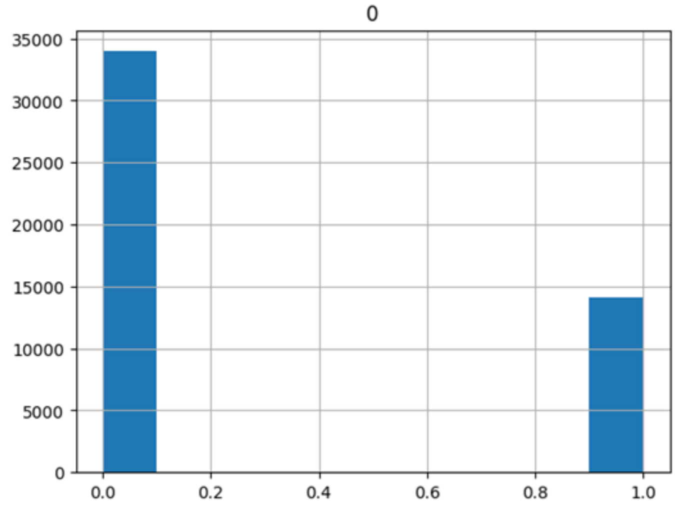

Fig 3: Imbalanced Data

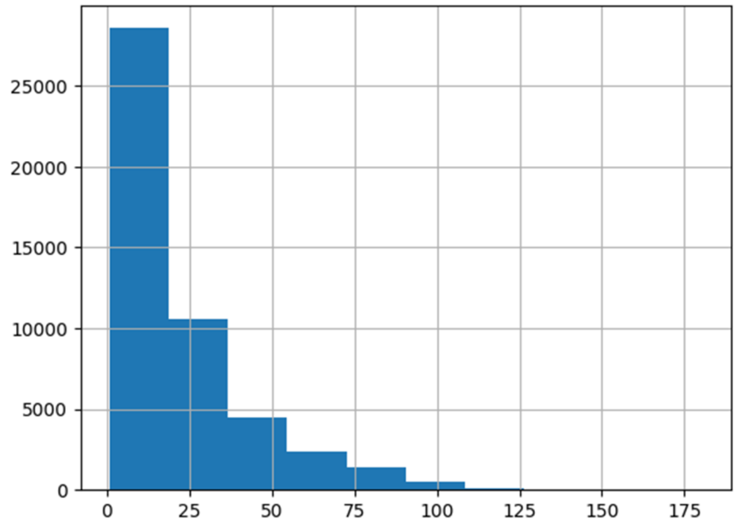

Fig 4: Vehicle Histogram

V. CONCLUSION

This paper proposes a new framework, ANN to forecast traffic congestion in smart city surroundings. The ANN techniques provide strong and effective solutions for managing traffic instantly. We have presented the ANN model, which is a new and innovative framework designed to predict traffic congestion in smart city environments. The advanced methodologies used by this model include the DATASET BALANCING Technique. This high-level technology solution shows promise in providing efficient management of traffic. The ANN has excellent ability to extract features of space and time from traffic images, making it suitable for prediction purposes.. The ANN model shows excellent results in our thorough evaluations with open-source datasets, especially from Kaggle. The superiority of the proposed model is evident across multiple metrics. The findings of the study indicate that the ANN model is not only effective in predicting traffic congestion, but it can also be adjusted and scaled to fit various urban situations. The application of this model might result in significant improvements for managing traffic movement. It could potentially reduce congestion along with travel time and related environmental impacts. The ANN model is a big advancement in intelligent transportation systems. It utilizes high-level techniques of machine learning and optimization algorithms, providing city planners as well as traffic controlling bodies with a powerful tool to enhance urban mobility. The future tasks will focus on refining this model more, incorporating real-time data flows and expanding its utilization within smart city frameworks to other domains. The model hopes to provide a smarter, more efficient and enduring solution for managing traffic in cities using ANN deployment. Ultimately, this could result in improved global living standards.

REFERENCES

[1] B. Vijayalakshmi, K. Ramar, N. Jhanjhi, S. Verma, M. Kaliappan, K. Vijayalakshmi, et al., "An attention-based deep learning model for traffic flow prediction using spatiotemporal features towards sustainable smart city," International Journal of Communication Systems, vol. 34, p. e4609, 2021.

[2] A. Hameed, J. Violos, and A. Leivadeas, "A deep learning approach forIoT traffic multi- classification in a smart-city scenario," IEEe Access, vol. 10, pp. 21193-21210, 2022.

[3] F. Wang, J. Xu, C. Liu, R. Zhou, and P. Zhao, "On prediction of traffic flows in smart cities: a multitask deep learning based approach," World Wide Web, vol. 24, pp. 805-823, 2021.

[4] S. Bhattacharya, S. R. K. Somayaji, T. R. Gadekallu, M. Alazab, and P. K. R. Maddikunta, "A review on deep learning for future smart cities," Internet Technology Letters, vol. 5, p. e187, 2022.

[5] Q. Chen, W. Wang, F. Wu, S. De, R. Wang, B. Zhang, et al., "A survey on an emerging area: Deep learning for smart city data," IEEE Transactions on Emerging Topics in Computational Intelligence, vol. 3, pp. 392-410, 2019.

[6] B. Liu, C.-T. Lam, B. K. Ng, X. Yuan, and S. K. Im, "A Graph-based Framework for Traffic Forecasting and Congestion Detection using Online Images from Multiple Cameras," IEEE Access, 2024

[7] S. Neelakandan, M. Berlin, S. Tripathi, V. B. Devi, I. Bhardwaj, and N. Arulkumar, "IoT-based traffic prediction and traffic signal control system for smart city," Soft Computing, vol. 25, pp. 12241-12248, 2021.

[8] S. Khan, S. Nazir, I. García-Magariño, and A. Hussain, "Deep learning-based urban big data fusion in smart cities: Towards traffic monitoring and flow-preserving fusion," Computers & Electrical Engineering, vol. 89, p. 106906, 2021.

[9] R. M. AlZoman and M. J. Alenazi, "A comparative study of traffic classification techniques for smart city networks," Sensors, vol. 21, p. 4677, 2021.

[10] D. K. Reddy, H.S. Behera, J. Nayak, P. Vijayakumar, B. Naik, and P. K. Singh, "Deep neural network based anomaly detection in Internet of Things network traffic tracking for the applications of future smart cities," Transactions on Emerging Telecommunications Technologies, vol. 32, p. e4121, 2021.

[11] A. N. Muhammad, A. M. Aseere, H. Chiroma, H. Shah, A. Y. Gital, and I. A. T. Hashem, "Deep learning application in smart cities: recent development, taxonomy, challenges and research prospects," Neural computing and applications, vol. 33, pp. 2973-3009, 2021

[12] S. Majumdar, M. M. Subhani, B. Roullier, A. Anjum, and R. Zhu, "Congestion prediction for smart sustainable cities using IoT and machine learning approaches," Sustainable Cities and Society, vol. 64, p. 102500, 2021.

[13] X. Yin, G. Wu, J. Wei, Y. Shen, H. Qi, and B. Yin, "Deep learning on traffic prediction: Methods, analysis, and future directions," IEEE Transactions on Intelligent Transportation Systems, vol. 23, pp. 4927-4943, 2021.

[14] G. Perumal, G. Subburayalu, Q. Abbas, S. M. Naqi, and I. Qureshi, "VBQ-Net: A Novel Vectorization-Based Boost Quantized Network Model for Maximizing the Security Level of IoT System to Prevent Intrusions," Systems, vol. 11, p. 436, 2023

[15] Navarro-Espinoza, O. R. López-Bonilla, E. E. García-Guerrero, E. Tlelo-Cuautle, D. López-Mancilla, C. Hernández-Mejía, et al., "Traffic flow prediction for smart traffic lights using machine learning algorithms," Technologies, vol. 10, p. 5, 2022.

[16] J. James, "Citywide traffic speed prediction: A geometric deep learning approach," Knowledge-Based Systems, vol. 212, p. 106592, 2021

[17] A. N. Aledaily and K. Yadav, "Deep learning techniques for the prediction of traffic jam management for smart city infrastructure," in Artificial Intelligence and Blockchain in Industry 4.0, ed: CRC Press,

2024, pp. 163-183.

[18] K. L.-M. Ang, J. K. P. Seng, E. Ngharamike, and G. K. Ijemaru, "Emerging technologies for smart cities' transportation: geo-information, data analytics and machine learning approaches," ISPRS International Journal of Geo-Information, vol. 11, p. 85, 2022.

[19] X. Li, H. Liu, W. Wang, Y. Zheng, H. Lv, and Z. Lv, "Big data analysis of the internet of things in the digital twins of smart city based on deep learning," Future Generation Computer Systems, vol. 128, pp. 167-177, 2022.

[20] International Journal of Intelligent Systems and Applications in EngineeringIJISAE, 2024, 12(23s), 71–83|83[20]D. Hemanand, G. V. Reddy, S. S. Babu, K. R. Balmuri, T. Chitra, and S. Gopalakrishnan, "An intelligent intrusion detection and classification system using CSGO- LSVM model for wireless sensor networks(WSNs)," International Journal of Intelligent Systems and Applications in Engineering, vol. 10, pp. 285–293-285–293, 2022

[21] M. Bai, Y. Lin, M. Ma, P. Wang, and L. Duan, "PrePCT: Traffic congestion prediction in smart cities with relative position congestion tensor," Neurocomputing, vol. 444, pp. 147-157, 2021/07/15/ 2021.

[22] M. Akhtar and S. Moridpour, "A review of traffic congestion prediction using artificial intelligence," Journal of Advanced Transportation, vol. 2021, p. 8878011, 2021.

[23] N. U.Khan, M. A. Shah, C. Maple, E. Ahmed, and N. Asghar, "Traffic flow prediction: an intelligent scheme for forecasting traffic flow using air pollution data in smart cities with bagging ensemble," Sustainability, vol. 14, p. 4164, 2022.

[24] T.Devi, K. Alice, and N. Deepa, "Traffic management in smart cities using support vector machine for predicting the accuracy during peak traffic conditions," Materials Today: Proceedings, vol. 62, pp. 4980-4984, 2022.

[25] A. Campbell, A. Both, and Q. C. Sun, "Detectingand mapping traffic signs from Google Street View images using deep learning and GIS," Computers, Environment and Urban Systems, vol. 77, p. 101350, 2019.

[26] R. Al-qudah, Y. Khamayseh, M. Aldwairi, and S. Khan, "The Smart in Smart Cities: A Framework for Image Classification Using Deep Learning," Sensors, vol. 22, p. 4390, 2022.

[27] A. G. Ismaeel, K. Janardhanan, M. Sankar, Y. Natarajan, S. N. Mahmood, S. Alani, et al., "Traffic pattern classification in smart cities using deep recurrent neural network," Sustainability, vol. 15, p. 14522, 2023.

[28] Jenifer and R. Priyadarsini, "Improved mayfly optimization and LightGBM classifier for smart city traffic prediction," Indian Journal of Science and Technology, vol. 15, pp. 2085-92, 2022.

[29] D. O. Oyewola, E. G. Dada, and M. B. Jibrin, "Smart City Traffic Patterns Prediction Using Machine Learning," in Machine Learning Techniques for Smart City Applications: Trends and Solutions, ed: Springer, 2022, pp. 123-133.

[30] H. Deekshetha, A. Shreyas Madhav, and A. K. Tyagi, "Traffic prediction using machine learning," in Evolutionary Computing and Mobile Sustainable Networks: Proceedings of ICECMSN 2021, ed: Springer, 2022, pp. 969-983