# To Explore and Analyze the Role of IOT, Artificial Intelligence and Machine Learning in Solving the Commuting Problems of Smart Cities

स्मार्ट शहरों में आवागमन करने की समस्याओं को हल करने में आईओटी, आर्टिफिशियल इंटेलिजेंस और मशीन लर्निंग की भूमिका का अन्वेषण और विश्लेषण करना

**A**

**Thesis**

**Submitted for the Award of the Ph.D. degree of**

**PACIFIC ACADEMY OF HIGHER EDUCATION AND RESEARCH UNIVERSITY**

By


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**2024**

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I**, AVINASH DANGWANI S/O SHRI SUNDER DANGWANI** resident Thane District Maharashtra, hereby declare that the research work incorporated in the present thesis entitled **"To Explore and Analyze the Role of IOT, Artificial Intelligence and Machine Learning in Solving the Commuting Problems of Smart Cities"** (स्मार्ट शहरों में आवागमन करने की समस्याओं को हल करने में आईओटी, आर्टिफिशियल इंटेलिजेंस और मशीन लर्निंग की भूमिका का अन्वेषण और विश्लेषण करना) is my original work. This work (in part or in full) has not been submitted to any University for the award or a Degree or a Diploma. I have properly acknowledged the material collected from secondary sources wherever required.

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**Avinash Dangwani**

# PREFACE

The increase in the smart city initiatives in the past decades has made the world community appreciate the depth of the complicated problems of the urban settings and they appear to be in desperate need of the new ideas how to deal with them. It is undeniable that the world is getting more and more connected and the pace of urbanization is quickly increasing. This situation makes it much more promising that a variety of smart technologies and systems can be put into practice to effectively increase the efficiency and sustainability of urban systems and significantly enhance the quality of life for city inhabitants.

The given thesis represents the outcome of the thorough investigation and further studies which shows how machine learning algorithms may be used to solve major commuting issues in smart cities. By combining the cross-system perspective of computer science, urban planning, and data analytics, the study explores the complex dance between technological creativity and municipal management.

Such a trip is not about reaching the sizeable figure; rather, it is about the travel itself. It navigates the universe of machine learning methods, starting from the classical algorithms to the cutting-edge ones submitted to the differentiable nature of the challenges of smart cities, to determine which one offers the most suitable and effective solution to all these predicaments. Careful experimentation and comparative analysis of different machine learning approaches are the major pillars of this research. It refrains from settling on the side of the various algorithms and consensus is reached on their effectiveness in real world based on the findings.

I firmly hope that the claim presented herein contributes significantly to the ongoing discussion of the design, implementation, and another international level matter of smart cities governance. The proposed research is divided into six chapters, which gives complete roadmap of the research scope and implementation.

**Chapter – 1 Introduction:**

It emphasizes on the basic terminology of research topic, it creates awareness about requirement of smart transportation in smart city, merits and demerits of this terminology. This chapter highlights the critical transportation issues such as traffic

congestion, seat availability, bus tracking system, lack of bus interval information, and the need for enhanced passenger communication tools such as public addressing system. It also discuss role of Internet of Things, Artificial Intelligence and Machine learning Algorithms in effectively addressing commuting issues in smart cities.

**Chapter – 2 Literature Review:**

It focuses on the groundwork done on smart transportation till date. Its manifest will be to denote gaps in research already done. It highlights the innovative work done or proposed by various Authors in the relevant fields.

**Chapter – 3 Research Methodology:**

This chapter signify the role of different research methodologies adopted to study a research problem, along with the underlying logic behind them. This chapter also include, Hypothesis to be tested, Scope of study, various IOT data collection methods, research design and different tools required for analysis of machine learning algorithms.

**Chapter – 4 Feature Extraction and Data Processing using IoT:**

This chapter focuses on features selection and data processing. Feature extraction aims to reduce the number of features in a dataset by selecting required features from the existing ones (and then discarding the redundant features). These new reduced set of features were being summarize most of the information contained in the original set of features. Out of twenty one features, only seven features were filtered using eight feature selection Machine learning algorithms.

**Chapter – 5 Utilization of AI and ML Prediction Algorithms:**

This chapter discuss how we can make use of Artificial Intelligence and Machine Learning algorithms for predicting Traffic congestion. Machine learns from experiences; Algorithms develop multiple models and each model is analogous to an experience. The main objective of Machine Learning algorithm is to improve prediction accuracy for Traffic congestion. This doctoral thesis embarks on a detailed exploration of nine prominent machine learning algorithms, evaluating their performance across a spectrum of critical performance metrics. The primary objective of this research is to conduct a rigorous comparative analysis of machine learning algorithms, shedding light on their strengths, weaknesses, and applicability in diverse scenarios. The evaluation

framework encompasses an array of performance parameters, including accuracy, incorrectly classified instances, kappa statistics, and various aspects of the confusion matrix such as true positives (TP), true negatives (TN), false positives (FP), false negatives (FN), precision, recall, and F-measure. The nine machine learning algorithms listed below are selected for this study represent a comprehensive spectrum of techniques commonly employed in real-world applications:

1. Bayes Net
2. Naïve Bayes
3. Logistic
4. SMO
5. IBk
6. KStar
7. MultiClass Classifier
8. Random Forest
9. RandomTree

This research contributes to the field of machine learning by offering a systematic comparative and in-depth analysis of nine prominent algorithms based on a set of performance parameters. Each algorithm is thoroughly analyzed and compared based on their performance using Udaipur traffic data set obtained from TOMTOM server. To assess the performance and ability of Machine learning models, K fold cross validation techniques and percentage split methods are used. K-Fold cross-validation involves splitting the dataset into K subsets (or folds) of approximately equal size. The model is trained K times, each time using K-1 folds as training data and the remaining fold as validation data. 10 fold, 25 fold and 30% split cases are analyzed for thesis.

Finally this doctoral thesis inquiries intellectual landscape through a focused hypothesis-driven study aimed at investigating usefulness of different technologies and different machine learning algorithms in solving commuting problems in smart cities.

**Chapter – 6 Conclusion and Future Scope:**

Last chapter put emphasis on the culmination of research on smart commuting and future improvisation that can be done, as learning is continuous process for any field of research and development. It also leave some open questions to be investigated in future for researchers.

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# ABBREVIATIONS

| | |
|---|---|
| AALS | Accident Alert Sound System |
| AI | Artificial Intelligence |
| ANN | Artificial Neural Network |
| API | Application Program Interfaces |
| AQI | Air Quality Index |
| ARIMA | Autoregressive Integrated Moving Average |
| ATM | Adaptive Traffic Management |
| AUC | Area Under ROC Curve |
| AV | Autonomous Vehicles |
| CNN | Convolution Neural Networks |
| CoAP | Constrained Application Protocol |
| CRN | Cognitive Radio Networks |
| DL | Deep Learning |
| ETM | Electronic Ticketing Machines |
| FN | False Negative |
| FP | False Positive |
| FPGA | Field Programmable Gate Array |
| FPR | False Positive Rate |
| GRU | Gated Recurrent Unit |
| HTTP | Hypertext transfer protocol |
| IBK | Instance-Based k-Nearest Neighbors |
| IBSO | Improved Binary Swarm Optimization |
| ICT | Information Communication and Technology |
| IoT | Internet of Things |
| IEEE | Institute of Electrical and Electronics Engineers |
| ITS | Intelligent Transportation System |
| KNN | k-Nearest Neighbours |
| LPWAN | Low-power wide area network |
| LSTM | Long Short-Term Memory |
| MaaS | Mobility-as-a-Service |
| ML | Machine Learning |

| | |
|---|---|
| MLP | Multilayer Perceptron |
| MQTT | Message Queuing Telemetry Transport |
| OSM | Open Street Map |
| PAS | Public Addressing System |
| RF | Random Forest |
| RNN | Recurrent Neural Networks |
| ROC | Receiver Operating Characteristics |
| SARIMA | Seasonal Auto Regressive Integrated Moving Average |
| SCs | Smart Cities |
| SDN | Software-Defined Network |
| SEE-TREND | Secure Early Traffic-Related Event Detection |
| SFC | Static Feedback Control |
| SMO | Sequential Minimal Optimization |
| SOAP | Simple Object Access Protocol |
| SSL | Secure Socket Layer |
| SVM | Support Vector Machines |
| TMS | Transport Management System |
| TN | True Negative |
| TNSTC | Tamil Nadu State Transport Corporation |
| TP | True Positive |
| TPR | True Positive Rate |
| UTAUT | Unified Theory of Acceptance and Use of Technology |
| VKT | Vehicle Kilometers Traveled |
| VMT | Vehicle miles travelled |
| WSDL | Web Services Description Language |

# SYMBOLS

| | |
|---|---|
| μ | Mean |
| σ | Standard Deviation |
| χ | Chi – square |
| π | Pi |
| α | Significant Level |
| f | Frequency |
| Ef | Expected Frequency |
| β | Standardized Coefficient |