Chapter – 3
Research Methodology

3.1 Introduction

The Internet of Things is a technological system that replaces human interaction with a variety of tools and gadgets. This makes it possible for smart cities to sprout up all over the world. The internet of things, which contains several technologies and allows interactions between them, has sped up the development of smart city systems for sustainable living, greater comfort, and increased productivity for people. A wide range of industries are significantly impacted by the Internet of Things for Smart Cities, and its operation depends on a number of different underlying technologies. The Internet of Things in Smart Cities is in-depth examined in this study. Following the architectures, networking, and artificial algorithms that support these domains in IoT-based Smart City systems, the major elements of the IoT-based Smart City environment are provided.

IOT, Data science, Artificial Intelligence, and Machine Learning are just a few of the technologies that are coming together to form the Fourth Industrial Revolution, which has the potential to dramatically alter how public transportation information systems are seen. Artificial intelligence technology is capable of self-correcting and has a brain like a person. A subset of artificial intelligence called machine learning replicates how people learn. With the aid of IoT, it is necessary to investigate the usage of artificial intelligence and machine learning to address issues with the public transportation information system. To improve users' experiences using public transportation, research must be conducted on various artificial intelligence and machine learning algorithms using IoT and GPS to show real-time bus arrival time information, bus interval information, and seat availability.

3.2 Significance of Research

Research methodology is the way in which research problems are solved systematically. Research methods are the strategies, processes or techniques utilized in the collection of data or evidence for analysis in order to uncover new information or create better understanding of a topic. It is a science of studying how research is conducted scientifically. Under it, the researcher acquaints himself/herself with the various steps generally adopted to study a research problem, along with the underlying logic behind them. Research methodology deals with scientific results, the hypothesis which is the outcomes of the objectives with the results. Research methodology is defined by the source of information on which the work will be done. The tools and technology to work on the information are chosen carefully to result in the positive outcome of the hypothesis.

3.3 Problem Statement

Our research work is an attempt to understand the importance of IoT, Artificial Intelligence and machine learning in solving commuting problems. The central problem focuses on:

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

The research work studies the level of automation work, commuting issues, explore the technologies for improving reliability of public transportation system of smart cities, simulate data using IOT, Artificial Intelligence and Machine Learning Algorithms to resolve commuting problems and find trends, issues, challenges, suggestions, and future potential of commuting problems in smart cities. Overall, the research work finds the usage of IOT, Artificial Intelligence and Machine Learning techniques in solving the commuting problems for hassle-free journey in smart cities.

3.4 Objectives

An objective creates vision and converts it into measurable targets. Objectives direct our activities toward achieving the goals and vision. Objectives bring motivation among stakeholders and help in decision making. It brings clarity, focus, provides direction and motivates us to measure progress. Objectives create the environment of clear and transparent communication to achieve the targets. It also helps us to continuously improve to reduce errors and bring better results close to set targets. The main urge behind our research is to solve commuting problems using IOT, Artificial Intelligence and Machine Learning technology and making smart public transport systems for smart cities. The objectives of research are:

1. **To study the commuting and traffic congestion issues associated with smart cities.**

2. **To analyze the different technologies used for enhancing the transportation system for smart cities.**

3. **Comparative analysis of various existing IoT based traffic prediction models and traffic control systems for smart cities.**

4. **To develop a machine learning predictive model for Smart Transportation System.**

5. **To analyze the performance of machine learning predictive model for Smart Transportation System based on various performance measures.**

6. **To address the implementation issues related to deployment of Intelligent Transportation System.**

7. **To identify the most appropriate machine learning approach related to traffic congestion monitoring and transportation management system for Smart cities.**

The main goal of research work is to use various analyzing tools to create model, and study commuting problems in smart cities and provide solutions with the help of IoT, AI and ML algorithms for stress free smart commuting. Research being focused on smart public transport information systems to achieve above mentioned objectives.

3.5 Hypothesis

Hypothesis is nothing but a tentative statement or proposed explanation made based on limited evidence as a starting point for further investigation. The following hypothesis is being tested for proposed research work.

H_o1: There is no significant difference between technologies used for enhancing the transportation system for smart cities.

H_o2: The Machine learning-based traffic prediction models have average performance scores of greater than or equal to 75%.

Hypothesis is playing vital role in the field of IoT, AI and ML for problem formulation, problem solving, testing, continuous learning, Decision making and predictive modelling. Hypothesis help us in successful completion of the project.

3.6 Scope of Study

Our study is focused on Implementation of IoT, Artificial Intelligence and Machine Learning Algorithms to solve commuting problems. Smart Transportation Systems are increasingly integrating IoT, Machine Learning and Artificial Intelligence to revolutionize transportation networks. Machine Learning algorithms optimize traffic management by predicting congestion and adapting traffic signals in real time. Predictive maintenance powered by Machine Learning prevents infrastructure failures, saving costs and enhancing safety. Artificial Intelligence-driven public transportation planning improves routes and schedules based on dynamic factors. The limiting factors or challenges are data collection complexity, data privacy and security, continuous data access, Interoperability issues, overloaded wireless networks and continuous model monitoring and adaptation. The scope of IoT combined with Artificial intelligence and Machine Learning is very vast and promising.

3.7 Research Design

The research design for the study encompasses elements of both quantitative and qualitative research designs. It incorporates literature review, data collection, comparative analysis, model development, performance evaluation, and addressing implementation issues. The quantitative aspect involves data collection on commuting patterns, traffic flow, congestion levels, transportation infrastructure, and performance metrics. Statistical analysis techniques are applied to compare technologies, models, and performance measures. Machine learning algorithms are used for predictive modelling and performance evaluation. The qualitative aspect includes the literature review, which synthesizes existing knowledge and identifies gaps. Interviews, surveys, and focus groups may be conducted to gather insights from commuters, transportation authorities, and urban planners, addressing implementation issues and obtaining feedback on the effectiveness of transportation systems. Overall, this research design can be considered a mixed methods approach, combining quantitative analysis and qualitative insights to provide a comprehensive understanding of smart transportation systems and traffic management in smart cities.

3.7.1 Information Collection Procedure

Information is gathered on commuting patterns, traffic flow, congestion levels, transportation infrastructure, and smart city initiatives from relevant sources such as transportation authorities, urban planning departments, and IoT sensor networks. Collected information on the performance of existing transportation technologies and traffic prediction models etc. The different Information collection methods used are:

1. By Observation

In observation procedure, various companies, traffic departments, public places were visited to understand the problems and solutions adapted. The following places were visited:

a) Pyrotech company Udaipur Rajasthan India to understand Automation work of Street lights used in smart cities.

b) AGV Ambernath Maharashtra India to get acquainted with IoT Enabled video Door phone, Smart IoT Enabled battery management system.

c) The Brihan Mumbai Electric Supply and Transport Undertaking GM's office BEST Marg Colaba Mumbai to get traffic congestion data.

d) BEST Planning department Wadala Mumbai to collect fleet management and traffic congestion data.

e) Udaipole Udaipur Rajasthan India pay and park to understand automation of parking allotment and to collect parking allotment data.

Countless hours spent on observation and contacting people had given me insights of commuting problems in smart cities. This helped me to understand and analyze the actual traffic problems of smart cities. I am thankful to authorities who not only shared their knowledge and experience with me but also helped me in connecting with subject matter.

2. Through Interviews

Personal interactions were conducted with leading industry people like chairman of Pyrotech company Udaipur Rajasthan, Director of AGV Systems MIDC Ambernath Maharashtra, General manager of BEST Bhavan Colaba Mumbai Maharashtra and Deputy Head Planning Department Wadala Mumbai Maharashtra. All the dignitaries were interviewed on usage of IoT, Artificial intelligence and Machine learning in smart city transportation. Their opinion and views were considered to carry out research in IoT, Artificial intelligence and Machine learning to solve commuting problems in smart cities.

3. Through Questionnaire

The Google survey form was designed for fog computing, IoT, Artificial intelligence and Machine Learning algorithm questionnaire and feedback was collected online using designed google forms. The data was collected from eminent personalities in the technical field and from different regions / places. This feedback data was used for Hypothesis testing using python as tool.

4. Through Participation in Conference

To collect insight of subjects and dive deeper into the details of IoT, Artificial intelligence and Machine learning algorithm following conferences were attended.

a) 12th International Conference on **"Sustainable Global trends: Planet People and Profit"** on 16-17 April 2021 Organized by Pacific University Udaipur.

b) Virtual International conference **"Emerging Era of Applications of Computers"** on 15-16 January 2022 Organized by Pacific University Udaipur.

c) 4th Springer International Conference on **"Mobile Computing and Sustainable informatics"** on 11-12 January 2023 Organized by Tribhuvan University Nepal.

d) 38th Indian Engineering Congress Conference on **"Re-imagining tomorrow: Shaping the future through Disruptive and Interdisciplinary technologies"** on 27-29 December 2023 Organized by The Institution of Engineers India at Jabalpur.

I am grateful to all Conference Organizers and my fellow presenters or researchers who not only provided me with the platform to showcase my talent but also helped me in gaining rich technical experience by actively participating in conferences to collect data. These gatherings have provided me the stage for scholarly exchange which helped me allot in coming out with Machine learning solutions for traffic congestion problems.

5. Through Participation in Competitive Exams

To set high research standards and equip ourselves with the latest trends and techniques various Machine learning courses were successfully completed from high ranking institutes listed below.

a) EDUXLABS (Esoir Business Solution LLP) Certificate course on **“Applied Deep learning for Medical data analysis” from** 27.10.2020 to 9.11.2020.

b) Faculty Development program on **“Research and Publication Ethics”** from 2.01.2021 to 7.01.2021 Organized by Pacific Business School Udaipur.

c) Two days National Conclave on **“Intellectual Property rights”** on 26.07.2021 and 27.07.2021 Organized by Pacific University Udaipur.

d) Twelve weeks Online course on **“Data Analytics with Python”** from January 2023 to April 2023, Organized by NPTEL (Funded by Govt of India) and successfully completed with consolidated score of 82% with **elite silver medal**.

e) Four weeks Online course on **“Python for Data Science”** from July 2023 to August 2023, Organized by NPTEL (Funded by Govt of India) and successfully completed with consolidated score of 78% with elite silver medal and secured **All India rank One** (Top 5%).

Participation in certification courses and competitive exams helped me in sharpening my technical skills, enhanced my understanding about machine learning algorithms and encouraged me to use machine learning algorithms to solve real life traffic congestion problems. Competitive exams have produced the spirit of continuous learning in me and motivated me to take up the traffic congestion problems.

3.7.2 Comparative Analysis of Technologies and Models

Analyze various technologies used for enhancing transportation systems in smart cities, including intelligent traffic management systems, connected vehicles, smart parking systems, and transportation network optimization algorithms. Evaluate the strengths and weaknesses of different technologies based on factors such as effectiveness, scalability, cost implications, and integration capabilities. Compare and analyze existing IoT-based traffic prediction models and traffic control systems, considering accuracy, real-time capability, scalability, and adaptability.

3.7.3 Machine Learning Predictive Model Development

Designed and developed a machine learning predictive model for smart transportation systems using the gathered data and insights from the literature review. Utilize appropriate machine learning algorithms such as regression, decision trees to predict traffic congestion and optimize transportation routes. Train and validate the predictive model using historical traffic data and real-time traffic information.

3.7.4 Performance Evaluation

The performance of the developed machine learning predictive model are analyzed using various performance measures such as prediction accuracy, incorrectly classified instances, kappa score and various confusion matrix parameters such as TP rate, FP rate, precision, recall and F1-score. Compare the performance of the model with existing traffic prediction models and assess its effectiveness in predicting traffic congestion and optimizing transportation systems.

3.7.5 Machine Learning Approach Selection

Evaluate different machine learning approaches related to traffic congestion monitoring and transportation management systems for smart cities. Compare the suitability and performance of various machine learning algorithms, such as Random Forest, Random Tree, Bayes net, naïve Bays, SMO, IBK, Logistic, KStar and Multiclass classifier in addressing traffic congestion issues. Recommend the most appropriate machine learning approach for traffic congestion monitoring and transportation management in smart cities. Summarize the research findings, including the analysis of commuting patterns, traffic congestion issues, technologies, and machine learning predictive models. Provide recommendations for policymakers, urban planners, and transportation authorities on improving smart transportation systems, mitigating traffic congestion, and implementing intelligent transportation solutions in smart cities.

3.8 Data Collection Sources

The primary goal of the research work is to examine and find the technologies associated with the smart city project. To find new emerging technologies that can impact the transportation system in smart cities also improving the reliability of public transportation system of smart cities. Predictive model based on Artificial Intelligence and Machine Learning Algorithms is being developed to resolve commuting problems. Following are the secondary sources which were being used for data collection:

i. Research papers and articles from Springer, IEEE[1], Wiley, Sage, Elsevier etc.

ii. Computer science engineering, IT[2] journals for the comparative analysis.

iii. Government websites that offer information on training initiatives taking place in the area.

iv. Books on IoT, Artificial Intelligence, Machine Learning, Deep Learning & Data Science.

v. The datasets are being collected from:

   a. Kaggle
   b. Chicago Traffic data
   c. tomtom.com
   d. Data World etc.

I extend my gratitude to all Journal publishers, Book publishers and websites for providing valuable data sets and information, without which it would not have been possible to conclude my research.

3.8.1 Chicago Dataset: "Chicago_Traffic_1000"

Chicago Traffic Tracker is being used as a secondary source to collect data for model development. The Chicago Department of Transportation maintains and publishes the Chicago Traffic Tracker website, which provides real-time traffic updates along arterial streets. The site contains data on Average Daily Traffic volumes, traffic signal locations, intersections with automated red-light enforcement cameras, automated speed enforcement camera placements, dynamic messaging sign locations, and at-grade rail crossings that affect travel to and from Midway Airport. The website is constantly evolving as an ongoing project, with Chicago Department of Transportation anticipating future enhancements such as the addition of route-level alerts, live images from traffic cameras, truck routes etc. Following are the credentials of the Chicago data set.

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[1] Institute of Electrical and Electronics Engineers

[2] Information Technology

- Instances: 1000
- Attributes: 21
- Details: Chicago Traffic Tracker: Congestion Estimates by Traffic Regions
- Data Owner: Chicago Department of Transportation
- Time Period: March 2018 - Current, with occasional gaps due to system maintenance and other temporary technical issues.

- Frequency: Data are updated every 10 minutes
- Data Reduction: Number of instances included were the latest 1000 records.

The Chicago Traffic Tracker shown in figure 3.1 utilizes real-time GPS traces from Chicago Transit Authority buses to estimate traffic congestion on nonfreeway arterial streets. Updated every 10 minutes, it provides two types of congestion estimates: Traffic Segments offer observed speeds for one-half mile segments in a specific traffic direction, covering around 300 miles of principal arterials, while Traffic Regions provide average traffic conditions for all arterial street segments within a region composed of two or three community areas with comparable traffic patterns.

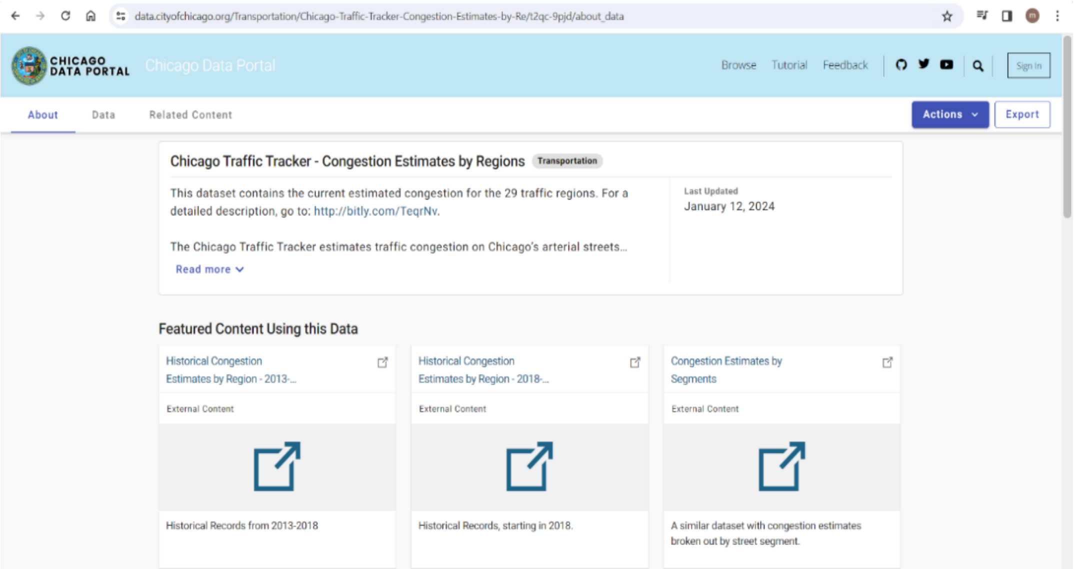
Figure: 3.1: Chicago Traffic Tracker

Source: Chicago Traffic Tracker [16]

The attributes such as Time, Region_ID, Speed, Region, Bus_Count, Num_Reads, Hour, Day_Of_Week, Month, Description, Record_Id, West, East, South, North, Nw_Location, Se_Location, Community Areas, Codes Assigned, Wards and Class

Label were being considered. Detail view of the traffic can be seen in the “Chicago Traffic Tracker” with various tools available in the real time application. The relevant dataset can also be downloaded from Chicago city portal [17] as shown in figure 3.2.

Figure 3.2: Chicago Data Portal



Source: Chicago City Portal [17]

The Chicago Traffic Tracker, managed by the Chicago Department of Transportation, offers real-time updates on arterial street traffic conditions, Average Daily Traffic volumes, and various relevant information such as signal locations and camera placements.

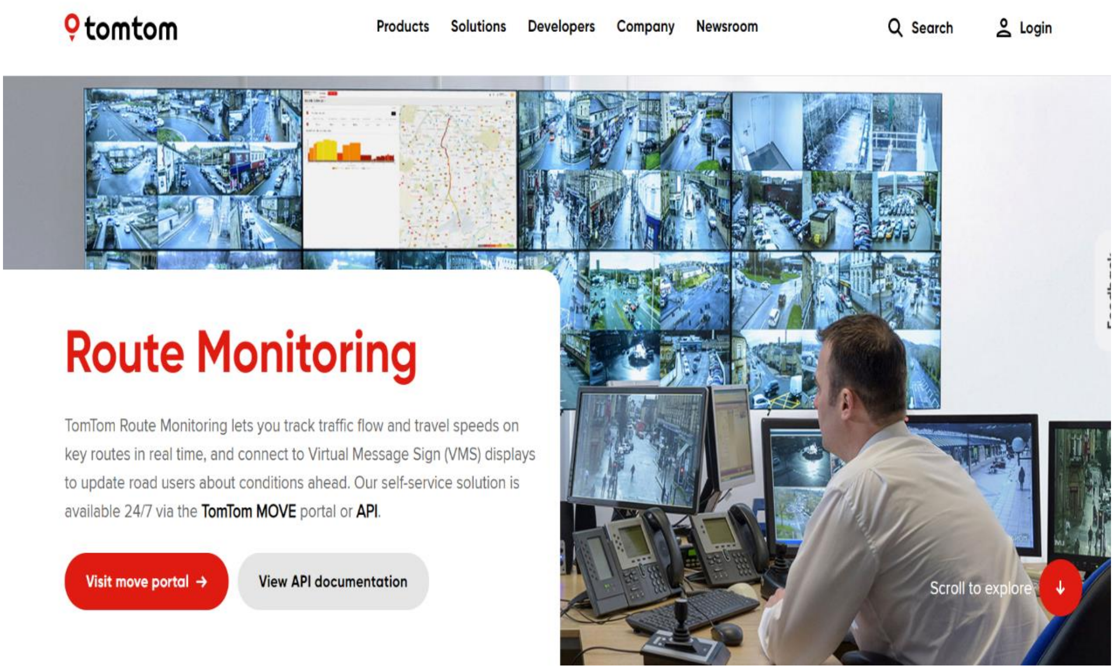
3.8.2 Udaipur Dataset: “Udaipur Traffic”

TomTom traffic server is used to collect real time traffic data of Udaipur city. TomTom traffic server provides information about traffic density, speed of vehicles, traffic congestion, number of vehicles on the road, delay time on the roads and historical traffic values at world level. TomTom server provides various traffic statistics through various products like Traffic stats, Route Monitoring, O/D Analysis, Junction Analytics and Road Analytics. These products are available through MOVE portal or via API. These products are available on trial basis for one month or also on usage basis. These products are helpful for transport planners, researchers to make smart decisions. Following are the credentials of tomtom server data set.

- Number of Instances: 1000
- Number of Attributes (After Feature Extraction): 7
- tomtom Site: https://www.tomtom.com/traffic-index)
- Product Details: Traffic stats, Route Monitoring, Junction Analytics
- Data Owner: tomtom
- Time Period: Sept 2023 – October 2023, with occasional gaps due to system maintenance and other temporary technical issues.
- Frequency: Data are updated every 3 minutes (Approximately 40 samples collected / day)

Figure 3.3 shows Route monitoring product from tomtom server. All key routes of the world from different countries can be monitored in real time. It gives route information like vehicle speed and tracks traffic flows. Custom routes of any city can be defined to get detailed information of travel times, traffic delays and speed of vehicles. This will help traffic planners to take smart decisions.

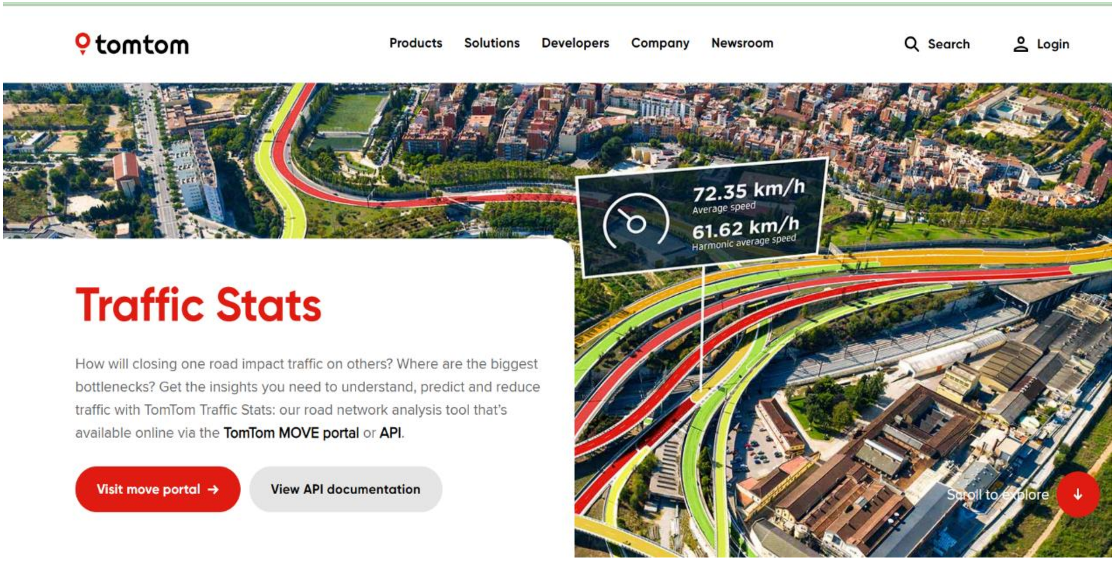
Figure 3.3: tomtom Route Monitoring



Source: Route Monitoring product [18]

Figure 3.4 shows Traffic Stats product from tomtom server. It gives information like traffic density, travel times and traffic density on the roads. Along with present real time traffic data it also provides the largest historical traffic database. This present and past traffic data helps planners in traffic management.

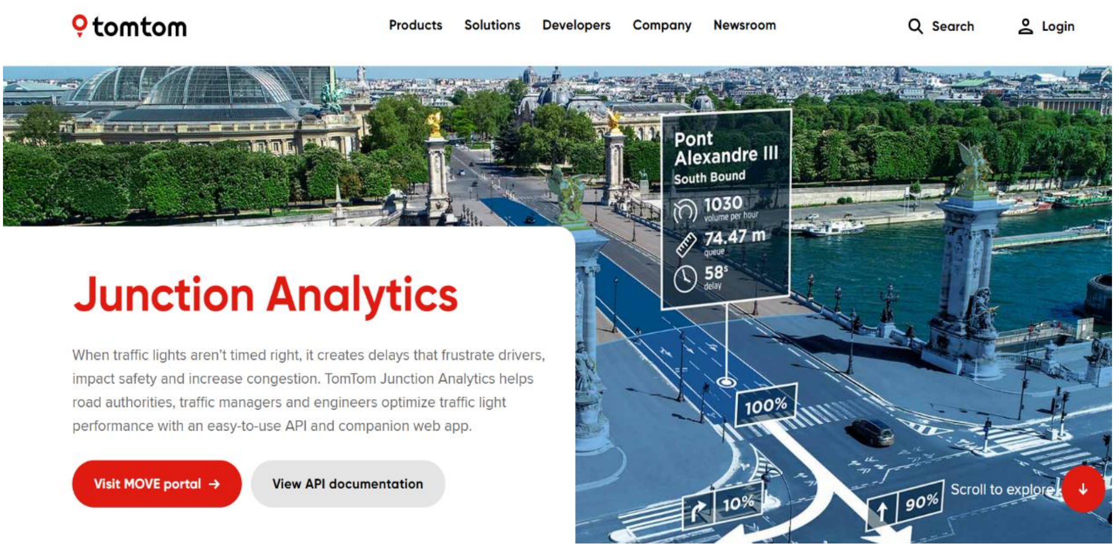
Figure 3.4: tomtom Traffic Stats



Source: Traffic Stats Product [19]

Figure 3.5 shows Junction Analytics product from tomtom server. It gives information about city junction traffic. This analytical tool gives understanding of how drivers move through interactions to control traffic signal timings on junction to reduce congestion.

Figure 3.5: tomtom Junction Analytics



Source: Junction Analytics Product [20]

3.9 Tools and Techniques

To evaluate the performance and effectiveness of the smart transportation systems, various metrics and statistical methods were employed. Percentage analysis, measures of central tendency, measures of dispersion, cumulative frequency, correlation coefficient, and regression analysis were used to analyze the collected mining data. Hypothesis testing was performed using the Chi-Square test. The study involved the simulation of data and model building, utilizing multiple regression analysis. A conceptual model based on regression was developed to examine the significance of different technologies and the reliability of public transportation systems in smart cities. Additionally, the study aimed to assess the usefulness of IoT, Artificial Intelligence, and Machine Learning-based models in addressing commuting problems. The Weka tool and Python were used for simulation and predictive analysis. Overall, the study employed a research design that combined qualitative and quantitative research approaches. The qualitative nature of the study facilitated the exploration of various concepts and ideas, leading to findings and recommendations for improving smart transportation systems in smart cities.

3.9.1 Weka Tool

The Weka Experimenter is a tool within the Weka software package that allows users to design, run, and analyze machine learning experiments systematically. It is particularly useful for comparing multiple machine learning algorithms and configurations on various datasets, helping researchers and practitioners make informed decisions about which algorithms work best for their specific tasks. Here's a more detailed explanation of the Weka Experimenter's key features and functionalities:

a. Experiment Design: The Experimenter allows users to design experiments by specifying different machine learning algorithms, datasets, and evaluation metrics. Users can choose from a wide range of classification, regression, and clustering algorithms available in Weka. They can also select multiple datasets to test the algorithms' performance across different data domains.

b. Parameter Sweeping: Users can explore the effect of different parameter settings on the performance of machine learning algorithms. The Experimenter enables parameter sweeping, where users can specify a range of values for certain parameters of the algorithms. The Experimenter then systematically runs experiments with different parameter combinations to find the optimal settings.

c. Cross-Validation and Evaluation Metrics: The Experimenter supports various techniques for evaluating machine learning models, including cross-validation (k-fold cross-validation, leave-one-out cross-validation, etc.). Users can select different evaluation metrics such as accuracy, precision, recall, F1-score, and others to assess the performance of the algorithms.

d. Batch Execution: The Experimenter can run experiments in batch mode, allowing users to schedule multiple experiments to run sequentially or concurrently. This feature is particularly useful for running large-scale experiments overnight or on computing clusters.

e. Result Analysis and Comparison: After the experiments are completed, the Experimenter provides detailed summary reports and visualizations of the results. Users can compare the performance of different algorithms on various datasets using statistical tests and visualizations like charts and graphs. This comparative analysis helps users identify the best-performing algorithms and configurations for their specific problem domains.

f. Reproducibility: The Experimenter ensures the reproducibility of experiments by allowing users to save the experiment configurations and results. Researchers can share these configurations and results with others, making it easier to validate and replicate experiments.

g. Integration with Other Weka Tools: The Experimenter seamlessly integrates with other Weka tools and interfaces, allowing users to utilize preprocessing techniques, attribute selection methods, and various machine learning algorithms available in Weka.

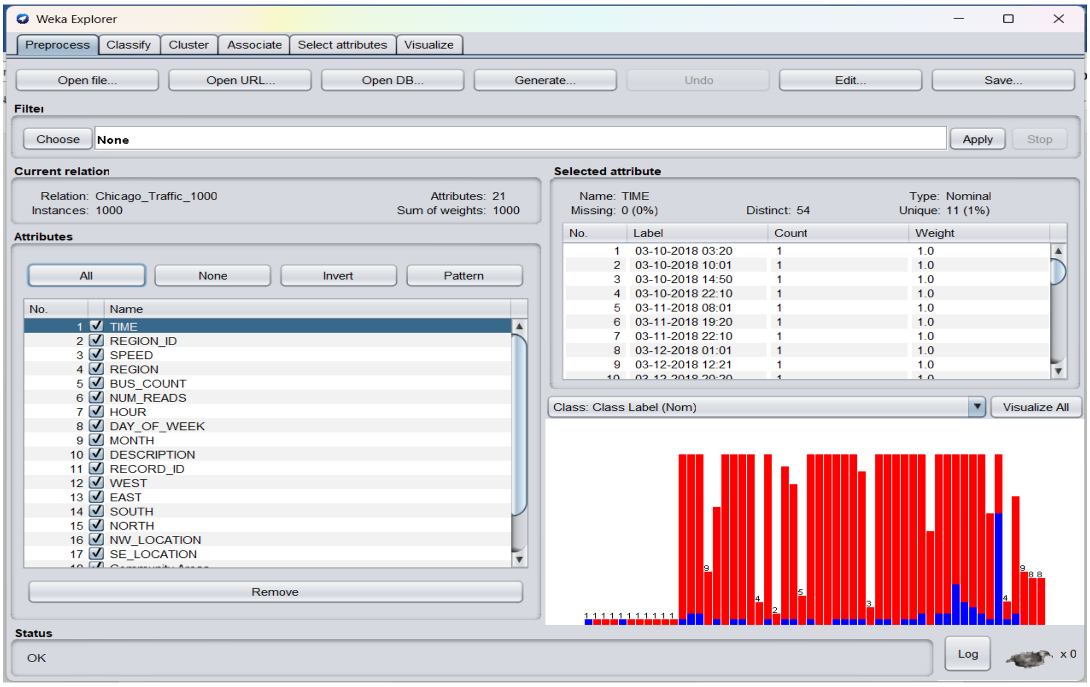
3.9.1.1 Components and Techniques

The Weka Experimenter provides a user-friendly environment for designing, running, and analyzing machine learning experiments. Its capabilities make it a valuable tool for researchers and practitioners who want to systematically evaluate and compare different machine learning algorithms and configurations on multiple datasets. Some key tools and techniques available in Weka Explorer include:

- Preprocessing Tools
- Classification Algorithms
- Clustering Algorithms
- Attribute Selection
- Evaluation Techniques
- Visualization Tools

Figure 3.6 shows the preprocessing tool in Weka applied to Chicago_Traffic_1000. This interface includes details about the number of instances, number of attributes, relation, selected attribute tab etc. In the present scenario the details of the Time attribute are shown in the selected attributes tab.

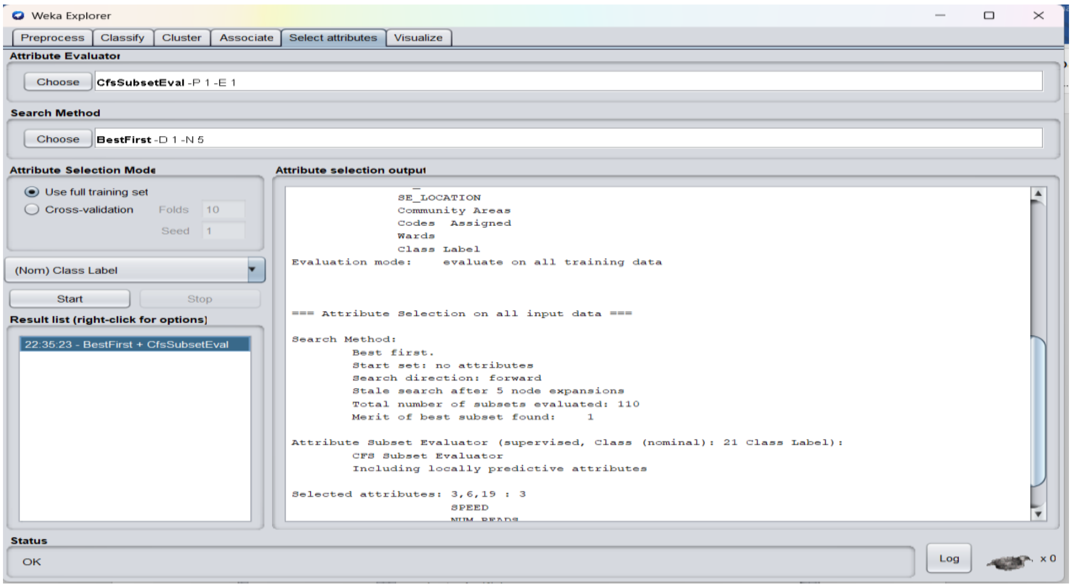
Figure 3.6: Preprocessing Step Tool



Source: Weka Tool

Figure 3.7 shown below is the attribute selector. Many times, data set contains redundant attributes which are insignificant in the analysis, therefore removing the unwanted attributes from the data set is necessary to develop good machine learning algorithms.

Figure 3.7: Attribute Selection



Source: Weka Tool

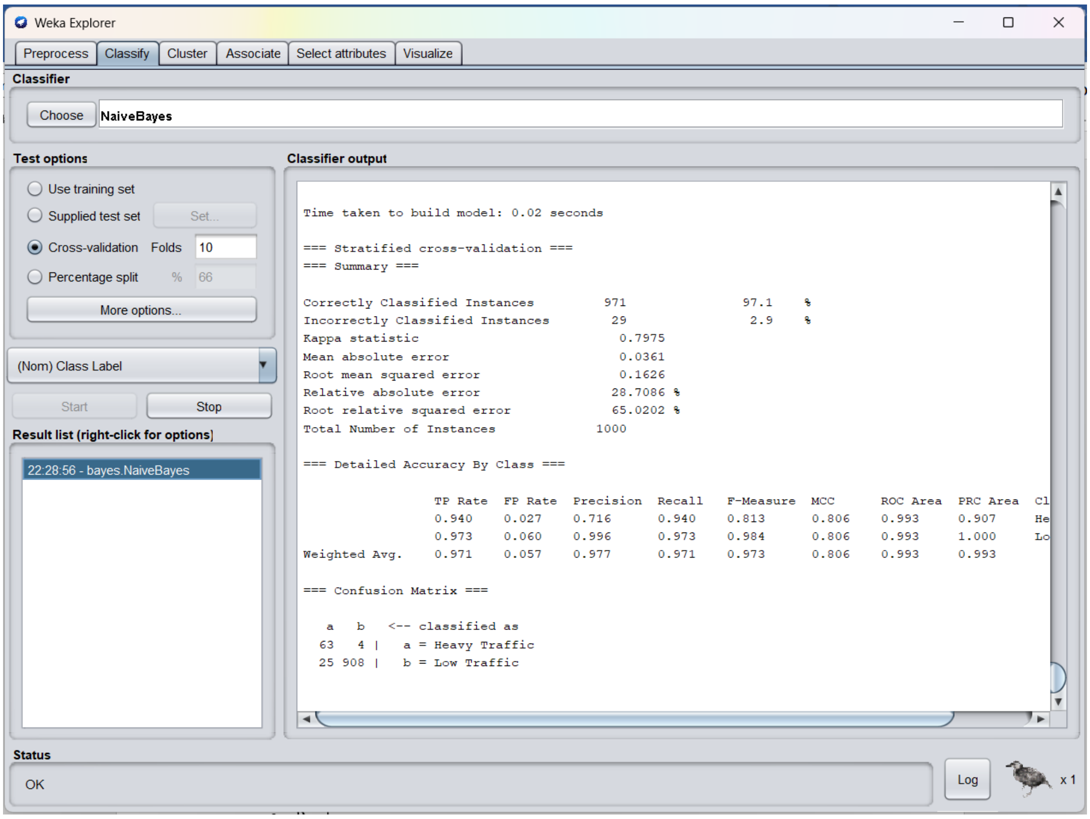
Weka has the facility to select required attributes for the designing machine learning algorithm. All selected attributes of Chicago_Traffic_1000 dataset can be seen graphically in the following figure 3.8.

Figure 3.8: All Attribute (Applied on Dataset Chicago_Traffic_1000)

Source: Weka Tool

Figure 3.9 shown below is the Classifier window in Weka tool which is used to select classifier algorithm from the set of available Machine learning algorithms. This window has four testing options Training set, supplied test set, Cross-Validation and Percentage split. We have used number of folds and percentage split options under cross-validation option.

Figure 3.9: Classification Algorithms Tool

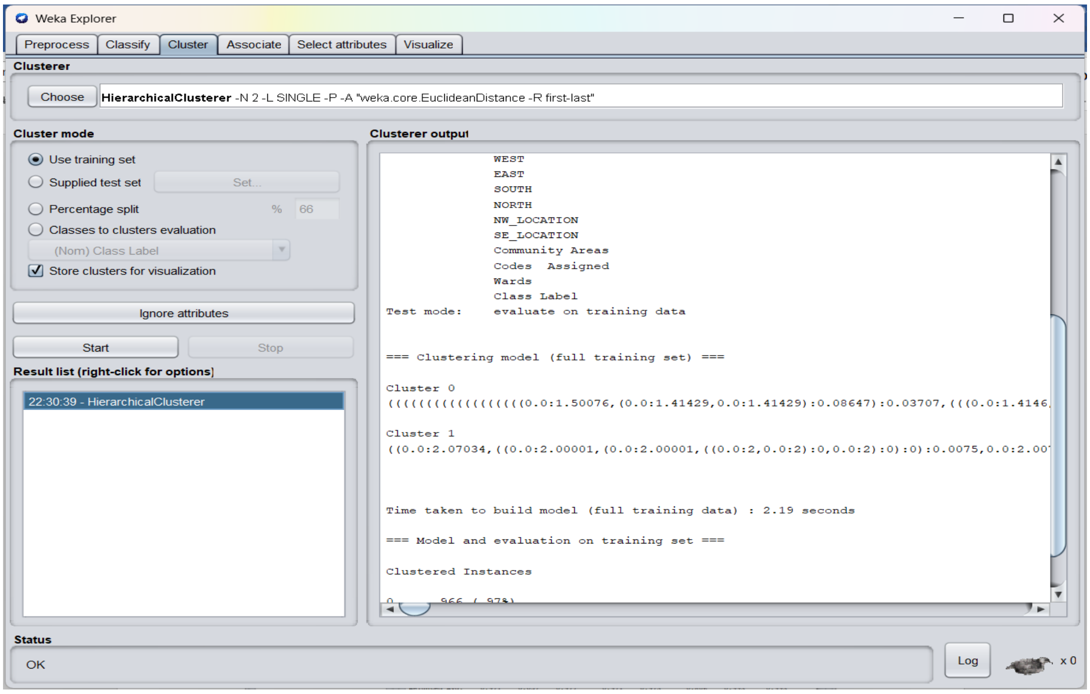


Source: Weka Tool

In the absence of your own training set or client supplied training set the cross-validation or percentage split options are selected. In our research 10-fold cross – validation, 25-fold cross – validation and 30% split options are used on nine different classification algorithms to develop machine learning algorithms for traffic forecasting.

Figure 3.10 shows the Clustering Algorithm window which is used to find groups of similar types of instances in the dataset. Weka allows execution of several clustering algorithms such simple KMeans, Hierarchical Clusters and so on.

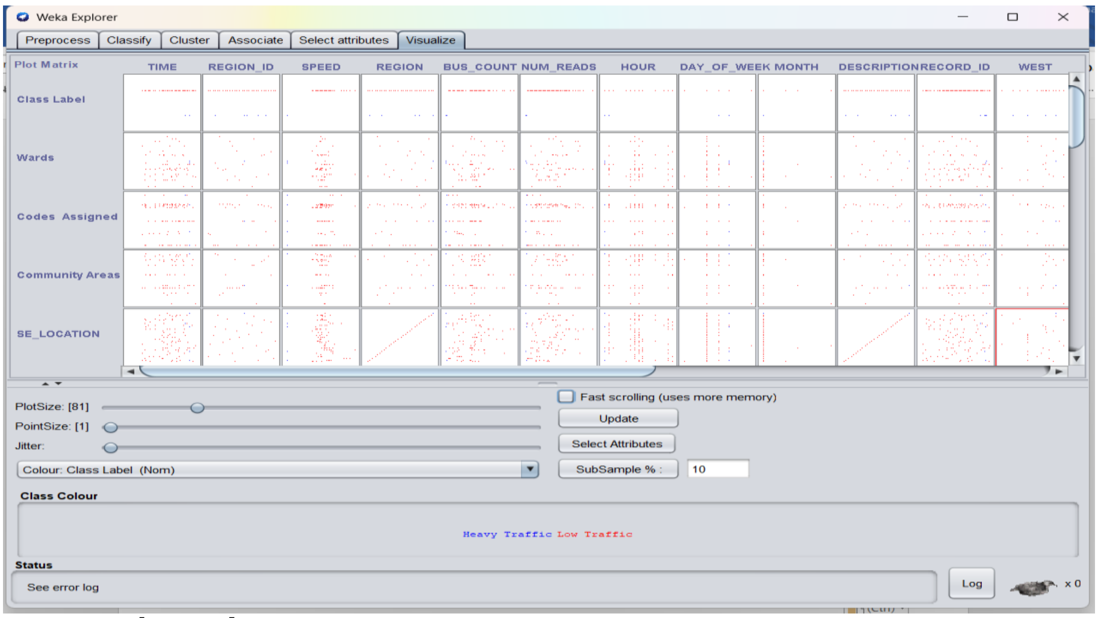
Figure 3.10: Clustering Algorithm



Source: Weka Tool

Figure 3.11 shown below is Visualization Tool is the Graphical user interface tool which allows users to visualize their processed data after execution of Machine learning algorithms. There are various graph attributes which can be used to control graphical plots. It has various options like plot size, attribute select, class color selection to control graphical display output.

Figure 3.11: Visualization



Source: Weka Tool

These figures show the application of various tools and techniques Weka being applied to the considered data set Chicago_Traffic_1000. The classification and clustering algorithms were being applied based on configuration settings either cross validation or split percentage.

3.9.2 Python

Python offers a wide range of libraries and tools that make feature extraction from various types of data (such as text, images, and numerical data) efficient and convenient. Here are some popular libraries or tools/techniques used for feature extraction in Python:

- Scikit-learn.
- Natural Language Toolkit
- OpenCV
- Pandas
- Feature-engine

The combined featured extraction matrix being designed using the python programming language. Feature extraction techniques are essential for transforming raw data into a format suitable for machine learning. For numerical data in Pandas Data Frames, specific features are extracted by selecting relevant columns. These methods enable effective preparation of data for machine learning models. Also, other statistical analysis is done using Python.

a. Hypothesis Testing Tools:

To test the framed null hypotheses, three types of statistical methods were used. The applied tests were Pearson Chi-Square test, ANOVA Test and T-Test.

b. Chi-Square Test:

The Chi-Square test is a statistical method used to determine if there is a significant association between categorical variables. It compares observed frequencies with expected frequencies, assessing whether any differences are statistically significant.

c. ANOVA Test:

ANOVA is a statistical technique used to compare means of three or more groups to determine if there are statistically significant differences. It assesses the variability within and between groups, helping to understand whether observed differences are likely due to random chance or actual group effects.

d. T-Test:

The t-test is a hypothetical test which is used to find out whether the average calculated for criteria from sample data is different from a value claimed by researchers. The one sample t test left tail or right tail is used to compare the mean of sample data with claimed value of researchers.

3.10 Summary

This research work aims to address various aspects of smart transportation systems and traffic management in smart cities. It encompasses a mixed methods approach, combining quantitative analysis and qualitative insights. The research objectives include studying commuting and traffic congestion issues, analyzing technologies for enhancing transportation systems, comparing IoT-based traffic prediction models and traffic control systems, developing a machine learning predictive model, evaluating its performance, addressing implementation issues, and identifying the most appropriate machine learning approach for traffic congestion monitoring and transportation management. The research begins with a comprehensive literature review to identify gaps in existing research and frameworks. Data collection involves gathering information on commuting patterns, traffic flow, congestion levels, transportation infrastructure, and smart city initiatives. Comparative analysis is conducted to evaluate different technologies and IoT-based traffic prediction models, considering factors such as effectiveness, scalability, cost implications, and integration capabilities. The research also involves the development of a machine learning predictive model for smart transportation systems. Historical and real-time traffic data are utilized to train and validate the model. Its performance is evaluated using various performance measures, comparing it with existing models. Implementation issues related to the deployment of intelligent transportation systems are addressed, including infrastructure requirements, data privacy and security, scalability, and user acceptance.

Recommendations and strategies are proposed to overcome these challenges. Furthermore, different machine learning approaches for traffic congestion monitoring and transportation management in smart cities are evaluated. The suitability and performance of various algorithms, such as neural networks, support vector machines, or ensemble methods, are compared to identify the most appropriate approach.

In conclusion, this research aims to provide a comprehensive understanding of commuting patterns, traffic congestion, technologies, IoT-based models, machine learning predictive models, implementation issues, and machine learning approach selection for smart transportation systems in smart cities. The findings will contribute to the development of effective transportation strategies, the mitigation of traffic congestion, and the successful implementation of intelligent transportation solutions in smart cities.