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Cloud-Based Approach For Analysis of Road Network: A Predictive Initiative

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***Abstract*— Analysis of Road Network has been important perspective of research from the long duration. Conventional techniques are not efficient enough for presenting results in accurate manner. Developments in ICT has led to incorporation of smart sensors for acquiring traffic data in real time. In addition to this, with the innovations of efficient data analytic techniques, effective decision-making models can be developed for provisioning effective services. In this paper, data analytics techniques are used to classify roads on the basis of traffic density in real time. This classification is further used to present a predictive model for future traffic information. Such futuristic prediction will enable services in numerous applications like road directions, road network developments, and road analyzations. In order to validate the proposed model, the system analyzed with online available dataset using WEKA toolkit. Results depicts that the system formulated is very efficient and proper in comparison to other conventional techniques.**

***Index Terms*—ICT, Big Data Analysis, Road Network Analysis, Weka Toolkit**

I. INTRODUCTION

The road network presents a critical role in developing any country structure. It is main carrier for any country's social-economic and transportation[1]. Nowadays researchers have dedicated their attention to develop the proper road network[2]. However, development of efficient road network present important challenge for any research scientist. In addition to this, analysis of road network presents another crucial challenge to future development and directions of road network. In 2008, Speičys and Jensendefines a network graph for interaction of road structure with different cities acting as nodes[3]. This led to the development for analysis of roads for traffic assessment and evaluation. In the geography of road network, road network analyzation has become one of the crucial problems nowadays. In fact, road networks have become so dense nowadays that it is difficult to analyses these using manual procedures. Figure 2 demonstrate the road network for different countries along with density information provided.
Development brought in the field of Information and Communication Technology (ICT) has led to development of smart sensors and actuating devices capable to perceiving information with minute detail in real time[4]. In the field of transportation, these sensors can be easily embedded along roadside and poles for sensing information about the road traffic for every acquiring every minor detail in real time.

A. Role of Data Analytics

With innovations brought in big data mining, analysis of big data has become very efficient over the past few years. Especially in complex environment like analysis of road traffic network where data is complex and ever changing, these decision-making

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techniques plays a major role[5]. Data analysis indulges extraction of useful data from large bunch of datasets and allows user to identify and discover hidden pattern, sequence, and information. In addition to this, the decision-making capability of data mining techniques has made it possible to derive useful results, which were nearly impossible earlier due to under developed technology. Henceforth, incorporation of data analytics in assessment and evaluation of road network based on traffic and utility will prove effective and efficient[6]. Data mining is a complex procedure which involves multiple tasks executing in sequential manner. These tasks include pre-processing, data cleansing, classification or clustering, analyzation and finally, decision-making. An overview of data mining techniques has been depicted in Figure 1.

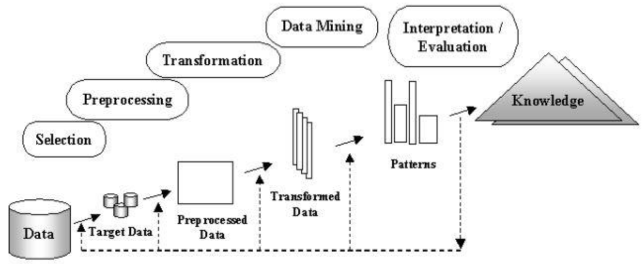

Figure 1: Step by step procedure in Data Mining[7]

Inspired from these aspects, this paper utilizes the techniques involved in data mining for effective evaluation of road network. Specifically, numerous sensors are used to acquire data about road-traffic in real time. These sensors are small internet enabled devise capable of transmitting data to cloud in real-time. This data is pre-filtered and cleaned for any error in data acquisition. Based on the acquired data, road network is classified into different categories using a probabilistic model i.e. High Traffic Road (HTR), Medium Traffic Road (MTR), and Low Traffic Road (LTR). Based on the classification, numerous decision-making models are developed like predictive analysis to determine the futuristic traffic condition of the road based on time of the day. Such prediction will enable effective decision making while selection of road by user in real-time.

This paper is organized into following sections: Section II provides literature review of numerous related contribution that

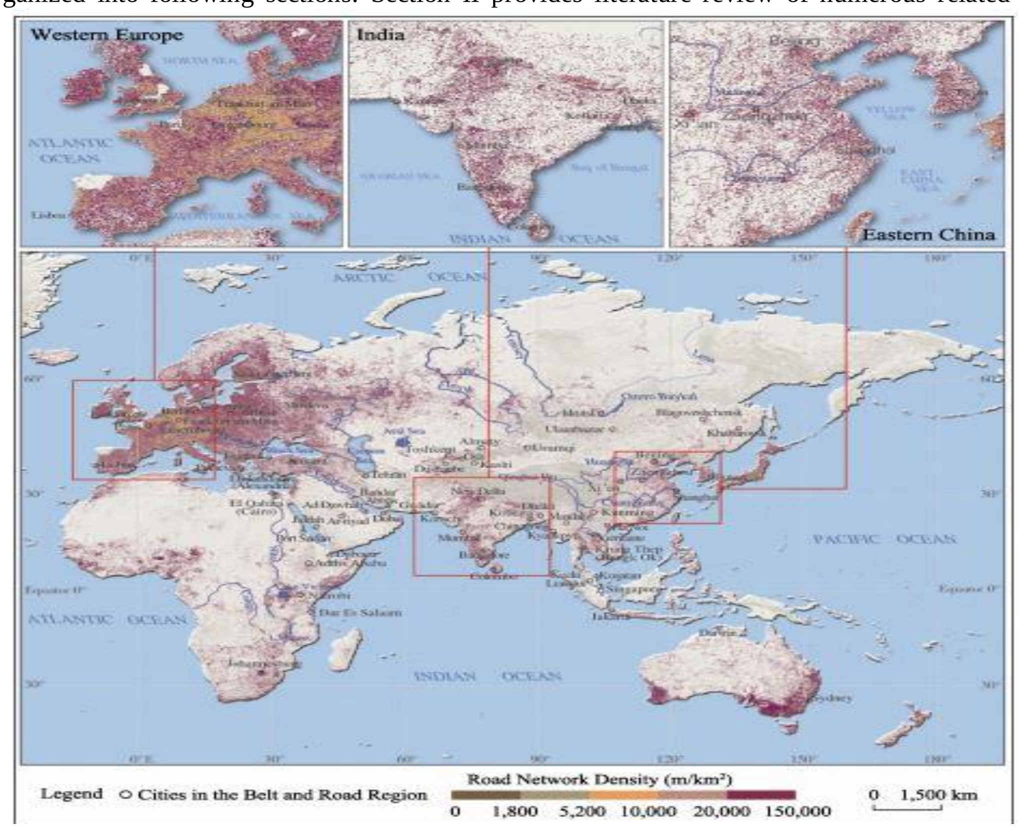

Figure 2: Road Network Density

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have been put forth by various researchers in the current field. Section IIIdiscusses the proposed modelling technique based on data mining and decision making. The experimental implementation has been performed in Section IV to depict the validity of the propose technique. The paper is concluded in Section V with a few key points in discussions.

II. LITERATURE SURVEY

This section reviews some of the important contribution in the field of road network assessment based on different modelling techniques. Besides this, the incorporation of data mining-based decision modelling in different environments has been shown in the further sections.

A. Road Network Assessment Modelling

Numerous contributions have been put forth by researchers in all over the world in the area of road network traffic analysis and evaluations. Zheng et al. [8] proposes an efficient road based traffic assessment model for prevention of road accidents using intelligent vehicles. The proposed technique is developed using Hidden Markov Model (HMM) and various related techniques. The major purpose of the proposed technique concerns with evaluating the steering angle in every time interval during road traffic assessment and secondly, determination of road traffic risk in numerous geographical regions. In addition to this, road traffic has been determined and shown in visualized manner to the user using time variant risk map. The presented technique was validated in different experimental implementations and effective results were obtained. Vijay et al.[9] has presented a model to categorize traffic noise during speed, traffic volume in different categories. These include (L_{eq}, L_{peak}, L_{max} and L_{min}) levels. Authors determined a correlation between honking horns and traffic density based on different levels as discussed before. Moreover, authors were able to quantify these noise levels effectively using audio spectrum. The proposed technique suggested that the loud noise should be considered as a major concerninevaluatingroad network-based traffic in places where honking has been ageneral practice. This study characterizes noise produced by traffic and theeffect of loud noise for future abatement studies. Khan et al. [10] reviews some of the important techniques in evaluation of road network assessment. The majoraim of the presented study incorporates summarization of current practices and modelling of assessment techniques for road network traffic. In addition, this, author highlighted numerous ways for evaluating road network traffic in terms of geographic system, space scale exposure assessment, amount of data and nature of traffic data for structuring geometric data.Cartwright[11] has presented the study to depict the impact of road accidents on human life due to inappropriate road network. The study depicted that nearly 50 million people were injured in the United Kingdom in a year. However, the conclusion was drawn by the author that no steps have been put forth by the government to safety of people from road accidents. In [12], Halim et al. recognized traffic noise as a major concern in lowering the quality of life in different industrial communities. Authors have survey different regions of Klang Valley to depict the impact of road noise on the traffic accidents and noise pollution. The determined study depicted the high noise pollution in different residential areas of Klang Valley as noise pollution was exceeding as compared to level determined by World Health Organization (WHO). Fuentes et al. [13] explored the utilization of attribute based context in the vehicular domains. Specifically, authors have focused on three representative aspects which are Idemix, U-prove and VANET technologies.Shaohui et al.[14] focused on traffic operation risk assessment of road section involving high rate of bridges and tunnels. Initially, the mean speed and variation coefficient of speed of vehicles are determined as the traffic operation risk index and are considered as independent variable. Along with this, mean risk level index is built as the dependent index. Based on this multivariate linear model for traffic is established. Numerous experimental trials were conducted based on the proposed model. The results obtained demonstrated that the proposed model highly effective efficient in analyzing the risks involved in the road network traffic.Sousa et al. [15] proposed a model for analyzing the bridge lifetime based on traffic condition of the road. The proposed model was implemented numerically on the accumulated data and effective results were obtained.

B. Data Mining based Decision Analysis

As discussed previously, data mining has a wide range of applicability in various industrial sectors, extending from healthcare industry to transportation industry. Apart from these, numerous data mining methods have been presented by researchers around the world, that are ableto extract useful data segments based on heterogenous formats, patterns, and state of generation of data features like time, and space. Consequently, numerous researchers have been working on deploying these techniques different applications. *Rochd et al.*[16]have surveyednumerous algorithms and techniques for extraction of divergent data using Spark and Hadoop models for enormous data. Specifically, authors have focused on identifying similar item-sets in the accumulation of large data sets, in terms of time, frequency, and other features. *Leung et al.* [17] presented a constrained-based data analytical and mining technique which focused on retrieving frequent patterns that are specific to certain group of users. In addition to this, the presented technique executes in fog and cloud computing environment. In such environment, analysis and computationsare performed at network edges and network servers of the underneath architecture. *Hoi et al.*[18]proposed a constrained-based data analysis and mining algorithm which enables huge number of users to simultaneously vote for their specific certain patterns. The presented technique attains advantages of features like crowdsourcing, simultaneous crowd-voting, and data pre-filtering for data analysis and mining constrained frequent patterns in big data applications and services. *Manigandan et al.* [19] have utilized data

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analytical tools to assess and analyze business-related decision making. In addition to this, authors have presented an intelligent business techniquewhich is capable of provisioning decision-making results in time intensive manner. Additionally, authors have used different data mining tools to generated official reports like sequence, trends, growth rate, and profit. Moreover, classification and clustering techniques have been efficiently incorporated in the presented model to propose numerous enhancements in the overall model. For experimental implementation purpose, authors have utilized WEKA tool for obtaining results on different datasets.

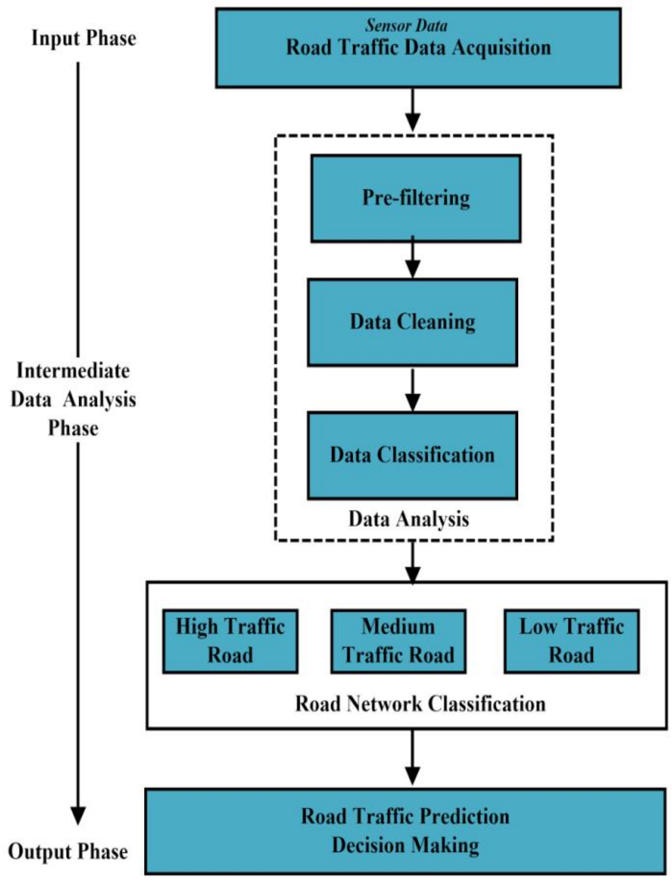

Figure 3. Proposed Model of Road Network Analyzation

III. Proposed Model

Figure shows the proposed technique of traffic-based road network analyzation. The presented technique comprises of different phase which performs certain predefined tasks and provides necessary services to neighboring phases. Initially, data is acquired from various sensors and actuators embedded on road sides, which is transferred to the remote desktop using wireless technologies. Each acquired data is of statistical nature and therefore is feasible to classify it in the next phase. Based on the road traffic conditions in real-time, roads are categorized into three categories including High Traffic Road (HTR), Medium Traffic Road (MTR), and Low Traffic Road (LTR). Classification of road is performed based on the probabilistic values using Bayesian Classification Techniques. The final phase involves effective analyzation of road network for provisioning decision making services like prediction, and self-organized mapping. Each of the phase is defined ahead in detail.

A. PHASE 1: Data Acquisition Phase

It is the initial phase of the proposed model for analysis road network based on traffic conditions in real time. In this phase, numerous sensors, actuators and devices are embedded alongside road at different points. These devices have the capability to sense data of moving vehicles in real-time. In addition to this, these devices have the ability to transmit data to remote storage, probably a cloud database for further analyzation. Moreover, these devices make it feasible to compute effect details regarding the traffic condition of roads in real time. Also, since these devices are to automate the data transmission, the probability of error generation if minimal. These devices include sensors like camera, RFID tags, and other vehicular devices. Once the data is safely accumulated in the database, then it is feasible to perform data analyzation using different data mining techniques. These techniques are defined in the next phase.

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B. PHASE 2: Data Analysis Phase

Data Analysis Phase is the second phase of the proposed model. In this phase numerous tasks of data mining are performed in synchronized manner. These tasks include data filtering, data cleaning, and data classification. Each of these have been defined ahead in detail.

B.1 Data Filtering

Data Filtering involves removing the unnecessary data from the accumulated dataset, which enables feasible computation in the analyzation and classification.This conveys that the test beds comprise of the data according to the user needs only, without considering the data which is repeated, inappropriate, or precise. In order to alter reports, investigate the results or different information, various data filters are used.In other words, data filtering is reducing the dimensionality of the dataset for feasible analysis. In the current scenario, the data filtering involves removing data like pedestrians on the road network.

B.2 Data Cleaning

Data cleaning, also termed as data cleansing by some authors, is a significant part of the procedure involved in formulating data for analysis. Data cleaning is a part of data preparation, which also comprises of testing, matching data files, selecting cases, and other tasks that are essential to prepare data for analysis.

Missing and erroneous data can result in significant problematic reliability and validity of study results. Many difficulties can be evaded through cautious survey and study design. During the data accumulation study, observant monitoring and data cleaning can catch problems while they can still be secured. At the end of the proposed model, multiple imputation actions may be used for data that are irretrievable.

B.3 Data Classification

It is aprocedure of shaping data into groups for properoperative and well-organizedusage.A well-thought-out data classification organizationprovides vital data to discover and fetch easily. It is of great importance for managing hazard, permittedinvention, and agreement. Data classification technique must specify that which methods and techniques the model should accept in order to categorize the data and must define the roles and responsibilities of individuals of the organization regardingmodelling of data. Once a data-classification structureisformulated, security norms that defineappropriate practice handlingfor everygroup and storage norms that specify the lifetimenecessities of datamust be addressed.

In the proposed model, data classification results in categorization of the data into predefined categories. In the current scenario, different categories formulated are High Traffic Road (HTR), Medium Traffic Road (MTR), and Low Traffic Road (LTR). The classification is performed using a probabilistic parameter Naïve Bayes (NB) technique. Naïve Bayes technique is a machine learning classifier technique based on simple probabilistic classifiers with assumption between features. In other words, it is a conditional probability model defined as: Given a problem with instance to be classified, represented by a vector (x_1, x_2, x_3, x_n) indicating "n" features, then it assigns probabilities

$$P(C_K|x_1,x_2,x_3,,,,x_n)$$

For every K possible outcomes. The above-mentioned formula is inappropriate in the case when the number of features is very large(n). Henceforth, above formula is reformulated as follows

$$P(C_K|x) = P(C_K)P(x|C_K)\ |P(x)$$

With different number of features, this can be extended to formulate the following formulae

$$P\ (C_K|x_1,\ x_2,\ x_{3,,,},x_n) = P(C_K)\ \pi_{i=1\ to n}P(x_i|C_i)$$

Where $P\ (C_K|x_1,\ x_2,\ x_{3,,,},x_n)$ denotes the conditional probability for occurrence of event based on different parameters.

C. PHASE 3: Decision Making Mechanism

Decision Making Phase is the third phase of the proposed model. In other words, this layer performs assessment of the acquired data. The accumulated is classified into different classes using an efficient classification technique in the previous phase. This phase performed prediction of these data elements on the basis of real-time for effective determination of traffic volume of road network. The task of prediction is performed using predictive modelling technique. The predictive modeling used in the proposed model is Neural Network (NN). NN is a collection of inter-connected units or nodes known as artificial neurons. These neurons are connected to each other and are hidden to the outside. A neuron node acquires signal from input layer in the form of

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features and produce output based on weights and thresholds. A brief insight is provided in Figure 4. NN comprises of three layers, which are Monitoring layer, Learning Layer and Prediction Layer. Each of these layers is defined ahead in detail.

C.1 Monitoring Layer

This is the initial layer of the NN predictive model. In this layer, the NN monitors the features of the input data in real-time for producing results. The data in input from the layer which cautiously fed to the NN model for further assessment. This layer performs the initial task of allocation weights to the input data based on predefined thresholds and values. These thresholds are prefixed by the domain expert for further classification and prediction.

C.2Learning Layer

This is the second layer of the proposed prediction phase. In this layer, learning of the real-time conditions of road network is performed. Numerous features relating to conditions of traffic, noise, distance is determined and stored in the data base of the proposed model. In other words, based on the learned datasets of the proposed predictive mechanism, futuristic values are determined beforehand.

C.3Prediction Layer

Prediction Layer provides the output of the presented system in terms of probabilistic values of road traffic and conditions using mathematical techniques. In other words, numerous features are determined for estimating the road traffic in future which can be used for numerous applications and road geography maintenance.

Henceforth, based on the proposed system, it is possible to compute and evaluate various features of the road network traffic. In addition to this, such modelling technique can be accompanied with self-organized mapping system to provide next level view of road tracking and monitoring technique for users.

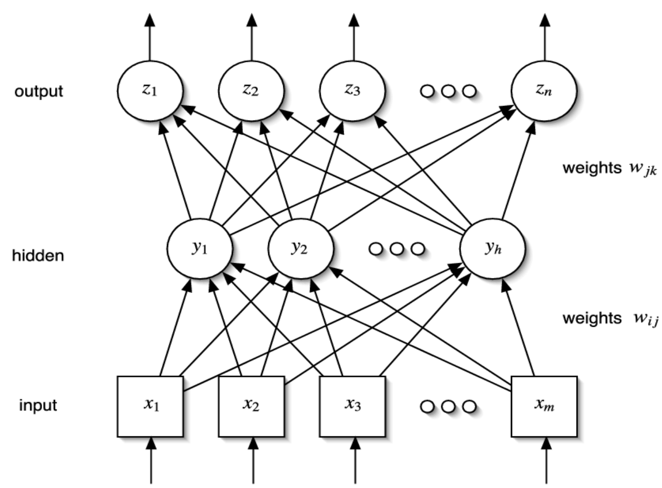

Figure 4: Neural Network Based Prediction

IV. Experimental implementation

This section performs the experimental assessment of the proposed model on the datasets using data analysis toolkit. For the proposed model, WEKA toolkit has been used for effective classification and prediction purpose of the datasets. For prediction purpose, Neural Designer, tool kit designed in python is used for prediction purposes.

A. Simulation Environment

As discussed, earlier Neural Designer tool have been used as the simulation tool for performing experimental implementing. The major purpose of using this tool is its efficiency and effectiveness in carrying the results. In addition to this, visualization mechanisms are provided in the tool for better understanding of the results. The proposed model is implemented on the online-datasets acquired from different databases. More details are provided in the section ahead. Figure 5 shows distribution of datasets among training and testing instances.

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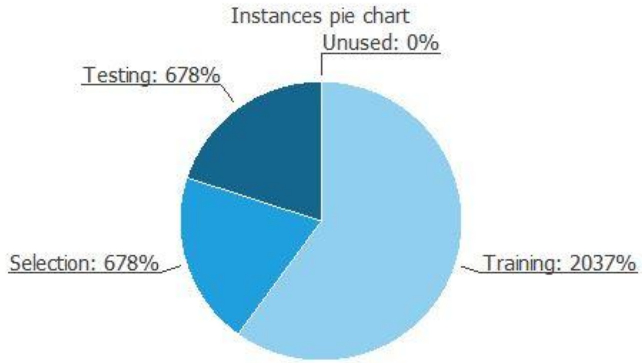

Figure 5: Dataset Instances

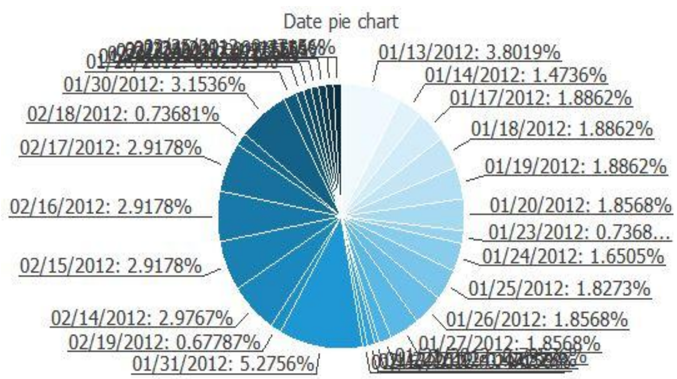

Figure 6: Data Distribution

B. Accumulation of Datasets

Acquiring real time data sets require large amount sensors and actuators embedded on road sides, which can costly. Henceforth, in order to acquire the datasets, online repositories where explored like UCI. UCI is a collection of large number of datasets acquired by researchers around the world for implementation. As a result, a suitable road traffic-based dataset is considered comprising of nearly 4000 data sets over the road network of United Kingdom. This dataset consists of traffic volume for 1 week on hourly basis. Moreover, such datasets make it feasible to acquire real-time analyzation for prediction of traffic volume. Figure 6 provides a pie chart representation of accumulated dataset over hourly basis. Figure 12 provides numerous histograms for hourly distribution of traffic over a period of 12 hour.

Table 1 : Neural Network

	Inputs number	Perceptrons number	Activation function
1	941	3	HyperbolicTangent
2	3	3	HyperbolicTangent
3	3	1	Linear

Table 2: The table shows all the errors of the data

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	Training	Selection	Testing
Sum squared error	6.61946e+11	2.17473e+11	2.21144e+11
Mean squared error	3.24961e+08	3.20757e+08	3.26171e+08
Root mean squared error	18026.7	17909.7	18060.2
Normalized squared error	16.3164	14.6323	13.381
Minkowski error	4.82989e+09	1.5871e+09	1.60584e+09

C. *Decision Making Efficiency*

In the decision-making layer, different training and testing strategies are used and compare to identify the effective neural network model for prediction of the real time- traffic data. In the experimental implementation, three training strategies are used namely, Quasi-Newton, Gradient Descent and Conjugate Gradient. Based on different training strategies, different results were obtained are shown in various figures. Each figure of implementation has specific output mentioned in the figure caption. Figure 7, Figure 8 and Figure 9 shows the plots of respective training strategies and error history. Table 1 and Table 2 provides an overview of modelled neural network the dataset considered. Table 3, Table 4 and Table 5 shows the statistic results of error acquired during training form the datasets. For prediction purpose, Linear regression-based algorithm is used. Results are computed and shown in Figure 10 and Figure 11.

V. Conclusion

Data mining and analysis has been developed over the period of time. In recent years, research has been carried out by

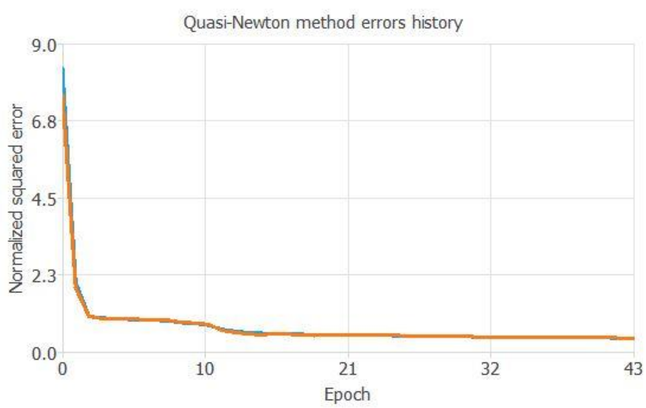

Figure 7: Linear and Selection Error

Table 3: Quasi Newton Method

	Value
Final parameters norm	34.2
Final training error	0.401
Final selection error	0.4
Final gradient norm	0.362
Epochs number	43
Elapsed time	01:00
Stopping criterion	Maximum training time

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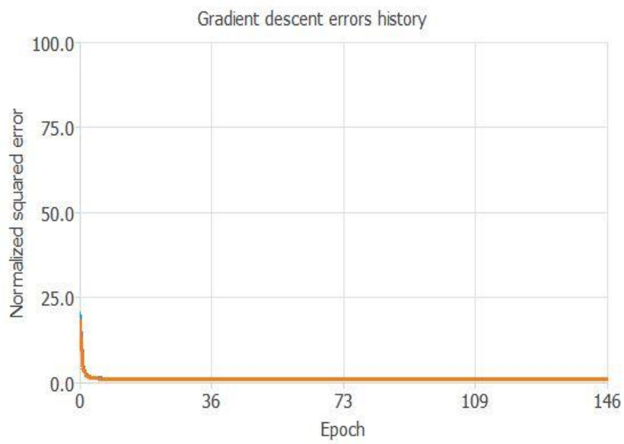

Figure 8: Training and Selection Error

Table 4:Loss function

	Value
Final parameters norm	30.8
Final training error	1.02
Final selection error	0.991
Final gradient norm	0.0958
Iterations number	146
Elapsed time	01:00
Stopping criterion	Maximum training time

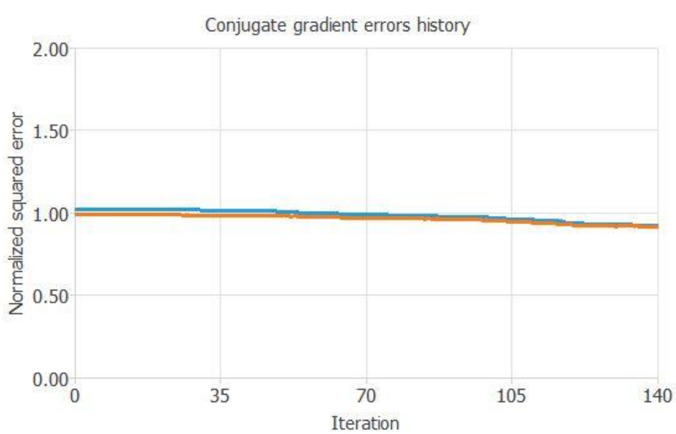

Figure 9: Training and Selection Error

Table 5: Results by the conjugate gradient optimization algorithm.

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	Value
Final parameters norm	30.7
Final training loss	0.921
Final selection error	0.917
Final gradient norm	0.153
Iterations number	140
Elapsed time	01:00
Stopping criterion	Maximum training time

researchers around the world to provide successful results in the field of decision making. This paper utilizes the effectiveness of data mining and analysis to provide effective results in analysis of road network based on traffic condition in real- time. Specifically, a four-phase model is proposed that enables successful determination of road traffic in real time.

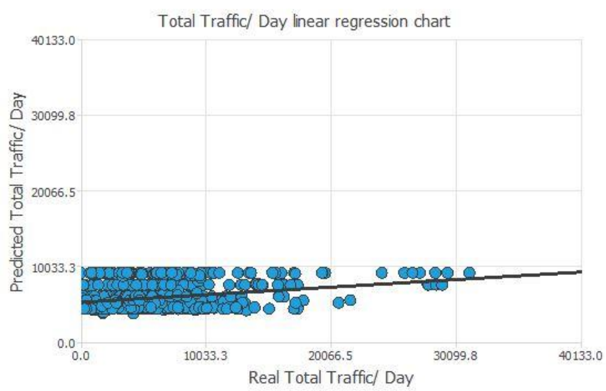

Figure 10: Linear Regression Plot

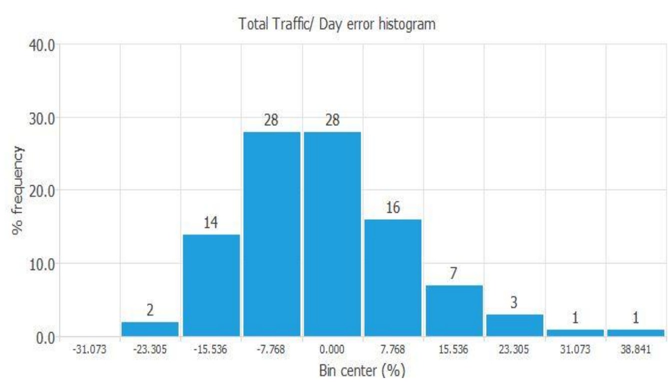

Figure 11: Error Distribution

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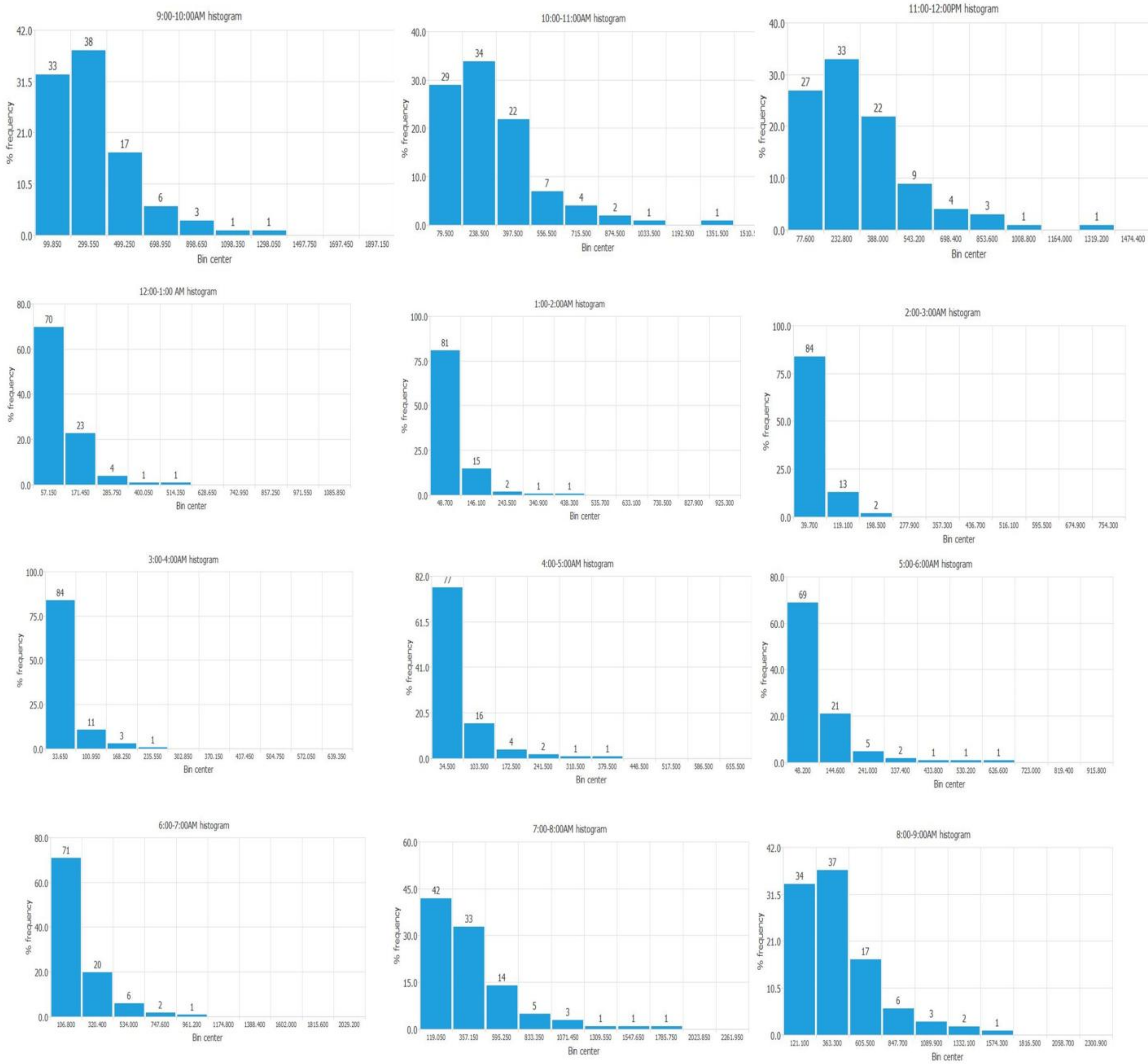

Figure 12: Histogram Chart

For validating the proposed model, numerous experimental implementations are performed on online database using WEKA toolkit. The results show that the proposed model is effective and efficient in determination of traffic rate in real time. Moreover, the visualization of the proposed model can also be performed using self-organization mapping technique.

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