Deep Intelligent Prediction Network: A Novel Deep Learning Based Prediction Model on Spatiotemporal Characteristics and Location Based Services for Big Data Driven Intelligent Transportation System

D. Venkata Siva Reddy, R.Vasanth Kumar Mehta

Abstract: The concept of big Data for intelligent transportation system has been employed for traffic management on dealing with dynamic traffic environments. Big data analytics helps to cope with large amount of storage and computing resources required to use mass traffic data effectively. However these traditional solutions brings us unprecedented opportunities to manage transportation data but it is inefficient for building the next-generation intelligent transportation systems as Traffic data exploring in velocity and volume on various characteristics. In this article, a new deep intelligent prediction network has been introduced that is hierarchical and operates with spatiotemporal characteristics and location based service on utilizing the Sensor and GPS data of the vehicle in the real time. The proposed model employs deep learning architecture to predict potential road clusters for passengers. It is injected as recommendation system to passenger in terms of mobile apps and hardware equipment employment on the vehicle incorporating location based services models to seek available parking slots, traffic free roads and shortest path for reach destination and other services in the specified path etc. The underlying the traffic data is classified into clusters with extracting set of features on it. The deep behavioural network processes the traffic data in terms of spatiotemporal characteristics to generate the traffic forecasting information, vehicle detection, autonomous driving and driving behaviours. In addition, markov model is embedded to discover the hidden features .The experimental results demonstrates that proposed approaches achieves better results against state of art approaches on the performance measures named as precision, execution time, feasibility and efficiency.

Keywords: Big Data, Intelligent Transportation System, Deep Learning, Prediction, Spatiotemporal analysis, Location based services.

I. INTRODUCTION

Nowadays Big data solutions have been employed in all areas of research perspectives and it is becoming undeniable. In particular, big data techniques have become more popular in health care and transportation system [1]. Especially transportation has much attention due heavy exploration and utilization of vehicles leading to large traffic congestions and other incidents. Due to large exploration of traffic data, it becomes mandatory to model architecture to predict and cluster the traffic data based on the various constraints and dynamic traffic environment.

Normally traffic data is collected using GPS devices, Sensors and probes. The unsupervised learning model has been applied in large extent to classifying and clustering of the traffic data [2]. However it has profound impacts on learning architecture employed for processing the large scale traffic data. In addition it suffers from high computational complexities and it neglects the utilization of the influencing characteristics of the data [3].

In order to build an efficient and scalable system for storage and data management, a novel deep intelligent prediction model has envisioned for operation of the large velocity of traffic data along spatiotemporal characteristics. Further, location based service has been incorporated on the proposed architecture to suggest the available parking information, traffic density and other services on the specified location. It is mentioned as hierarchical model.

Prediction model have shown high importance in recommendation and forecasting services in an effective manner. Thus underlying traffic information is processed with deep learning models for clustering based on set of extracted features [4]. The deep learning of the traffic data predicts the potential road clusters for passengers, traffic forecasting information, Vehicle detection and helps in autonomous driving behaviours. Moreover Hidden markov model adapted to system provides the hidden features such as road type and point of interest features [5].

The remainder part of this article has been sectioned as follows. In section 2, related work of the particular problem has been analysed in depth on machine learning and computational intelligence models. Section 3 describes the proposed architecture of deep intelligent network incorporating spatio temporal characteristics and location based services. In section 4, experimental results are presented on evaluating its performance on various measures against its state of art approaches. Finally section 5 concludes the paper.

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II. RELATED WORKS

Many approaches have been generated to resolve the challenges in organizing and predicting the large volume of traffic data to discover valuable information on processing using big data analytics. The approaches is given as follows

A. Pattern Identification

The pattern identification aims to determine the hidden and large occurrence of the features. For instance, it helps to analyze and predict the hidden and large normal features based on time depend and density depend traffic information [6]. The analysis extracts most familiar areas and its propagation patterns of the vehicle through incorporating location based services and sensor technologies to meet the data analytics requirement in traffic management. The purpose of intelligent transportation system is predicting the valuable information on diverse sources.

i. Systematic Big Data Fusing Framework For Traffic Data Management

The traffic data evolve with time and contain abundant information posing a crucial need for data collection. Each type of data has specific advantages and limitations on overall state of transportation system. Systematic fusing of traffic data produces effective prediction results on pattern identification on the feature differences, structure differences, resolutions differences and finally on the precision value [7]. Data processing and mining techniques, such as natural language processing and analysis of streaming data, require further revolutions in effective utilization of real-time traffic information.

ii. Heterogeneous Data Learning Approach- An Accelerated Unsupervised Model

An extracting knowledge from a huge volume of unlabeled heterogeneous traffic data can be processed effectively by employing fast unsupervised heterogeneous learning model is becoming increasing requirement. In the traffic information, there might be Heterogeneous Data which may lead high computational complexity while processing with normal unsupervised learning model [8]. On employment of multiple kernels extreme learning machine, information will be extracted from multiple sources of the data repositories to learn the heterogeneous data representation on its closed form of solutions. It enables its data extraction with less execution time.

B. Location Based Recommendation System

Nowadays, Recommender systems are exploring in large extent as it is constructed to search the content of interest from large volume of information stored in the distributed server in massive amount. It carried out for acquiring meaningful knowledge from enormous and complex data since data structure and Volume of the data is exploring. Recommendation system has been incorporated location based service to identify the mobility pattern of the passengers in order avail the traffic density information and free parking space information's. On extraction of spatiotemporal characteristics, efficiency and flexibility of the model has been increased.

i. GPS Data Enabled Recommendation System

Recommendation system is used to predict the rating and preference of the passenger on analysis of cluster records which contains the features of the traffic information's. Global Positioning System (GPS) gathers and records the time and location information [9]. On processing large-scale trajectory data, it is possible to calculate the probability and the time to reach specified destination with presence and absence of traffic density.

ii. Determining The Optimal Level Of Enforcement Using Fuzzy Based Expert System

Intelligent Transportation system is gaining more importance as it employs the electronic payment system for using road infrastructures. Towards employing the electronic fee collection system, level of enforcement has to be determined using decision making system. The supervised learning model based decision making system cannot detect the optimum level for the fees recommendation. In order to obtain the optimal decision making system against eliminating the possibility of manipulating this decision process, fuzzy expert system has to be employed to obtain the optimal level of enforcement [10]

III. PROPOSED MODEL – DEEP INTELLIGENT PREDICTION NETWORK

In this section, detailed architecture is proposed as deep learning framework, which is modelled to predict the features to the particular trajectory. The figure 3.1 represents the architecture of the proposed model.

A. Preliminaries

Traffic data is processed using undirected graph G (V, E), In this, v denotes the set of vertices and E denotes the set of edges (Road Segments connecting two edges). The long edge is segmented into shorter segments along the length of 200meters. For POI and data trajectories, road network is categorized into multiple clusters and estimate the potential information like traffic density, Vehicle moving speed and brake points etc for each cluster [11]. Top K road cluster are recommended to the passenger of the vehicle.

B. Extreme Graph Spatiotemporal Clustering Of Traffic Data

Initially formed road cluster are obtained towards further processing based on spatiotemporal preference on incorporation of the location based services. It is carried out due to vast amount of diverse and complex data. The mobility of the data is dynamic, hence it cumbersome to predict the potential cluster. On adoption of Extreme graph clustering, optimal cluster will be obtained for dynamically changing traffic information's. Extreme graph clustering generates the association matrix on based on the vertices connection with weights of the edges [12].

Association Matrix A =

$$= \begin{pmatrix} cov(a,a) & cov(a,b) & cov(a,c) \\ cov(b,a) & cov(b,b) & cov(b,c) \\ cov(c,a) & cov(c,b) & cov(c,c) \end{pmatrix}$$

$$A = \begin{bmatrix} c1 & c2 & c3 \\ c4 & c5 & c6 \end{bmatrix}$$

{c1, c2, c3} = Instance of the cluster

Matrix value is represented as

$$A_{ij} = \frac{1}{n-1} \sum_{m=1}^{n} \left(d1 - \overline{X}_i\right)\left(dn - \overline{X}_j\right) + Xi$$

The expansion process and inflation process will undergo different iteration until reaches the steady state. The clusters are generated from the matrix values.

C. Mining Based Mobility Pattern

Mobility Pattern of the traffic data utilizes the Hidden Markov Model to extract the feature which evolves the specified period of time. The markov cluster is employed to adapt and mines the cluster instance which evolves over the specific time. Intuitively, markov cluster is established for the data with spatiotemporal characteristics [13]. In addition, there might be much association of data within a cluster and few data association between clusters its traffic data updating.

Mobility of the cluster is represented as M

$$M = u_{1k}x_{1i} + u_{2k}x_{2i} + \cdots + u_{pk}x_{pi}$$

$$\sum_{x=1}^{n} M_x = n$$

Where

U represents the source cluster at specific time

X represents the destination cluster at specific time

Mobility depends on the driving speed and length of the segment. The mining of cluster is approximated with cluster indices of the data interactions.

D. Feature Extraction

It extracts the normal and hidden features from the markov cluster. Features are extracted mostly based on frequencies. For instance, features are extracted based on road types, traffic density, vehicle moving time and frequency of objects distributions near Point of interest. Furthermore, deep learning architecture generates the traffic forecasting information, vehicle detection, autonomous driving and driving behaviours through sub sampling functionalities.

The features extracted as distinct variable. It helps to determine the free parking space and vehicle detection etc. However this mechanism, effectively computes the objects located in the circular area. Feature extraction is explained with multiple cases [14]
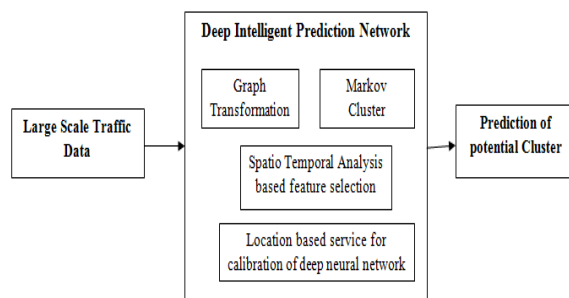

Figure 1: Architecture of the proposed model

POI can be presented in the single cluster or multiple clusters as data instance.

POI can be presented in the cluster for particular time period or multiple time periods.

The optimal feature selection has been carried out on model tuning during the learning process. It learns as single sequence learning.

E. Prediction Using Deep Neural Network(DNN)

Deep Neural Network (DNN) has been employed to overcome difficulty arising due to data outliers in clusters on employing a non-iterative training process. The features that is important for discrimination has been computed through normal and hidden layer. The prediction models employed in this section has capability to learn complex functions and data structures while irrelevant variations are suppressed.hih performance has been achieved in determining the data structure of large scale data. DNN structurally incorporates hidden layer along with a visible layer. The learning model establishes the mutual data connections between visible and hidden layers. The Bias values have to be updated frequently for both the hidden layer and visible layer. It automatically learns and infers the spatial dependency.

$$P(X,Y) = \frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{(n-1)}$$

The objective function of the prediction is given by

$$P(x,y) = \alpha \frac{l_t(x,y)}{\sum_i l_t(x,y_i)} + (1-\alpha)\frac{f(x,y)}{\sum_i f(x,y)}$$

Where l_t is the location information at specific time

Prediction is hierarchical and operates with spatiotemporal characteristics and location based service to predict potential road clusters for passengers [15].

Algorithm: Prediction of Traffic forecasting Clusters

Input: Traffic data

Output: potential Cluster

Process

For instance G = 1 to W do

Generate the instance a training data for Traffic data

For i = 1 to M do

Calculate class C = {V1, V2, V3...}

      Where v1, v2 are input vectors of the road cluster

End for

 Extract ()

    Feature set = {V1(x, y), V2(x, y)...}

If   Similarity difference between v1 and v2 > threshold

Initialize Random Cluster

Else

Optimize the parameter using Spatiotemporal Characteristics and weight

     Weight W =

$$V1\sum_{k=0}^{n}\binom{n}{k}x^k a^{n-k} + V1\sum_{k=0}^{n}\binom{n}{k}x^k a^{n-k} \dots Vn$$

Predict ()

$$P = \frac{W \pm \sqrt{x^k a^{n-k} - 4c}}{2n}$$

Recommend for specific Road segment ={ Available Parking space | vehicle Density | traffic Congestion }

   It automatically learns and infers the spatial dependency. The size of the feature map is reduced in sub layer in the prediction operation.

IV. EXPERIMENTAL RESULTS

In this section, performance analysis and computation of the Intelligent Transportation prediction model has been carried out using set up information and performance measuring metrics against various data sizes of the traffic information.

A. System Design

Experimental analysis is carried out with an Intel Core I3 processor with 2620 Processors (2.0 GHz) and 8 GB RAM and 1GB Hard disk using Dotnet programming. The data taken for processing is 750 GB containing traffic information at various time periods and different location .Additionally GPS and other sensor information has been calibrated with location based service to obtain the POI.

B. Performance Metric

 Deep learning techniques predict the short-term travel demand as data has been exploited from electronic payment data sources and location traces in the real time. It achieves the less computation time for acquiring. The performance metric considered for evaluation of the proposed intelligent transportation model consider the following

- Precision
- Average Execution Time

i. Precision

It is defined as fraction of predicted objects that are relevant against the total of retrieved data in the markov cluster. The figure 2 describes the performance evaluation of the intelligent transportation models. It has been obtained for different combinations and with minor fluctuations in the data. To deal with randomness and local optimisation issues of the prediction results, the Threshold information and values of coefficient array in the neural network has been utilized.
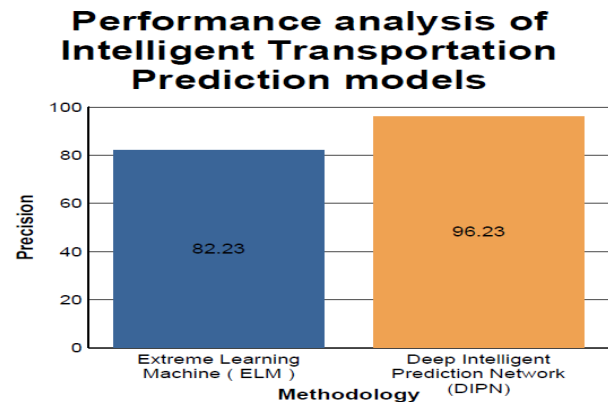

Figure 2: Performance analysis of Intelligent Transportation Prediction Model on Precision metric

ii. Average Execution Time

It defines the time constrainst to process the data set to obtain the predicted cluster value on specified time. The figure 3 represents the performance analysis of the intelligent transportation model on terms of average execution time. The traffic network spatial-temporal dependencies integration into deep learning models will reduce the computation complexities. The traffic data are huge in volume and velocity. The model is represented in detail on their specification and Complex on their architecture.

The deep learning model prefers to consider both temporal and spatial correlations inherently on the location based services for proving the prediction for short-term passenger requirement to on-demand transport service for enjoying the intelligent transportation experience. Other factors considered for enhancing the performance includes land use and origin-destination data. Generalization error model has been considered.
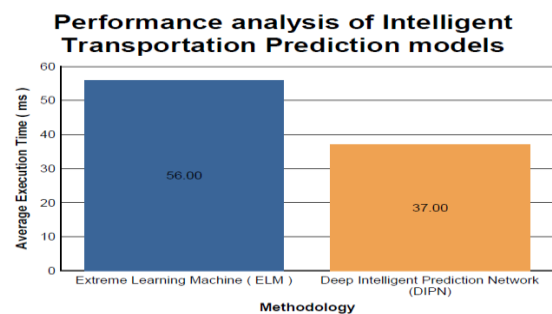

Figure 3 : Performance analysis of Intelligent Transportation Prediction Model on Average Execution Time

 The markov cluster has been employed to identify and realize a trade-off between precision and computation cost values. In this training clusters provides is no deviation on data association on clusters and between clusters.

The table 1 depicts the performance evaluation of prediction models.

Table 1: Performance evaluation of Intelligent Transportation Prediction models

Technique	Precision in percentage	Average Execution Time in ms
Existing: Extreme Learning Machine (ELM)	82.23	56
Proposed: Deep Intelligent Prediction Network (DIPN)	96.23	37

The experimental analysis proves that proposed model achieve better results as it non-parametric models employed automatically to learn the parameters from the data. The linear dependency feature lead to unsatisfactory results as feature set is large which is considered as more sensitive aspect. Finally, the efficiency of the proposed model has been improved when compared with state of art approaches.

V. CONCLUSION

We designed and implemented a new architecture named as deep intelligent network towards prediction of the potential cluster for passengers on traffic information. The prediction model conducted to cluster and classify the traffic information based spatiotemporal characteristics and location based services as big data paradigm. The feature set is designed based on hidden markov model and normal feature extraction models. It reflects the various characteristics with regards to various factors. The clustered information enables effective utilization of the data. However there have been some efforts made to system to recommend the passengers with parking spaces, road based traffic density and time based traffic density and finally it aids in autonomous driving of the vehicle. The performance of the proposed architecture has been evaluated through extensive experiment based on traffic data. On analysis of Experimental results, the flexibility and scalability of the model has found to be improved over state of art approaches.

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