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Review: Neural Network based Approach for Travel Time Prediction

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Abstract—*Travel time prediction is one of the important issues in various intelligent transport systems (ITS). In this paper the study of a travel time prediction model for non-recurrent events using Artificial Neural Network is presented. The broad objective of this paper is to study different travel time prediction models. This paper gives a broad idea about how to use Artificial Neural Network approach or soft computing approach for travel time prediction. In this model K- means algorithm is used to prepare the traffic data which is used to train neural network architecture. The data is clustered using K-means algorithm, each cluster is assigned a variable, these variables are used to provide input to the system, and the network is trained by using a sample dataset. This paper also gives an idea about the present and past prediction models with comparative analysis. Though this study current thrust area in ITS can be possible to identify. To acquire traffic data different techniques are suggested by different authors. In addition to this one prediction model is also suggested. In this suggested method acquired data is clustered using K-means clustering algorithm. Each cluster is assigned a cluster ID using Classification and Regression Tress (CART). The data is divided into two sets the first consists of 70% data that is used for training the system while the remaining 30% of the data is used for the testing purpose. The system is first trained using the sample dataset. In this paper Neural Network model with back propagation is used. The model is three layered with one input layer, one hidden layer and one output layer. Artificial Neural Network model has advantage over traditional methods because the system can be trained using sample datasets. The paper also focuses on constructing a model that is dynamic in nature, which exhibits high accuracy and speed when applied to large databases.*

Keywords: *Travel Time Prediction, K-means, Classification Aggregation Tree (CART), Neural Network (NN), Back Propagation Neural Network (BPNN), Artificial Neural Network (ANN).*

1. INTRODUCTION

As the density of vehicles is increasing day by day, the road network is growing proportional to the number of vehicles. Time travel prediction is gaining importance as it is used in many intelligent transport systems to make a better traffic control decisions. Time travel predictions can be used by transport agencies to prevent potential traffic congestion [1]. Various time travel prediction models are implemented like, auto regression integrated moving average model (ARIMA) for normal traffic congestion, Kalman filtering's dynamic linear model (KLM), Adaptive Dynamic Linear (ADML) to predict travel time in recurrent and non-recurrent conditions [1]. The traffic data like number of vehicles at various time periods of the day, road conditions, and weather conditions are acquired using detectors and sensors. The detectors are placed at a certain intervals.

The data collected is clustered using K means algorithm. Cluster ID is assigned to each cluster. A classification model is created using CART. Critical variables are identified and a dummy variable is created for every cluster Id of each 5 min sample. These critical variables are then given as input to the system and the travel time is predicted using the Artificial Neural Network System. Efficient traffic control can have a big impact on the CO2 emission [2,3]. The lesser the time taken by a vehicle to reach the destination the lesser will be the CO2 emission. Various technologies like advanced traveller information system (ATIS) are used in Intelligent Transportation Systems (ITS) [1].

2. RELATED RESEARCH

Travel time prediction is gaining importance nowadays. The travel time predicted can be used in efficient traffic management, planning of construction of roads, which can help in reducing the travel time of the drivers. The reduction in travel time is also directly proportional to the reduction in the CO2 emission [2]. Various models are proposed for predicting the travel time. These models have their own strengths and weaknesses. There are two ways in which the travel time can be predicted. The first ways is to use the path based estimation and the second one is to use the link based estimation. The paper "A New Travel Time Prediction Method for Intelligent transportation system" proposes a neural network model and data mining for predicting the travel time [4,5]. Artificial neural network model can reduce the mean absolute error significantly than any other model.

Various models are based on techniques like Autoregressive Integrated Moving Average Model (ARIMA), Dynamic Linear Model (DLM) and Adaptive Dynamic Linear Model (ADML) [1]. Travel time information is an important component of intelligent transportation systems (ITS), advanced public transportation system (APTS) is one of the applications of ITS. APTS can reduce the traffic congestions.

3. AUTOREGRESSIVE INTEGRATED MOVING AVERAGE (ARIMA)

Autoregressive integrated moving average (ARIMA) is a time series analysis model. These models can be used to predict the future points in the series. This model is referred as ARIMA (p,d,q) model where p,d,q are non-negative integers that corresponds to the autoregressive integrated and average of the moving parts of the model. Autoregressive integrated moving average (ARIMA) models can be used to predict the travel time in normal traffic conditions.

The steps in ARIMA model are as follows:-

a. Identification

The first step is to find out whether the model is stationary or not, this is done by using a graph of autocorrelation function (ACF). The series is stationary if the values cut off quickly, if the values drop down slowly the model is considered non-stationary. Differentiation can be used to convert a non-stationary series into a stationary series.

b. Estimation

Estimation is specified for the model which fits the variables determined in the identification phase. Various parameters that are required for the model are estimated.

c. Forecasting using the model:

Forecasting is done using the mean absolute relative error (MARE) and mean absolute percentage prediction error (MAPPE).

ARIMA model suitable for predicting the travel time only in normal traffic congestions but its accuracy reduces largely in non-recurring traffic congestions.

Dynamic Linear Model (DML)

Dynamic linear models are simplified forms of Gaussian processes. In Gaussian processes each parameter is related to the other in some way. Two equations are used to specify these models

a. Observation equation

$$\mathbf{Y}(t) - \mathbf{F}(t)^T \cdot \mathbf{z}(t) + \boldsymbol{v}(t)$$

b. State equation

$$\mathbf{z}(t) - \mathbf{G}(t) \cdot \mathbf{z}(t-1) + \boldsymbol{\omega}(t)$$

Where, Gt and Ft- Known matrices, (vt) and (wt) - Two independent white noise sequences with mean zero.

The normality is assumed by central limit theorem arguments. The cost to be paid of assuming the normality is the additional computational difficulties.

Adaptive Dynamic Linear Model (ADML)

Dynamic Linear Model assumes that the changes in travel time are constant, but the travel time changes considerably due to unexpected events like accidents, heavy rainfall. Adaptive dynamic linear models take into account the unexpected events to predict the travel time. Feedback control logic is used in Adaptive Dynamic Linear Model (ADML). The major components of ADML are

a. Surveillance subsystem:

This subsystem monitors the traffic conditions and collects the real time data. The data is collected by using CCTVs and other devices.

b. State intervention controller:

It is developed using feed forward control logic. The system is adjusted according to the changes by using prediction error signals as a reference.

c. State variation estimation module:

The tolerance is incorporated by using the equation

$$\varsigma = \begin{cases} 1, & \text{if } |T(t) - \widehat{T}(t)| \geqslant \varepsilon, \\ 0, & \text{if } |T(t) - \widehat{T}(t)| < \varepsilon \end{cases}$$

$\widehat{T}(t)$ and $T(t)$ are the observed travel times. ς is a binary variable that takes the value of 1 if the difference between the predicted and observed travel time is unacceptable to the decision-maker. The distribution of changes in the travel time is adjusted according to the error signals once the data is obtained. ADML model sustains from a drawback where the frequency of prediction adjustment is higher during the non-recurrent state than that in stable traffic conditions.

4. THE PROPOSED PROCEDURE OF TRAVEL TIME PREDICTION

a. Gathering of the traffic data:

Detectors are used to collect the traffic data at various locations on the road. The data like, the density of vehicles, average speed of the traffic and time are gathered. The gathered information is stored in the database [1].

b. Clustering of data:

Data is clustered using K-means algorithm. The clusters are created based on time, these clusters are assigned ID, a classification model (CART) is built and critical variables are identified [1]. These critical variables are used as input for the neural network.

c. Building an ANN model:

This is a three layered model. It has one input layer, one hidden layer and one output layer, 70% of the collected data is used for training the neural network and the remaining 30% is used for testing the model. Back propagation algorithm is used in this model.

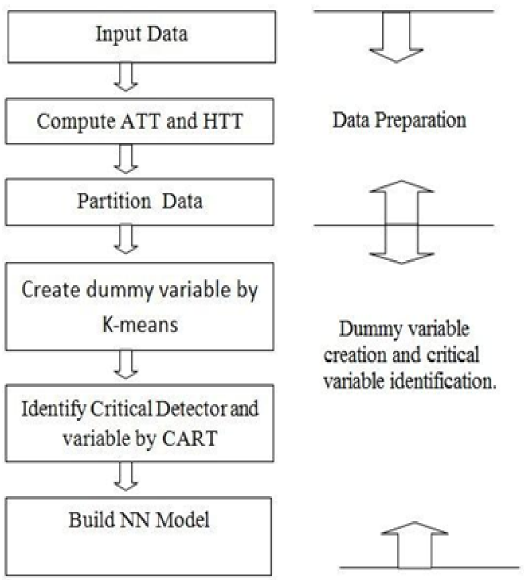

Fig. 1: Procedure for travel time prediction.

To calculate actual travel time and historical travel time

$$HTT_{ABt} = \{t_{Bi} - t_{Ai} | t - t_r \leq t_{Ai} \leq t \text{ and } Btt_{ABt}(1-0.4)\} \leq t_{Bi} - t_{Ai} \leq Btt_{ABt}(1+0.4)$$

$$ATT_{ABt} = \{t_{Bi} - t_{Ai} | t - t_r \leq t_{Ai} \leq tandBtt_{ABt}(1-0.4)\} \leq t_{Bi} - t_{Ai} \leq Btt_{ABt}(1+0.4)$$

Where,
HTT= Historical Travel Time.
ATT= Actual Travel time.
t_{Bi} = Time of vehicle i passing through point B.
t_{Ai} = Time of vehicle i passing through point A

Steps for creating a dummy variable

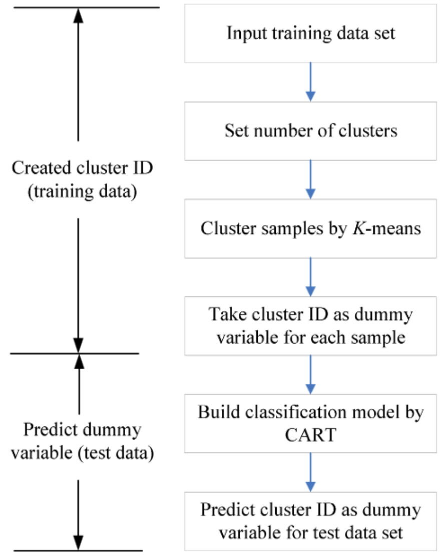

Fig. 2: Steps for creating a dummy variable

5. CLUSTERING

Clustering is a technique by which a given dataset can be divided into sets of similar data called clusters. The data elements in a cluster are similar to each other based on some property. The clustered data is easy to process since it has fewer variations. The data that is obtained by using the detectors is clustered using K-means algorithm.

6. CART

Prediction models are constructed by using Classification and Regression Trees (CART). CART is used in machine-learning. The data is partitioned and fitted within each partition using the prediction models. Dependent variables are used that take the unordered values. The error is measured in terms of wrong classification cost. Regression trees use dependent variables.

7. TRAVEL TIME PREDICTION USING NEURAL NETWORK

Artificial neural network model is used to predict the travel time. The neural network model that is proposed is of three layers. One input layer, one hidden layer and one output layer. Back propagation algorithms are used.

Back Propagation Neural Network

The Back Propagation Neural Network (BPNN) is proposed. The model is trained using a training dataset; the errors that are generated from the output layer are given as input to the input layer [9]. The BPNN model can be formulate much faster than the other models described.

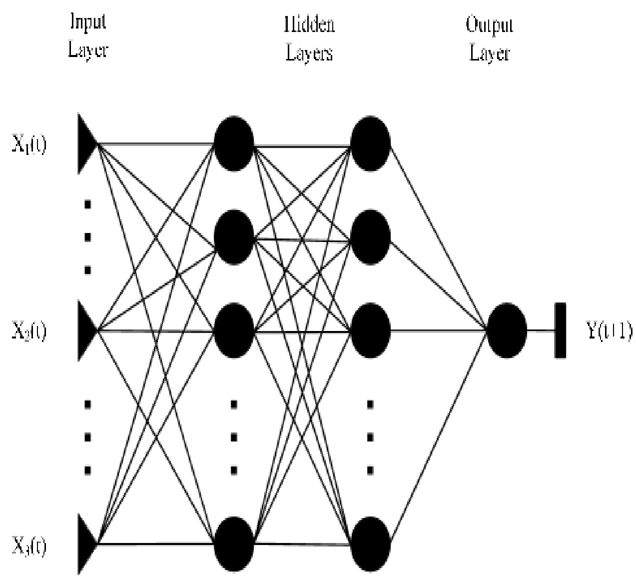

Fig. 3: Schematic overview of BPN

Training of the Neural Network

The Neural network model that is created is trained using a part of the dataset obtained. 70 % of the collected data is used for training the system and the remaining 30% is used for testing the system. The system uses the back propagation model. Network parameters are adjusted according to the maximum error gradients on the error surface when each time one sample of the input-output pairs is fed to the network.

8. CONCLUSIONS AND FUTURE WORK

This paper gives a highlight on various travel time prediction models that have been proposed. The shortcoming of each model is discussed, which can be helpful in selecting a model that is appropriate. A time prediction model which is based on Artificial Neural Network is proposed. This model is a three layered mode. The traffic data is collected by using the detectors. The data is stored in the database. This data is clustered using K-means algorithm. The clusters formed are assigned a cluster ID which is given as an input to the system.

CART is used to classify the data. The cluster ID is given as input to the system. The system generates the travel time by using Neural Network model. The system is first trained using a sample dataset. The work can be further extended to consider in forecasting of travel time which can have a significant impact on the road user satisfaction.

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