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Traffic Accident Prediction Model Using Deep Learning Approach in VANET– a Review

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Traffic Accident Prediction Model Using Deep Learning Approach in VANET– A REVIEW

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***Abstract*— In today's era, development in transportation is rising day by day. Vehicular Ad Hoc Network (VANET) is a crucial part of advanced transportation system framework. Number of vehicles is increasing rapidly due to their high need and demand by people. This reason somewhere also leads to increase in number of traffic accidents. Road traffic accident is a very serious threat to human life. It harms the safety of living environment as well. Thus it is essential to provide a prominent solution to this problem. Traffic accident prediction and prevention is an important step for vehicular safety purpose. Various traffic accident prediction techniques using machine learning and deep learning algorithms are being tested by researcher. The study of such techniques is done in this paper. This study may act as a benchmark to use particular method as per one's available resource. Also, after proper analysis of each of these methods, the scope for further development will increase that helps to create a space for new research.**

Keywords— Traffic accident prediction; vehicle safety; VANET; deep learning.

I. Introduction

The Vehicular Ad Hoc Network (VANET) is a rising new wireless networking concept. It is a promising approach for Intelligent Transportation System (ITS). The basic motive of transportation system is to provide the efficient as well as safe movement to passenger from one place to another. The economic development of any country is strongly linked with the availability of transportation. In the context of speedy evolution of modern transportation, due to big contradiction between human, roads and vehicles, the issues in traffic management are increasingly evident.

According to a survey conducted by World Health Organization, nearly 1.35 million people die every year as a result of road traffic crashes whereas around 20 to 50 million people suffer from non-fatal injuries. Such traffic accidents cost most of the nation's 3% of their gross domestic product [6]. Road traffic injuries are becoming one of the leading death causes for children and youth aged 5-29 years. Road traffic accidents lead to significant economic losses to not individual but also to their families and country as a whole. Thus traffic accident prediction is turning a key parameter to reduce vehicle crashes.

There are many factors that need to consider for traffic accident prediction purpose. Geometric characteristics of road, characteristics of drivers, traffic flow, weather conditions and environment of roads are some of the factors contributing for occurrence of road traffic crash. Many Studies and researches have been conducted to predict the mechanism of accidents, its frequencies, identification of hazardous location and casualties occurring due to traffic crashes.

Artificial intelligence is one of the leading fields that include both machine learning and deep learning. Machine learning is a subclass of Artificial Intelligence. K-Nearest Neighbour, Support Vector Machine, Naive Bayes are some of the algorithms of machine learning. However, analysis shows that machine learning algorithms require large time for testing of data. In addition to this research comes up with the next level of analysis using deep learning algorithms to consider an improvement in time of testing as well as accuracy. Deep learning signifies that machines can simulate human brain's learning behaviour. Deep Neural Network (DNN) is a concept under the supervision of deep learning. As the name Deep Learning signifies, it comprises of higher number of processing layers which contrasts with fewer number of layers with shallow learning architecture. The shift from shallow to deep learning allows to dealing with more intricate and non-linear functions. There are many areas where deep learning has exceeded human level performance and capability. Merging the vehicular network with deep learning, makes it convenient to predict and analyse the data collected in real time; thus significantly decreasing the occurrence of traffic accidents.

A. Vehicular Ad Hoc Network (VANET)

The term VANET refers to vehicular ad hoc Network. VANETs are used to provide navigation, safety and other roadside services. VANETs are a crucial part of Intelligent Transportation System framework and thus VANETs are also referred as Intelligent Transportation Network. The basic mechanism of VANET is that a vehicle can detect other vehicle in fixed vicinity allowing them to behave as nodes [4]. In the past few years, large amount of analysis and huge development projects have been undertaken by many agencies based on VANETs. Many of these projects have motive of network security enhancement, improving road safety, traffic condition optimization and reducing pollution. There are mainly two types of communication in VANETs: Vehicle to Vehicle (V2V): In V2V communication, two vehicles share traffic information and warning messages with each other. This information would include location, direction of travel, braking, speed and loss of stability. Vehicle to Infrastructure (V2I): In V2I communication, vehicles can communicate with road side units such as base stations, traffic signals

etc. V2I sensors are used in Intelligent Transportation System to record data and provide road users with real time advisories. Both of these VANET communication systems have capacity to advance transportation in various ways.

Applications of VANETs can be broadly classified into two categories: Safety applications and non-safety applications. Safety oriented applications of VANETs include situation awareness such as blind spot warning, adaptive cruise control and warning messages for electronic brake light and traffic light violation. These applications prioritise on saving the lives of human beings. These applications are used to avoid the risk of road traffic crashes by transmitting information about obstacles and hazards. According to a research, if driver gets an alert message half a second before the collision then more than half of the crashes can be avoided [13]. A fraction of a second is also important in decision making. Thus safety applications of VANETs are strictly time bounded. Non Safety oriented applications basically include the applications for comfort driving, entertainment and contextual information. These applications have less critical requirement and restrictions as compared to safety oriented applications. The travelers in a vehicle can enjoy the facility of internet connectivity where other conventional wireless options are not available. Various companies can use VANET for advertisement purpose. Web browsing, chatting, file sharing and gaming, these applications also find their place in VANET.

B. Deep Learning

Deep learning is a subclass of machine learning. Deep learning uses multiple numbers of layers to successfully extract higher level features from the raw input. Thus mechanism, of Deep learning works on multi neural network architecture. Study of neuron structure is crucial for understanding deep learning approach. The basic neuron model is as shown in fig.1.

1. Neurons: Neurons are the main building blocks for neural networks. An artificial neuron is also known as perceptron. It is a mathematical function, that receives one or more input and are multiplied by the values called "weights" and finally added together. These values are then passed to the activation function, resulting in neuron output.
2. Weight: Weight plays a vital role to specify the importance of feature in predicting the target value. A set of weighted input allows each artificial neuron to generate related outputs. If the weight associated with feature is positive then it specifies that there is a direct relationship between that feature and target value. If the weight associated with the feature is negative then it specified the inverse relationship between feature and target value.
3. Activation Function: Activation function signifies the computational efficiency of a training model and ultimately helps the network to learn complex patterns in data. The summation of weighted input is forwarded to activation function. It leads to provide the threshold requirement to the summed input.

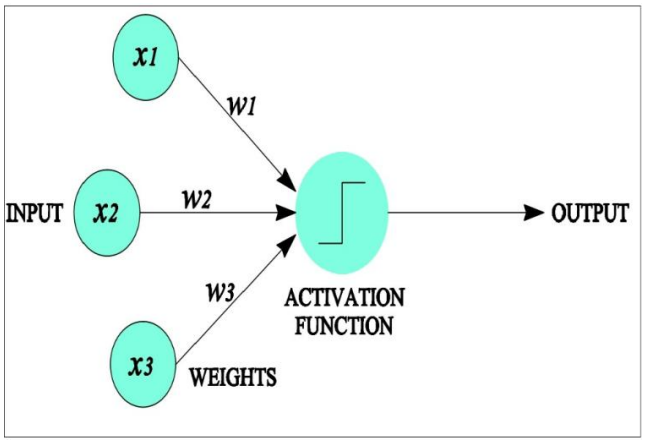

Fig. 1. A Simple Neuron Model

4. Neuron Network: Deep learning comprises of very huge and deep neural network. Many layers of neurons are arranged in an organized manner just like in the brain of human cells. The learning process of neuron is performed with these layers. The weighted input is passed through several non linearities before converted into the output. The schematic view of Deep Neural network (DNN) is as shown in fig 2.

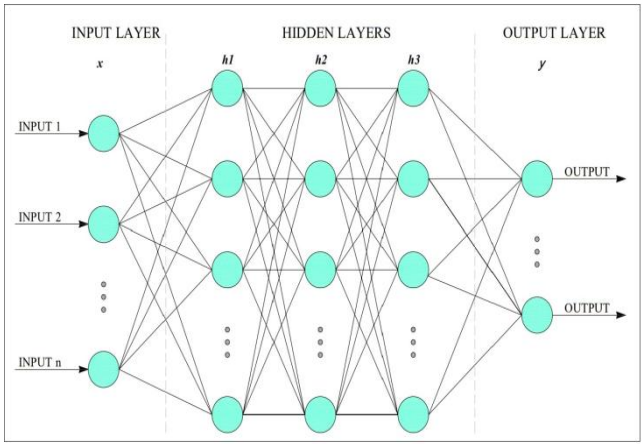

Fig. 2. Deep Neural Network

a. Input Layer: Input layer is responsible for receiving the initial data. These inputs can be loaded from external source as well. The number of neurons in this layer is depending on the shape of training data. Input layer takes the input, performs the calculation via its neurons and then forward it to the subsequent layers
b. Hidden layer: These layers are stacked between input and output layer, it allows neural network to adopt more complicated features. Number of hidden layers could be more than one in a network. Larger number of hidden layers indicates that more complex problem can be solved by the network. The main purpose of these layers is to perform the non-linear transformations of input entered into the network.

The use and architecture of hidden layer varies from case to case.

c. Output layer: The last layer of the network is responsible for generating the final result.

C. Methodology

Traffic accident prediction comprises of several procedures in order to predict the crash severity. Various techniques are still being analysed by researcher for more accurate and efficient prediction. Artificial Intelligence plays important role to serve this purpose. In machine learning technique, the extraction of feature is done manually, whereas in deep learning the selection of feature is done on the basis of input data provided to the system. In deep learning, every level learns to modify its input data into more abstract form. Thus deep learning algorithm is used in proposed work for traffic accident prediction. Fig. 3 shows the block diagram of proposed work.

a. Input data and training dataset: The initial step of the process is to teach the accident prediction model with a dataset. UK car accident dataset is used to train the detection module. The input data can also be collected via external sources such as sensors, CCTV etc. This data is transferred to the next step that is preprocessing.

b. Data Processing: Pre-processing refers to all modifications on the raw data before it is fed to deep learning algorithm. It helps to prepare the raw data and makes it more suitable for deep learning model. Pre-processing is a very crucial process as it directly impact on the success rate of the model. Data is said to be unclean if it have missing attribute, contain noise, wrong or duplicate data. The output of pre-processing is then forwarded for feature handling purpose.

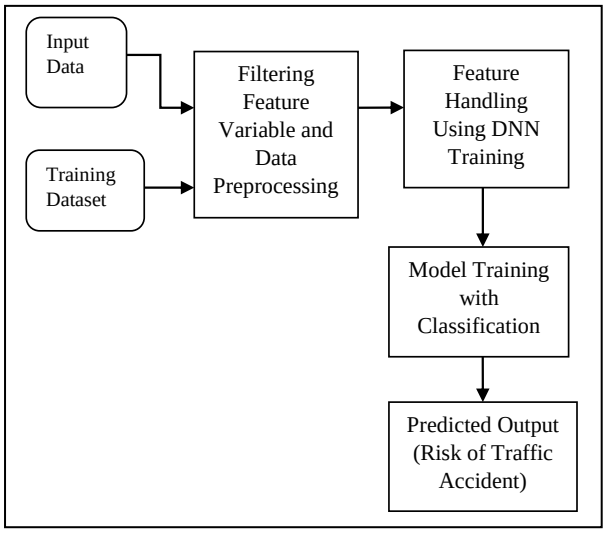

Fig. 3. Block diagram of proposed work

c. Feature Handling: Feature handling is also referred as feature extraction. Different deep learning kernels are responsible for extraction of features autonomously. The features could be vehicle type, speed, weather condition, travel time and other various characteristics. These extracted features are then passed to the deep learning classification.

d. Model training with classification: With the help of deep learning algorithm, the model gets trained and classifies data into specific categories by predicting their class.

e. Predicted Output: After classification, the system gives the output that predicts the risk of traffic accident. If any dangerous situation arises then immediately driver gets alert with warning message.

II. LITERATURE SURVEY

Intelligent Transportation System has experienced a huge attention in recent years from industry as well as academia for the purpose to sort the issues regarding traffic problems. Many recommendations and analysis are being provided by researcher in the field of transportation and automation. Traffic accident prediction is one of such field. Machine learning and deep learning; two subcategories of Artificial Intelligence are being extensively used for this motive.

Aixia Zhang et al. [1] developed a three layer BP neural network model to predict the traffic accidents of the year 1998-2009 in China. The model has trained based on several influencing factors of traffic accidents like highway mileage, total population, civilian vehicle ownership, passenger turnover etc. The proposed algorithm is depends on the gradient search of the least mean square algorithm. The BP neural network uses tangent transfer function or S-type logarithmic transfer function and linear function. The output value of the model will limit in between 0 and 1, if S-type transfer function is used. Whereas model output can take any value if linear function is used by output layer. The prediction model has nine input vectors and three output vectors. The test results verify the prediction error of number of deaths, direct economic loss and number of accidents.

Qiong et al. [2] proposed a method for car collision prediction in vehicular ad hoc network using support vector machine (SVM). The proposed system includes three phases. Initially, simulation of VANET with car collision is designed to get collision data. Further, the historical data is used to train SVM model. In last phase, the alert message and suggestion has been given to driver after the prediction of dangerous situation. For each vehicle five parameters were selected including acceleration, speed, collision state, location (x, y coordinate) and direction. The response time of the driver and the time required to take necessary action are considered for making system more reliable. The accident rates are decreased by 63% if proper action is taken by driver within the specified time interval.

Haithao Zao et al. [3] developed a driving risk prediction algorithm. The algorithm is based on a principal component analysis to de-correlation a large amount of data in VAMET, and BP neural network to train the model. The risk prediction has been done by trained model as well as real time driving information, driver information and traffic information collected by VANET. The UK car accident dataset is used to trained the model. The training set and testing set are divided

according to a ratio of 9:1. Furthermore, the result of this proposed system is analysed by comparing it with support vector machine algorithm. The simulation result shows the 92.5% of accuracy using PCA-BP neural network in different dataset.

Mari Kirthima et al. [4] proposed the use of vehicular ad hoc network with K Nearest Neighbour Classifier (KNN) for creating a prototype of a system that can notify drivers of an impending accident occurred due to forward and rear collision. For obtaining the current vehicle location, a positioning system using Wi-Fi triangulation is utilized. Each vehicle is provided with Node MCU ESP8266 Wi-Fi module. For identification purpose, every module is furnished with unique ID. Polynomial regression is used for location extraction. The system also provides GUI that can be used by traffic department to monitor roads in case of accident. The result shows the 90% of accuracy for detection of real time vehicle location (x coordinate). But proposed system fails to identify lane changes of the vehicle due to inaccurate y coordinates.

Lu Wenqi et al. [5] established a traffic accident prediction model using TAP-CNN. Convolutional Neural Network is a supervised learning multi-layer neural network. The two core modules: convolution layer and pool sampling layer are used to recognize the feature extraction function of Convolutional Neural Network. This paper uses the United States I-15 highway 160 mile- 166 mile road accident dataset. Several traffic accident influencing factors such as weather and traffic flow are taken into consideration. Convolutional Neural Network is used to build the traffic accident prediction model, which provides a reference for the forecast of the traffic accident. Further the test result of TAP-CNN is compared with TAP-BP model. The prediction accuracy of TAP-CNN comes 78.5% which is seven times more than that of TAP-BP algorithm

Ming Zheng et al. [6] demonstrated a novel traffic accident's severity prediction model based on Convolutional Neural Network (CNN). The system basically considers combination relationship among traffic accident's features. The Feature Matrix to Gray Image (FM2GI) is proposed by researcher to convert a single feature relationship of traffic accident's data into gray images. The proposed model was implemented in python using TensorFlow deep learning framework. The severity prediction was categorized into three different layers: slight, serious and fatal. For performance analysis of trained model, the test results were compared with other machine learning algorithm like K Nearest Neighbour and Support Vector Machine

Zhe Peng et al. [7] developed a new deep learning framework (DeepRSI) to analyze a real time road safety index prediction from data mining concept. The proposed system considered the spatio- temporal relationship of the vehicle GPS trajectories and external environmental factors. The researcher have focused on two main issues regarding VANET i.e. road safety analysis and driving safety analysis. The data required to train the model were collected from authoritative official organizations in New York City. Furthermore, the experimental results were compared with other machine learning algorithm including K Nearest Neighbour (KNN), decision tree (DT) and Artificial Neural Network (ANN), which signifies the highest precision of proposed DeepRSI is 90.7%

Haitao Zho et al. [8] proposed a traffic accident prediction system using Convolutional neural Network. The researcher analysed that traditional machine learning algorithm shows poor expression ability and these algorithms extract features manually. The CNN based trained model was capable of extracting features autonomously using Convolutional Neural Network Kernel. The CNN training model output ranges in between 0 and 1. The probability of traffic accident is lower if the output value is more biased towards zero. If the output value tends towards one then there is a great chance of accident to be takes place. The real time traffic and vehicle driving information is transferred to the edge server by the base station and the roadside micro cloud. Edge computing releases the resources of the network by reducing the data transmission to cloud. The simulation result specified the model had accident prediction accuracy of 95%, which is much better as compared to traditional algorithm like BP neural network.

Chunjiao Dong et al. [9] demonstrated the model that comprises of two modules, unsupervised feature learning module and supervised fine tuning module. A multivariate negative binomial (MVNB) acts as a regression layer in supervised fine tuning module. The dataset used to train the module was collected from Knox country in Tennessee. The crash data have been divided into five categories including possible injury crashes, incapacitating injury crashes, non-incapacitating injury crashes, capacitating injury and PDO crashes. The proposed model helps to explore the intricate interactions between traffic, road, various environmental elements and traffic accidents. Other than geometric design feature and traffic factors, the impacts of pavement surface characteristics are also examined. It ultimately helps to address traffic safety problems for maintenance and roadway design. The test result shows that average accuracy of prediction given by proposed model can be improved by 121.37% compared to support vector machine. It has better performance in terms of small error variance than that of other machine learning algorithm.

III. SUMMERIZED WORK DONE

Table 1 shows the comparative analysis of various methods used for traffic accident prediction including both machine learning and deep learning approach.

TABLE 1. SUMMARY OF METHODS USED FOR TRAFFIC ACCIDENT PREDICTION

REF NO.	METHODOLOGY	RESULT
1.	Traffic accident prediction using three layers BP neural network, implemented in C++ 6.0.	Number of accident prediction error rate is between 0.68% to 1.57%
2.	Support Vector Machine is used for car collision prediction in VANET, on MATLAB 2011b.	If driver follows suggestion from time interval 5 sec, then accident rates are decreased with 63%
3.	Principal Component Analysis and BP neural network algorithm is used for driving risk prediction, Implemented in Python.	Prediction accuracy is 92.5%
4.	K Nearest Neighbour classifier is used to notify driver about an impending accident, simulated in C++ programming.	90% of accuracy for detection of vehicle location (x coordinate). But fails to identify lane changes due to inaccurate y coordinate.
5.	Traffic accident prediction model using TAP- CNN.	Accident prediction accuracy is 78.5%
6.	FM2GI algorithm along with TASP-CNN is used to predict traffic accident severity, implemented in Python using Google's open source TensorFlow.	Average recall predicted by TASP-CNN is 93.2%
7.	Deep learning framework (DeepRSI) is used to analyze road safety index, implemented on Intel Core i7 machine with 32 GB RAM and NVIDIA TITAN X graphics card.	Highest precision is 90.7%
8.	Convolutional Neural Network is used to establish a traffic crash prediction model, using Python's high level network API framework Keras.	Accident prediction accuracy of 95%
9.	Unsupervised feature learning module and supervised fine tuning module is used, implemented on MATLAB.	Average accuracy of prediction can be improved by 121.37% compared to SVM.

IV. CONCLUSION

Traffic accident prediction is an essential step in advanced transportation system for providing safety to passengers. This paper gives a review of various methods used for traffic crash prediction in vehicular ad hoc network. From the analysis, it comes to know that, there are many factors that need to consider for crash prediction such as direction and speed of vehicle, weather conditions, geometric characteristics of road, traffic flow, location etc. Accident prediction can be implemented by many ways using artificial intelligence, machine learning. But for attaining more efficiency, deep learning is an advanced method for accident prediction.

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