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Research Article

A Novel Approach on PPG-RAP Kernel for Symbiotic Pavement Calamity Forecast using Optimized Machine Learning Techniques

V.Priya [1] , Dr C.Priya [2]

[1] Research Scholar,Department of Computer Science,Vels Institute of Science,Technology and Advanced Studies (VISTAS),Chennai. priyasudhagar.v@gmail.com
[2] Associate Professor and Research Supervisor, Department Of Information Technology,Vels Institute of Science,Technology and Advanced Studies(VISTAS) Chennai. drcpriya.research@gmail.com

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Abstract

Injuries due to road accidents are one of the most prevalent causes of death apart from health related issues. In the year of 2016, about 1.35 million deaths are occurred because of road traffic, according to the statement of World Health Organization in worldwide which reveals that for every 25 seconds a death occurs. To reduce the death rate due to road accidents, it is necessary to analyze the factors affecting the road conditions and come up with the algorithm to reduce the probability of their occurrence.The factors like lighting condition, Road surface, temperature, visibility and vehicle are related to traffic accidents, to determine accident zone some of these factors are most important.This research proposes the PPG-RAP classification algorithm in order to find out the relevant patterns and to predict the accident zones and its severity based onthe various traffic accidents with the help of influential environmental features of road accidents.The real time data also used to evaluate the efficiency of PPG-RAP classifier. To clean and preprocess the data, transformation and arithmetic mean computation is used. The optimum features are selected from the dataset using Binary particle swarm optimization (BPSO) based feature selection method.

Keywords: Road accident prediction, transformation, BPSO, PPG-RAP, environmental features.

INTRODUCTION

With the rapid development of the automobile industry, the number of cars has increased dramatically. The ratio of vehicle to traffic roads has been unbalanced due to the drastic increment in traffic volumewhich leads to repeated traffic accidents and morality [1]. So that it is mandatory for department of traffic management to take measures to assure security and safety of humans goods transportation [2–4]. A difficult system with multiple factors is called as road traffic system;these factors will be complex for managers to deal with traffic problems which because of uncertainty occurrence in road accidents which frequently results in poor management of road accidents.[5]

Accidents occur due to various kinds of factors which can be broadly classified into two groups: internal and external factors. These factors determine the reason behind the occurrence of the accident. Internal factors include driver's fault, driver under influence, distribution, etc. External factors include the environment in which the car was being driven, that is, weather conditions, poor road conditions, fog, rainfall, partial visibility etc. To develop a system that analyses all these factors and predicts these occurrences, machine learning concepts have been used. Machine Learning algorithms and models are used by a researchers to perform specific tasks without further need of instructions, making use of patterns and draws inferences. [6]The algorithms used to build mathematical model of given data which is referred as training data to classify or predict the road accident data.

Supervised Learning algorithms create a mathematical model of a training set that contains one or more inputs and a desired output. Most of the ML algorithms works based on classification and regression [7]. When the outputs are restricted with specific limit, then classification algorithms make use of it, otherwisethe regression algorithms are used. Unsupervised Learning algorithms use a data set that has only inputs and figure out a structure from such data, like grouping or clustering. These learn from test data and identify commonalities and give results based on the existence of such commodities in the piece of data. Semi-supervised learning algorithms make use of data sets in which some of the training examples are missing the desired outputs. Reinforcement Learning [8-9] is a type of machine learning that

works upon maximizing the notion of cumulative reward of the actions of software agents in an environment. This field is studied in many disciplines such as game theory, operations theory, information theory, swarm intelligence, statistics, genetic algorithms, etc., hence has a lot of generality.

LITERATURE REVIEW

Traffic accident prediction plays a very important role in traffic management and decision-making, which has attracted more and more attention in recent years.[10] In this work, a literature review is handled by using following two aspects which are machine learning based traffic accident prediction and deep learning based traffic accident prediction.

Y. Yoon et.al [11] presents a prediction of probabilistic trajectory of cut-in vehicles which exploits thedetails of interacting vehicles. Initially a probability distribution of behavioral parameters is estimated using Gaussian Process Regression (GPR), which indicates the motion of lane change characteristics.To train the lane-changing vehicles and adjacent vehicles data, Gaussian Process (GP) models are used. A path following model is also utilized to estimate the future states of the lane-change, which introduces virtual measurements based on the information of behavioral parameters. The autonomous vehicles control and motion planning is predicted with the proposed model. The autonomous vehicles predictive maneuvering against cut-in preceding vehicle is achieved by the unit called Model Predictive Control (MPC). The efficiency of proposed model has been calculated in terms of prediction accuracy.

J. Paul et.al [12] proposed methodology based on the multiclass model to analyze both of accident prediction their corresponding severity which is achieved by developing the better model to handle and avoid the road collisions.To identify the nature of the accident , there are five accident related casualties are merged. Various machine learning algorithms are used to Analyze sixty factors of five causalities. The better results are achieved using the algorithm like Decision Tree, Random Forest, Multilayer Perceptron and Categorical Naive Bayes but among these four the best outcome is achieved with Decision tree algorithm. Decision tree obtained about 99.77% accuracy for accident prediction and 99.80% for severity prediction With an F1 score of 98.68% and 99.80%.

Jie ZHANG et.al [13]presents the prediction of traffic accident duration which givesarequired basis for traffic mitigation measures after accidents. The traffic recovery time will be estimatedusing anaccident duration identification method which is related with velocity thermogram, then the vehicles will be detached from the scene after accident. The probability distribution of the accident duration can be evaluated by fitting the methods called AIC (Akaike Information Criterion) and the BIC (Bayesian Information Criterion), and from the results it is observed that the lognormal distribution is fitted best. The total duration and clearance time has been predicted with two multiple linear regression models.

H. M. Alnami et.al [14] presents traffic accident severity predictionusing real life traffic and accident data for a Florida highway. The responders and the drivers will get the benefit, when the prediction accuracy is more accurate. The pandemic will made the situation worse, when there is a high demand for responders. The random number of emergency vehicle will be dispatched by the emergency center, when the accident will happen. Many of the time these numbers will greater than the number of vehicles in various locations by eliminatingsome resources to respond to concurrent accidents. Moreover,the growth of emergency vehicles could initiatesecondary accidents, because for every ten accident one of them is a secondary accident. The author gives an accurate prediction for the number of emergency vehicles needed based on the accident severity.

K. S. Boujemaa et.al [15] proposes the first end-to-end recommendation framework for road safety. The data analysis and action recommendation tasks have been modeled using three layered architecture. Different traffic accident prediction models have been analyzed with state of the art methods like machine learning and deep learning methods. A new methodology has been developed to predict the action recommendation task, model interpretations, actions definition, and road-action interactions matrix annotation.

METHODOLOGY

The main aim of the proposed methodology is to designthe prediction Model usingPPG-RAP algorithm.In this section the proposed model has been explained and the results arecompared with the J48, Classifier models . Figure 1 showsthat theflow diagram of predictive system for road accident.

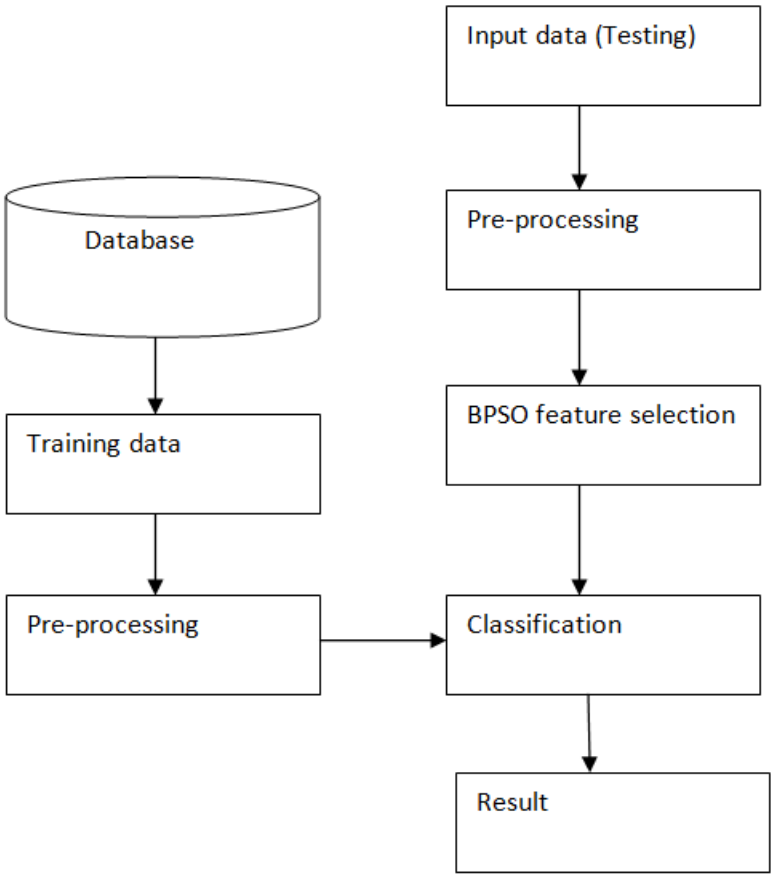

Fig 1 Block diagram of proposed method

Data Pre-Processing on Accident Predcition

Data preprocessing is an important stage for handling the data before using it in the data mining algorithms.[16] This process mainly involves the steps like data cleaning and transformation.

Selection of Data Collection While operating on prediction programs, data is the most important part. The whole project assumes a very vital role, i.e. the system depends on that information.So data collection is the first step and the crucial step that should be carried out properly.The chosen data set is based on the different factors and constraints which is taken into consideration for prediction method.[17]

Transformation of Data

After choosing the dataset, the next step is to clean the data and convert it into the desired format as the dataset we are using may be of format[18]. Features used in the dataset may be in different file formats.So the feature parameters should converted into same kind that supports the type prediction method.The reason for this step was that the data set may contain the constraints that the prediction system does not need and, including them, complicates the system and may extend the processing time.Another justification for cleaning data is that the data set may also contain null values and garbage values.So the solution to this problem is to delete the garbage values when the data is transformed. [19]

Arithmetic mean computation for filling missing values

After cleaning and transforming the data it is ready to continue processing. After the data was cleaned, necessary constraints should be taken.[20] The entire dataset split into two pieces which is in the ratio of 70-30.The Arithmetic mean is added to that part of the data that lets the algorithm learn alone and predict

future data or uncertain data.The algorithm is performed, in which taken from the cleaned data only the necessary constraints.[21]

The mean (arithmetic) is the most popular and efficient number indicator of a data set's center. Let us have x1,x2, ... For a certain attribute, such as salary, xN is a set of N values or observations. The mean of this set of values is

$$\vec{x} = \frac{\sum_{i=1}^{N} x_i}{N} \quad (1)$$

$$\vec{x} = \frac{x_1 + x_2 + \cdots + x_N}{N} \quad (2)$$

FEATURE SELECTION ON ACCIDENT PREDICTION

A selection of attributes or the important variables from the original data is defined as feature selection which selects the subset of relevant features to design the predictive model.[22-23] The attributes are ranked using information gain and gain ratio to identify the most useful features. In this work Binary particle swarm optimization (BPSO) based feature selection is utilized to select the best features from the road accident dataset.

BPSO feature selection

The binary form of particle swarm optimization is referred as a Binary particle swarm optimization (BPSO) which has been proposed to solve the binary optimization tasks [24]. BPSO is similar to PSO which uses personal best (pbest) and global best (gbest) solutions to update the position and velocity of the particles.The velocity equation for each particle solution is given by

$$v_i^d(t+1) = wv_i^d(t) + c_1 r_1 \left(pbest_i^d(t) - x_i^d(t)\right) + c_2 r_2 \left(gbest^d(t) - x_i^d(t)\right) \quad (3)$$

Where v is the velocity

x - particle solution

w - inertia weight

c_1 and c_2 are the acceleration factors

r_1 and r_2 are the two independent random nubers in [0,1]

pbest -personal best solution

gbest- global best solution

i -Order of particle in the population

d -Dimension of search space

t - Number of iterations

The maximum velocity is denoted as Vmax and the minimum velocity is denoted as Vmin [25].

Then the velocity is converted into probability value using Equation (4), and the position of particle is updated using Equation (5)

$$S(v_i^d(t+1)) = \frac{1}{1 + \exp\left(-v_i^d(t+1)\right)} \quad (4)$$

$$x_i^d(t+1) = \begin{cases} 1, & \text{if} rand < S(v_i^d(t+1)) \\ 0, & \text{Otherwise} \end{cases} \quad (5)$$

Where rand - random number which is uniformly distributed between 0 and 1.

To attain the global optimum value in BPSOpbest and gbest plays an important role. Iteratively, the pbest and gbest are defined as follows

$$pbest_i(t+1) = \begin{cases} x_i(t+1), & \text{if} F(x_i(t+1)) < F(pbest_i(t)) \\ pbest_i(t), & \text{Otherwise} \end{cases} \quad (6)$$

$$gbest(t+1) = \begin{cases} pbest_i(t+1), & \text{if} F(pbest_i(t+1)) < F(gbest(t)) \\ gbest(t), & \text{Otherwise} \end{cases} \quad (7)$$

BPSO is introduced to formulate the feature selection(FS) problem as an optimization problem. There are mainly two kind of issues has been considered to enhance the FS method. A solution representation is considered as a first issue. Since FS is a binary optimization problem, then we choose to represent the

solution with a binary vector, where the 1 values indicate that the corresponding feature is selected, otherwise it is not selected. The solution size is the number of features in each dataset. The second issue is designing the fitness function, then in addition to the number of selected features, the classification accuracy must be taken into consideration. Thus, the proposed fitness function is considered for feature selection.

CLASSIFICATION

Classification is a next module of feature selection, machine learning algorithm is used to design the predictive model to identify the accident area.Classification techniques classify data into the predefined class label. Data classification mainly involves two steps. Data learning is the first step to analyze the training data and to build the model to train the data with predefined classes.In the second phase the testing data is classified based on the training model where the accuracy of the model is estimated using test data. [26]

PPG-RAP classification Accident prediction

Initially Decision Tree is used like a conditional control statements, which performs the research operations such as decision analysis. There occurs the problem of over-fitting when trees become deep enough. It is like a tree structure, where each node represents feature on bases of which one can get the outcome. Each leaf node holds the information related to the class label.Features are used as internal nodes of the tree and class are leaf nodes.The maximum margins of hyper plane are computed using support vector machine. To evaluate the peak distance between the class labels, maximum margin hyper plane is utilized.The training features which are nearer to the highest margin hyperplane is defined as support vectors.[27]A mathematical model of SVM algorithm is explained below. Assume a training set

$$Q = \{x_i, y_i\}_{i=1}^{N}$$

With input vector

$$x_i = (xi^1, \ldots xi^n)^T \in R$$

and target labels

$$y_i \in (-1, +1)$$

according to Vapnic Formula, satisfies the following conditions

$$\begin{cases} W^T\emptyset(x_i) + b \geq +1 & \text{if} y_i = +1 \\ W^T\emptyset(x_i) + b \geq -1 & \text{if} y_i = -1 \end{cases} \quad (8)$$

Which is equivalent to

$$y_i[W^T\emptyset(x_i) + b] \geq 1 \quad \text{if} i = 1 \quad (9)$$

Where the weight vector (maximum margin) and b is the bias

Kernel function

The set of mathematical functions which are used by support vector machine is termed as kernel function.The working of kernel function is to convert the given input features into the required form. To define the decision boundaries between the class labels, kernels function in SVM is utilized. In this work RBF kernel function is used to improve the prediction accuracy.

Pseudo code of PPG-RAP algorithm

Input: Road accident features data
Output: predicted label (normal zone, accident zone)
Step 1 load the features
Step 2 Transformation of data into the standard form
Step 3 Data cleaning
Step 4 Filling Missing values with arithmetic mean using equation(2)
Step 4 Feature selection using BPSO algorithm
Velocity of each particle calculation using equ (3)
Conversion of velocity into probability using equ (4)
Position of the particle calculation using equ (5)
Pbest and gbestupdation using equ(6) and equ (7)

Step 5 begin PPG-RAP classification byinput the selected features to the internal nodes of the tree using Decsision tree (DT)
Step 6 Train the features and relevant class labels using DT method
Step 7 Define RBF kernel for SVM classifier.
Step 8 Train the features again with SVM classifier
Step 9 Simulate the test data with SVM and DT
Step 10 Calculate the majority votes of predicted labels with SVM and DT
Step 11 Identify the zone as normal or accident.

EXPERIMENTATION AND RESULT EVALUATION

In this section performance of the J48 and proposed PPG-RAP classifier is discussed for and the metrics were analyzed. Different types of metrics has been analyzed and discussed in this sectionfind out which method gives the best performance on road accident prediction. The metrics like Accuracy, precision, recall and F1-measure measures were used for comparative analysis.

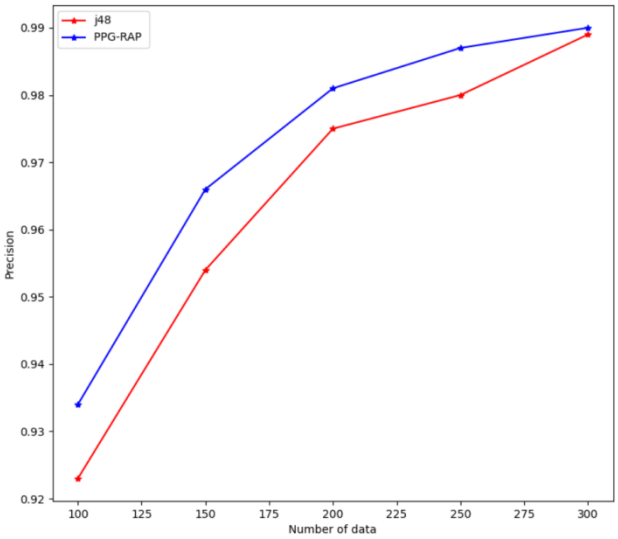

Fig 2 Precision graph comparison

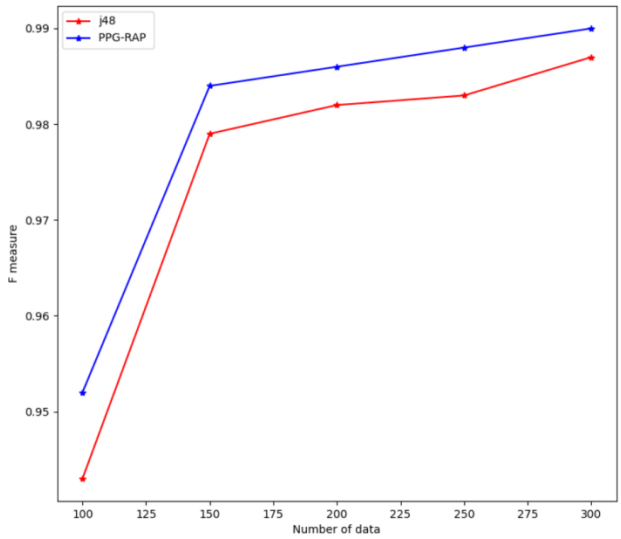

Fig 3 Fmeasure graph comparison

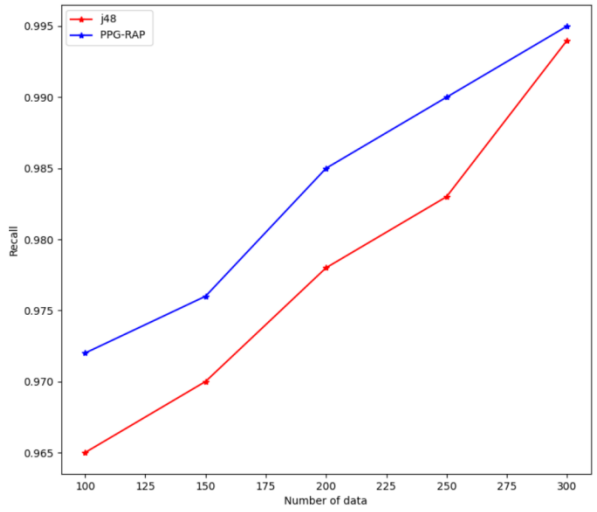

Fig 4 Recall graph comparison

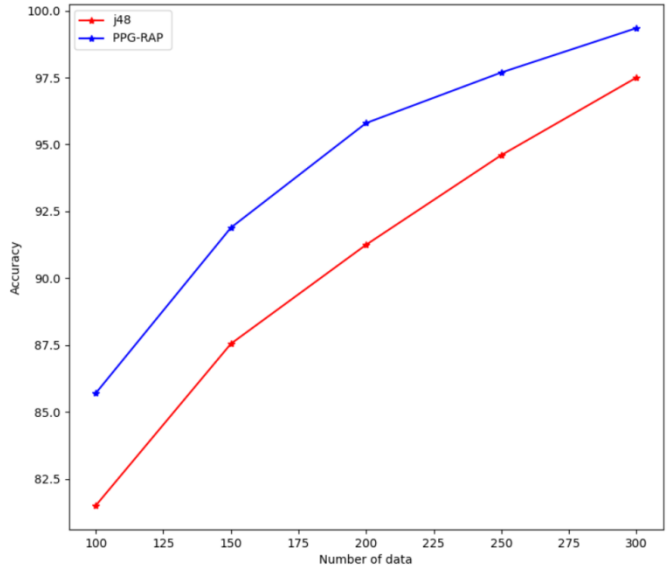

Fig 5 Accuracy graph comparison

The reliability of the output results are improved with independent testing data is achieved by using the PPG-RAP method. The proposed method is designed based on the two loops. The best feature subset and the optimal parameters are determined with inner loop. Further the efficiency of the PPG-RAP classifier is estimated using the outer loop. The group data is pre-processed and made as effective using data transformation and filling of missing values. The preprocessed data from these selected classes are split into 70:30 ratio, where 70% of the data are used for training and 30% of the data are used for testing. By utilizing BPSO feature selection, 12 features are selected among 14 features.

Table 1 Accuracy metric comparison

Number of data	100	150	200	250	300
J48[28]	81.5	87.55	91.25	94.6	97.5
PPG-RAP	85.7	91.89	95.8	97.69	99.35

Table 2 Precision metric comparison

Number of	100	150	200	250	300

data					
J48[28]	0.923	0.954	0.975	0.980	0.989
PPG-RAP	0.934	0.966	0.981	0.987	0.99

Table 3Recall metric comparison

Number of data	100	150	200	250	300
J48	0.965	0.970	0.978	0.983	0.994
PPG-RAP	0.972	0.976	0.985	0.99	0.995

Table 4F measure metric comparison

Number of data	100	150	200	250	300
J48	0.943	0.979	0.982	0.983	0.987
PPG-RAP	0.952	0.984	0.986	0.988	0.99

It has been observed that the classes which are predicted at the top level of the tree have good accuracy and the ones predicted at the lower levels have poor accuracy. In our experiment which was classified at the root node has 99.35 % accuracy.The evaluation parameters are the Precision, Recall, F measure and overall accuracy. Hence PPG-RAP performs well in classifying road accident data, compared to J48.

CONCLUSION

Road accident management is a important department which is related with the public health issue, so that it is necessary to address this problem. Data mining algorithms are found to be promising approaches in prediction of RTA severity. The machine learning based method, SVM is utilized and adopted in various domains after reaching high accuracy in that field. In this research, PPG-RAP algorithm is implemented using RBF kernel to predict road accidents. The experiment results show that PPG-RAP model with RBF has recorded the best accuracy (99.35%) and highest precision (99%). While J48 model has recordedcomparatively lowervalues of accuracy (97.5%).

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