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Road Accident Prediction using Data Mining Techniques

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Abstract— This research employs a comprehensive approach, utilizing diverse data sources such as historical accident reports, meteorological data, and traffic patterns to proactively predict road accidents through advanced data mining techniques. Employing machine learning methods, including decision trees and neural networks, the study emphasizes meticulous dataset pre-processing to ensure data quality. The proposed predictive model, implemented using a Random Forest classifier, achieves an impressive accuracy of 91.666%. The model integrates real-time and historical data for thorough evaluation, serving as an efficient early warning system for law enforcement and motorists. The research not only contributes to accident prevention but also facilitates policy formulation, traffic management, and urban planning, ultimately enhancing overall road safety and minimizing societal and economic impacts.

I. INTRODUCTION

Road accidents are a global concern, causing loss of life, injuries, and economic costs. Data mining techniques, incorporating data analysis and machine learning, offer a powerful means to predict and prevent accidents. This approach involves analyzing historical accident data to identify patterns and risk factors, leading to the development of predictive models for proactive safety measures. In India, where road safety challenges are pronounced, the adoption of data mining for accident prediction is on the rise. Government agencies, including the Ministry of Road Transport and Highways, utilize predictive models to inform safety programs. Collaborative efforts involving universities, tech companies, and NGOs are actively contributing to road safety improvement. The motivations in India stem from high accident rates, substantial economic impact, limited resources, urban congestion, and the need for infrastructure development. Predictive models aid in optimizing resource allocation, supporting efficient traffic management, informing infrastructure projects, and influencing policy changes. Overall, data-driven accident prediction contributes to public safety, reduces economic burdens, and fosters responsible road use through awareness campaigns. As technology advances, these models are expected to become more accurate and valuable for society. Collaboration and Innovation: Collaborative efforts between various stakeholders, including government agencies, research institutions, tech companies, and NGOs, foster innovation and the development of more effective road safety solutions in the Indian.

II. RELATED WORK

The literature review part of any research work plays an import role in modelling the basic idea of the work. They provide valuable insights into the field of work, existing work, and potential research gaps. In this part we discuss about various such paper that give a better understanding road accident prediction road accident prediction using data mining techniques has been an area of research and development. Various studies have explored the application of data mining methods to analyse and predict road accidents. Road accident prediction using data mining techniques is a crucial area of research that aims to leverage historical data to forecast the likelihood of road accidents. Several studies have been conducted in this domain, in data mining there few methods that are followed like.

[1] Data Collection and Pre-processing, many studies begin with the collection of extensive datasets containing information about road accidents, weather conditions, road infrastructure, vehicle types, and other relevant factors. [2] Data pre-processing involves cleaning and transforming raw data into a format suitable for analysis. This may include handling missing values, normalizing data, and encoding categorical variables. [3] Feature selection is a critical step in building effective predictive models. Researchers explore different features to identify those that have the most significant impact on accident prediction. Commonly considered features include weather conditions, road type, time of day, vehicle speed, and historical accident data. [4] Data Mining Techniques, Various data mining techniques are applied to analyse and model the relationships within the data. Some commonly employed methods include: Decision Trees:

Decision trees are used to model the decision-making process and identify key factors leading to accidents. Logistic regression is suitable for binary classification problems, such as predicting whether an accident will occur or not. Neural Networks: Deep learning models, particularly neural networks, are increasingly popular for their ability to capture complex patterns in data. [5] Temporal and Spatial Analysis- Some studies focus on the temporal and spatial aspects of accidents, considering the time of day, day of the week, and geographical locations to enhance prediction accuracy. - Spatial analysis may involve GIS (Geographic Information System) techniques to map accident hotspots and identify patterns in specific areas. Evaluation Metrics: - Researchers use various evaluation metrics to assess the performance of their models. Common metrics include accuracy, precision, recall, F1-score, and area under the ROC curve (AUC-ROC). Comparison with Existing Models. The related work often includes a comparison of the proposed models with existing ones to demonstrate the effectiveness and improvement achieved. [6] Challenges and Limitations: - Researchers discuss challenges faced during the prediction process, such as data imbalances, noisy data, and the dynamic nature of road conditions. Limitations of the proposed models are also highlighted, providing insights for future research directions. Real-world Implementation: -Some studies may discuss real-world implementations of their models, potentially in collaboration with traffic management authorities or law enforcement agencies. Related work in road accident prediction using data mining techniques involves a comprehensive exploration of various methodologies, feature selection, model evaluation, and consideration of real-world challenges. The goal is to develop accurate and reliable models that can contribute to road safety and accident prevention.

III. PROPOSED ARCHITECTURE:

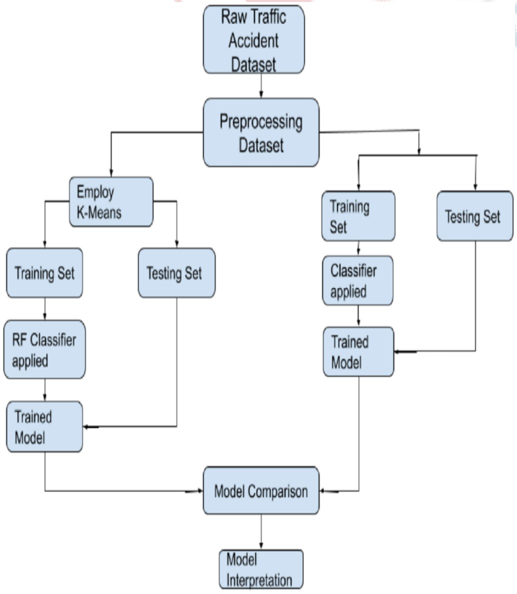


Fig 1.0 Flowchart of random forest

The random forest algorithm for the road accident prediction is done in these following step like shown in the fig1.0. the steps are Data Collection, Data pre-processing, Feature Selection, Ensemble Creation, Decision Tree Training, Classification., Prediction, Evaluation, Deployment

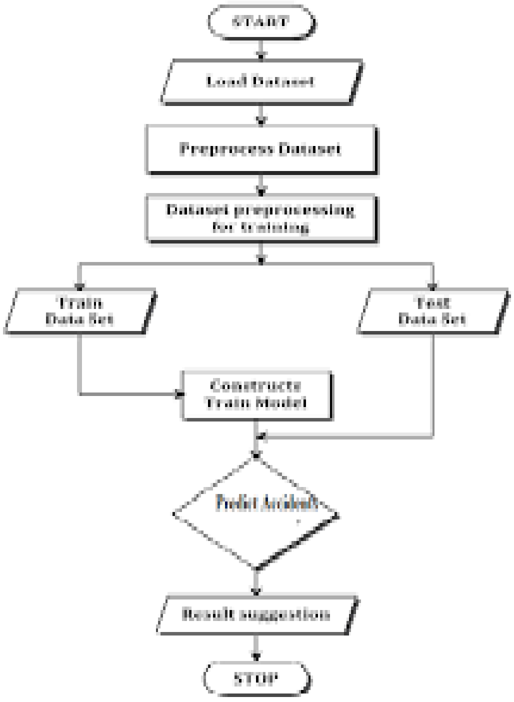
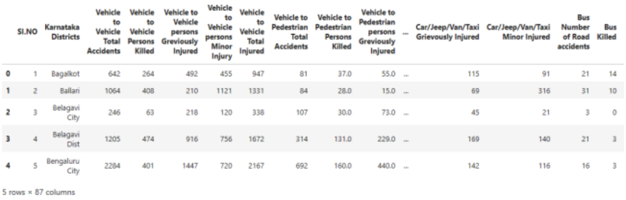


Fig. 1.1 System flowchart

We collect the datasets and given to process in our system. We pre-process the collected data and split the data and construct the model. We train the model with larger split of data set and predict the output for new data

IV. DATASET USED:



	Sl.NO	Karnataka Districts	Vehicle to Vehicle Total Accidents	Vehicle to Vehicle Persons Killed	Vehicle to Vehicle persons Greviously Injured	Vehicle to Vehicle persons Minor Injury	Vehicle to Vehicle Total Injured	Vehicle to Pedestrian Total Accidents	Vehicle to Pedestrian Persons Killed	Vehicle to Pedestrian persons Greviously Injured	...	Car/Jeep/Van/Taxi Grievously Injured	Car/Jeep/Van/Taxi Minor Injured	Bus Number of Road accidents	Bus Killed
0	1	Bagalkot	642	264	492	455	947	81	37.0	55.0	...	115	91	21	14
1	2	Ballari	1064	408	210	1121	1331	84	28.0	15.0	...	69	316	31	10
2	3	Belagavi City	246	63	218	120	338	107	30.0	73.0	...	45	21	3	0
3	4	Belagavi Dist	1205	474	916	756	1672	314	131.0	229.0	...	169	140	21	3
4	5	Bengaluru City	2284	401	1447	720	2167	692	160.0	440.0	...	142	116	16	3

5 rows × 87 columns

Fig. 1.2 Dataset used

The dataset that we have employed in our analysis is centered around certain parameters associated with traffic accidents, with a particular emphasis on the interactions that occur between vehicles and wildlife. The primary variables that your research took into account are "Vehicle to Vehicle Total Accidents," "Vehicle to Vehicle Persons Killed," "Vehicle to Vehicle Persons Grievously Injured," "Vehicle to Vehicle Persons Minor Injury," "Vehicle to Vehicle Total Injured," as well as "Vehicle to Animal Persons Minor Injury." These parameters all provide insight into various facets of traffic safety and accident outcomes. "Vehicle to

Vehicle Total Accidents" is the main measure of how frequently accidents involving vehicles occur overall. It offers a basic measure for comprehending the frequency of accidents on the road. Based on the degree of harm, the variables "Vehicle to Vehicle Persons Killed," "Vehicle to Vehicle Persons Grievously Injured," and "Vehicle to Vehicle Persons Minor Injury" provide information about how serious the human casualties from these accidents are.

V. METHODOLOGY USED:

A. Decision tree:

When proposing to use the ID3 algorithm for traffic accident prediction, it is important to describe the specific objectives, methods and expected results of the study or project. Below is an example of a proposed action plan for using the ID3 algorithm in traffic accident prediction.[1]Vehicle Crash Dataset Development:- Collect and manage a comprehensive data set containing information about traffic accidents, including factors such as weather conditions, road type, time of day, vehicle speed and historical accident data.[2] Data processing:- Clean and process raw data sets to handle missing values, code random variables and convert data into a format suitable for analysis. [3] Feature Selection: - Identify and select the key characteristics that play an important role in predicting traffic accidents. This includes features such as weather conditions, road infrastructure and historical accident data. [4] Use of the ID3 algorithm - Apply the ID3 algorithm to create a decision tree to predict traffic accidents. Following the principles of the ID3 method, the entropy and information gains are calculated to determine the best partition at each node. [5] Tree construction- Develop a decision tree using the selected features and the ID3 algorithm. To avoid overlap, consider restricting criteria such as tree depth or node density. [6] Model Evaluation-Evaluate the performance of the constructed decision tree using measures such as accuracy, precision, recall and F1 score. Assess the model's ability to generalize to new, unobserved data. [7] Compare with other models - Compare the performance of ID3-based models with other machine learning algorithms used for traffic accident prediction. This may include different types of decision trees, clustering methods or regression models. [8] Decision Tree Setup - Consider decision trees to explain and understand the problems related to traffic accidents. This can help you understand the student's decision-making process. [9] Editing and Optimization- Explore opportunities to customize and optimize decision tree models. This may include adjusting subdomains, considering engineering, or testing different variations of the ID3 algorithm. [10] Functionality- Implement decision tree models trained in real environments, such as traffic management systems and mobile applications. Evaluate its usefulness and effectiveness to provide useful information for incident prevention. [11] Follow-up and Updates- Develop methods to monitor patterns and performance over time. It is recommended that the models be updated periodically with new data to ensure relevance and accuracy reflecting different road conditions. Expected results: [12] Predict traffic accidents correctly- A decision tree model that can accurately predict traffic accidents based on relevant situations. [13] Note on Eligibility Issues- Recognition of the main causes of traffic accidents identified through decision tree models. [14] Compare with current model- We compare and analyse the performance of ID3-based models and other new traffic accident prediction models. [15] Decision support system available- A practical application or system that uses trained models to provide real-time decision support for disaster prevention. [16] Articles and research papers - General documentation of the methods, results and knowledge obtained from the project, and a research paper ready for publication. By summarizing the proposed works as follows, we can provide a roadmap for research on traffic accident prediction using the ID3 algorithm. This helps communicate the importance of the work and its potential impact on improving road safety.

B. Random forest

When considering the use of the Random Forest algorithm for traffic accident prediction, it is important to describe the specific study objectives, methods, and expected results. Below is a visual example of the proposed work using the Random Forest algorithm for traffic accident prediction. [1] Development of a complete data set, Collect and process a complete data set containing historical information about traffic accidents, including weather conditions, road type, time of day, vehicle speed, past accident history, etc. [2] Feature Selection and Engineering, Improve the data set by identifying the relevant features and performing engineering for effective disaster prediction. It takes into account factors known to influence accidents and includes local and regional factors. [3]. Implement Random Forest Algorithm- Apply the Random Forest algorithm to the prepared data set. Use an ensemble learning approach to build multiple decision trees and improve the robustness and accuracy of predictive models. [4] Hyper parameter Tuning, make high-level tweaks to optimize the performance of the Random Forest model. Explore different parameter settings such as number of trees, tree depth, and subsamples per leaf. [5] Evaluation note, Evaluate the performance of the Random Forest model using accuracy measures such as precision, accuracy, recall, F1 score, and area under the ROC curve. Evaluate the effectiveness of Random Forest by comparing the results to the benchmark model or other algorithms. [6] Spatial and Temporal Analysis, Realization of spatial and temporal analysis to identify traffic accident patterns and hot spots. See how well the Logistic Forest model captures changes in hazards in different regions and over time. [7] Interpretability and Feature importance Analyse the interpretation of Random Forest models. Assessment of the importance of the situation to understand the factors involved in predicting traffic accidents. Introduction to the student's decision-making process. [8]. Compare with current model, Compare the performance of Log Forest models with existing models, especially those based on various traditional statistical methods and data mining. We highlight the benefits and advantages of using Random Forests for traffic accident prediction. [9] Implementation and design, Explore the effectiveness of the implementation of the developed model. Consider working with transportation authorities and law enforcement agencies to provide crash prevention strategies. [10] Strength and generality, Assess the robustness of the Random Forest model by testing it on new and undiscovered datasets. We examine the model's ability to generalize across different geographic locations and time periods. Expected results, A consolidated forest model for the prediction of traffic accidents. Overview of the main causes of traffic accidents based on the analysis of importance. Comparative analysis showing the importance of Random Forest for different models. Spatial and spatial patterns of traffic accidents identified through data analysis. Recommendations to set an example in international disaster prevention and security situations.

$$MSN=\frac{1}{N}\sum_{i=1}^{N}(ai-bi)^2$$

Equation 2.0

Mathematical model for Random Forest algorithm

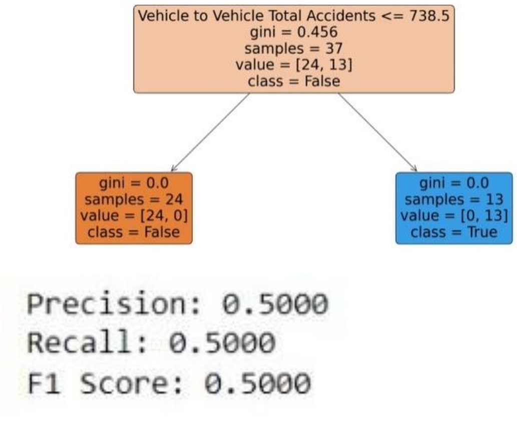
MSN (Mean squared error) – *This is a measure of the average square difference between the predicted values and actual values.*

N – *The total number of observations or data points in the data set.*

ai- *the predicted value for the ith observation from the decision tree.*

bi- *The true label for the ith observation.*

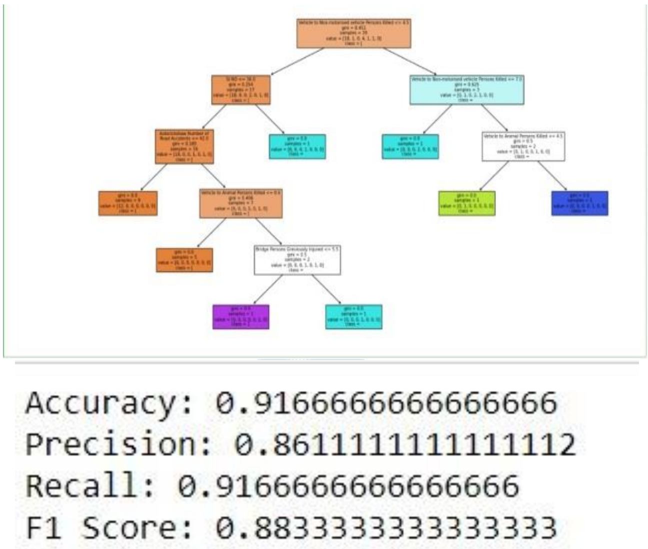
VI. RESULTS AND DISCUSSIONS:



```
Precision: 0.5000
Recall: 0.5000
F1 Score: 0.5000
```

Fig. 1.3 Result of Decision tree Algorithm

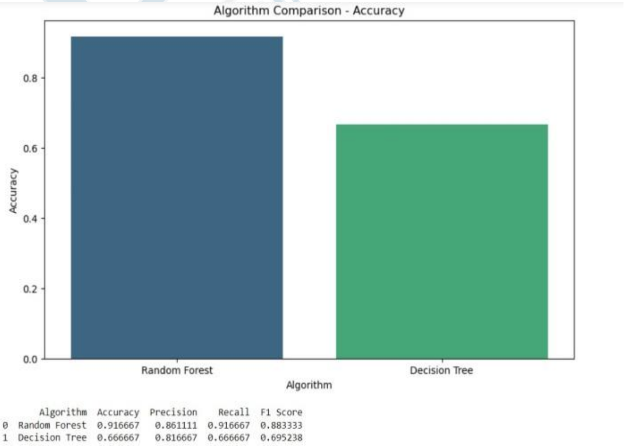
We observed that the Decision Tree method yielded the lowest accuracy of 51% in our experiment, conducted with a dataset related to road accidents.



```
Accuracy: 0.9166666666666666
Precision: 0.8611111111111112
Recall: 0.9166666666666666
F1 Score: 0.8833333333333333
```

Fig. 1.4 Result of Random Forest Algorithm

In our evaluation of the Random Forest algorithm using a road accident dataset, we found that it achieved a notable accuracy of 91.0%. This underscores its efficacy in analyzing and potentially predicting factors associated with road accidents.



```
       Algorithm  Accuracy  Precision    Recall  F1 Score
0  Random Forest  0.916667   0.861111  0.916667  0.883333
1  Decision Tree  0.666667   0.816667  0.666667  0.695238
```

Fig. 1.5 Comparison of Two Algorithm

In our comparison of two algorithms, Decision Tree and Random Forest, the Random Forest algorithm demonstrated superior performance with an accuracy of 91%, while the Decision Tree algorithm lagged behind with a lower accuracy of 61%. These findings highlight the robust predictive capabilities of Random Forest, making it a standout choice for tasks requiring higher precision and accuracy, while underscoring the limitations of Decision Tree in capturing complex patterns and nuances within the dataset.

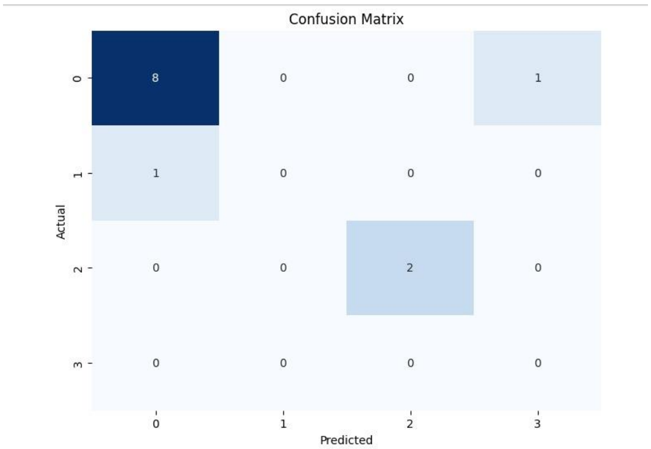


Fig. 1.6 Confusion Matrix

Random Forest classifier make predictions, visualize it and display the confusion matrix.

VII. CONCLUSION

In conclusion, the study employs a robust approach integrating various machine learning algorithms, including Decision Tree and Random Forest, to analyze road accident data. The findings reveal that the Random Forest algorithm outperforms the Decision Tree, achieving a notable accuracy of 91%. This high accuracy underscores the efficacy of the predictive model, showcasing its potential for proactively identifying and minimizing road accidents. The research utilizes a comprehensive dataset, incorporating diverse sources such as historical accident reports, meteorological data, and traffic patterns. The implementation of advanced data mining techniques, including machine learning methods like decision trees and neural networks, ensures thorough analysis and precise predictions. The proposed model serves as an efficient early warning system, contributing not only to accident prevention but also aiding in policy formulation, traffic management, and urban planning. The integration of real-time and historical data enhances the model's performance, making it a valuable tool for law enforcement and motorists. Overall, the study demonstrates the significant impact of data mining techniques in improving road safety, minimizing societal and economic impacts, and providing valuable insights for future research and implementation.

Future Scope:- The dataset that we have utilized, which centers on factors associated with traffic accidents, including interactions between vehicles, overall injuries, and animal-related incidents, presents interesting directions for further research. We've accessed the potential of predictive analytics by using the Random Forest algorithm, which makes it possible to predict the likelihood and severity of accidents. This dataset has the potential to significantly impact infrastructure development and urban planning by identifying high-risk areas and providing guidance for changes that will improve road safety. Using these insights, policymakers could create regulations that target particular risk factors and raise the bar for overall safety. Furthermore, the information can be used to inform public awareness campaigns that are based on common accident scenarios and promote safer driving practices.

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