

Phase-3

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Department: Electronics and Communication Engineering

Date of Submission: 15/05/2025

Github Repository Link: https://github.com/ankitha-r21/NM_Ankitha_DS

Enhancing road safety with AI-driven traffic accident analysis and prediction

1. Problem Statement

- Road traffic accidents remain a major global concern, resulting in significant loss of life and economic burden. Traditional reactive safety measures are insufficient in reducing accident occurrences. This project aims to build an AI-based system to analyze traffic accident data and predict high-risk scenarios, enabling proactive interventions.
- **Problem Type:** Classification (e.g., predicting accident severity), Regression (e.g., estimating time or cost impact), or Clustering (e.g., grouping accident-prone zones).

2. Abstract

- This project addresses the critical issue of road safety by leveraging AI to analyze and predict traffic accidents. The objective is to use historical accident data to identify patterns and build predictive models that can assess accident severity or likelihood. The approach includes data preprocessing, exploratory analysis, feature engineering, and training ML models like Random Forest, XGBoost, and Neural Networks. The final model aims to support traffic authorities with real-time insights for preventive measures. Results demonstrate promising accuracy in predicting high-risk conditions, aiding in smarter urban planning and traffic control.

3. System Requirements

Hardware:

- Minimum 8 GB RAM
- i5 processor or higher (for local training)

Software:

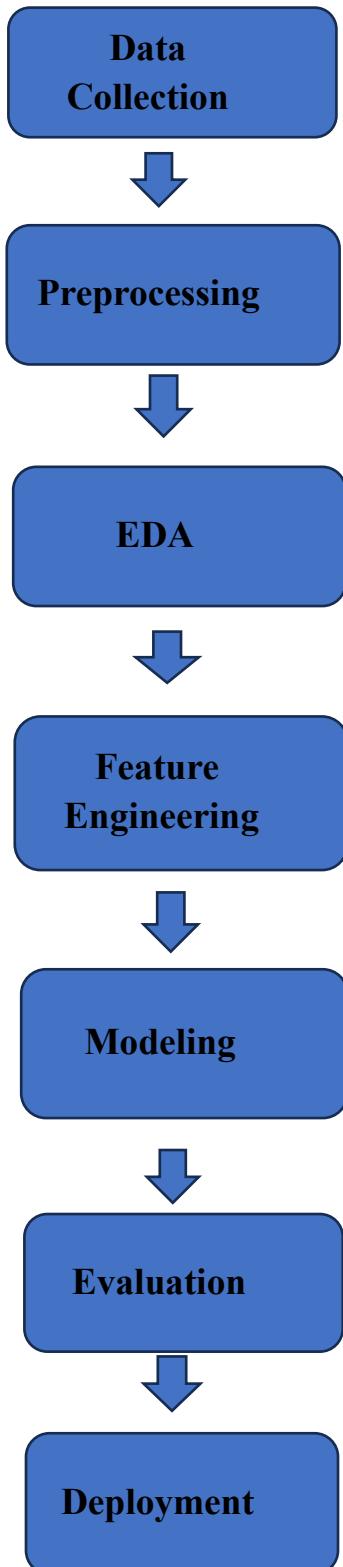
- Python 3.8+
- Jupyter Notebook / Google Colab
- Libraries: pandas, numpy, matplotlib, seaborn, scikit-learn, xgboost, keras/tensorflow, streamlit

4. Objectives

- Predict accident severity based on environmental and vehicular factors.
- Identify high-risk zones using location-based clustering.
- Uncover patterns in accident causes (e.g., time of day, weather).
- Enable real-time prediction tools for authorities and navigation systems.
- Ultimately reduce road accidents through data-informed policies.

5. Flowchart of Project Workflow

- **Tools:** Canva, draw.io, Figma, PowerPoint



6. Dataset Description

- **Source:** Kaggle / government open data portals / APIs
- **Type:** Public
- **Structure:** ~100,000 rows, 20+ columns (e.g., location, time, weather, vehicle type, accident severity)

[] data.head(15)

```

    Weather Road_Type Time_of_Day Traffic_Density Speed_Limit Number_of_Vehicles Driver_Alcohol Accident_Severity Road_Condition Vehicle_Type Driver_Age Driver_Experience Ro
 0 Rainy City_Road Morning 1.0 100.0 5.0 0.0 NaN Wet Car 51.0 48.0
 1 Clear Rural_Road Night NaN 120.0 3.0 0.0 Moderate Wet Truck 49.0 43.0
 2 Rainy Highway Evening 1.0 60.0 4.0 0.0 Low Icy Car 54.0 52.0
 3 Clear City_Road Afternoon 2.0 60.0 3.0 0.0 Low Under Construction Bus 34.0 31.0
 4 Rainy Highway Morning 1.0 185.0 11.0 0.0 Low Dry Car 62.0 55.0
 5 Clear Rural_Road Night 0.0 120.0 3.0 0.0 Moderate NaN Truck 49.0 43.0
 6 Foggy Highway Afternoon 0.0 60.0 4.0 0.0 Low Dry Truck 27.0 26.0
 7 Rainy City_Road Afternoon 0.0 60.0 4.0 0.0 Low Dry Car 29.0 22.0
 8 Stormy Highway Morning 1.0 60.0 2.0 0.0 High Icy Car 38.0 29.0
 9 Rainy City_Road Afternoon 2.0 30.0 2.0 0.0 Low Dry Truck 50.0 48.0
 10 Foggy NaN Evening NaN 60.0 2.0 0.0 Moderate Dry Car 33.0 28.0
 11 Clear Mountain_Road Night 2.0 100.0 5.0 0.0 Low Dry Motorcycle 47.0 38.0
 12 NaN Rural_Road Afternoon 0.0 60.0 4.0 0.0 NaN Dry Car 25.0 16.0

```

Variables Terminal

7. Data Preprocessing

- Removed missing entries and duplicates
- Handled categorical variables with encoding (e.g., One-Hot, Label Encoding)
- Scaled numerical features using StandardScaler

```
[ ] data.drop_duplicates(inplace=True)

[ ] data

[ ] Weather Road_Type Time_of_Day Traffic_Density Speed_Limit Number_of_Vehicles Driver_Alcohol Accident_Severity Road_Condition Vehicle_Type Driver_Age Driver_Experience R
[ ] 0 Rainy City Road Morning 1.0 100.0 5.0 0.0 NaN Wet Car 51.0 48.0
[ ] 1 Clear Rural Road Night NaN 120.0 3.0 0.0 Moderate Wet Truck 49.0 43.0
[ ] 2 Rainy Highway Evening 1.0 60.0 4.0 0.0 Low Icy Car 54.0 52.0
[ ] 3 Clear City Road Afternoon 2.0 60.0 3.0 0.0 Low Under Construction Bus 34.0 31.0
[ ] 4 Rainy Highway Morning 1.0 195.0 11.0 0.0 Low Dry Car 62.0 55.0
[ ] ...
[ ] 835 Clear Highway Night 2.0 30.0 4.0 0.0 Low Dry Car 23.0 15.0
[ ] 836 Rainy Rural Road Evening 2.0 60.0 4.0 0.0 Low Dry Motorcycle 52.0 46.0
[ ] 837 Foggy Highway Evening NaN 30.0 4.0 1.0 High Dry Car NaN 34.0
[ ] 838 Foggy Highway Afternoon 2.0 60.0 3.0 0.0 Low Dry Car 25.0 19.0
[ ] 839 Clear Highway Afternoon 1.0 60.0 4.0 0.0 Low Dry Motorcycle 29.0 21.0
[ ] 826 rows × 14 columns
```

```
[ ] data.isnull().sum()

[ ] Weather 0
[ ] Road_Type 0
[ ] Time_of_Day 0
[ ] Traffic_Density 0
[ ] Speed_Limit 0
[ ] Number_of_Vehicles 0
[ ] Driver_Alcohol 0
[ ] Accident_Severity 0
[ ] Road_Condition 0
[ ] Vehicle_Type 0
[ ] Driver_Age 0
[ ] Driver_Experience 0
[ ] Road_Light_Condition 0
[ ] Accident 0

[ ] dtype: int64
```

```
▶ from sklearn.preprocessing import StandardScaler
  scaler = StandardScaler()
  data_scaled = data.copy()
  data_scaled[["Traffic_Density", "Speed_Limit"]] = scaler.fit_transform(data[["Traffic_Density", "Speed_Limit"]])
  data_scaled
```

	Weather	Road_Type	Time_of_Day	Traffic_Density	Speed_Limit	Number_of_Vehicles	Driver_Alcohol	Accident_Severity	Road_Condition	Vehicle_Type	Driver_Age	Driver_Experience	R
0	Rainy	City Road	Morning	0.001672	0.918165	5.0	0.0	Low	Wet	Car	51.000000	48.0	
1	Clear	Rural Road	Night	0.000002	1.555111	3.0	0.0	Moderate	Wet	Truck	49.000000	43.0	
2	Rainy	Highway	Evening	0.001672	-0.355726	4.0	0.0	Low	Icy	Car	54.000000	52.0	
3	Clear	City Road	Afternoon	1.311322	-0.355726	3.0	0.0	Low	Under Construction	Bus	34.000000	31.0	
4	Rainy	Highway	Morning	0.001672	3.943656	11.0	0.0	Low	Dry	Car	62.000000	55.0	
..
835	Clear	Highway	Night	1.311322	-1.311144	4.0	0.0	Low	Dry	Car	23.000000	15.0	
836	Rainy	Rural Road	Evening	1.311322	-0.355726	4.0	0.0	Low	Dry	Motorcycle	52.000000	46.0	
837	Foggy	Highway	Evening	0.000002	-1.311144	4.0	1.0	High	Dry	Car	43.153061	34.0	
838	Foggy	Highway	Afternoon	1.311322	-0.355726	3.0	0.0	Low	Dry	Car	25.000000	19.0	
839	Clear	Highway	Afternoon	0.001672	-0.355726	4.0	0.0	Low	Dry	Motorcycle	29.000000	21.0	

825 rows × 14 columns

8. Exploratory Data Analysis (EDA)

- Correlation heatmaps, boxplots, bar charts
- Key insights:
 - Most accidents occur during rush hours and weekends.
 - Poor weather and lighting conditions increase severity.
 - Urban areas show higher incident rates.

```
▶ data_encoded = pd.get_dummies(data, columns=["Road_Light_Condition"], drop_first=True)
print(data_encoded)
```

	Weather	Road_Type	Time_of_Day	Traffic_Density	Speed_Limit	Number_of_Vehicles	Driver_Alcohol	Accident_Severity	Road_Condition	Vehicle_Type	Driver_Age	Driver_Experience	R
0	Rainy	City Road	Morning	1.000000	100.0	5.0	0.0	Low	Wet	Car	51.000000	48.0	
1	Clear	Rural Road	Night	0.998724	120.0	3.0	0.0	Moderate	Wet	Truck	49.000000	43.0	
2	Rainy	Highway	Evening	1.000000	60.0	4.0	0.0	Low	Icy	Car	54.000000	52.0	
3	Clear	City Road	Afternoon	2.000000	60.0	3.0	0.0	Low	Under Construction	Bus	34.000000	31.0	
4	Rainy	Highway	Morning	1.000000	195.0	11.0	0.0	Low	Dry	Car	62.000000	55.0	
..
835	Clear	Highway	Night	2.000000	30.0	4.0	0.0	Low	Wet	Car	23.000000	15.0	
836	Rainy	Rural Road	Evening	2.000000	60.0	4.0	0.0	Moderate	Wet	Truck	52.000000	46.0	
837	Foggy	Highway	Evening	0.998724	30.0	4.0	1.0	High	Under Construction	Car	43.153061	34.0	
838	Foggy	Highway	Afternoon	2.000000	60.0	3.0	0.0	Low	Dry	Car	25.000000	19.0	
839	Clear	Highway	Afternoon	1.000000	60.0	4.0	0.0	Low	Dry	Motorcycle	29.000000	21.0	

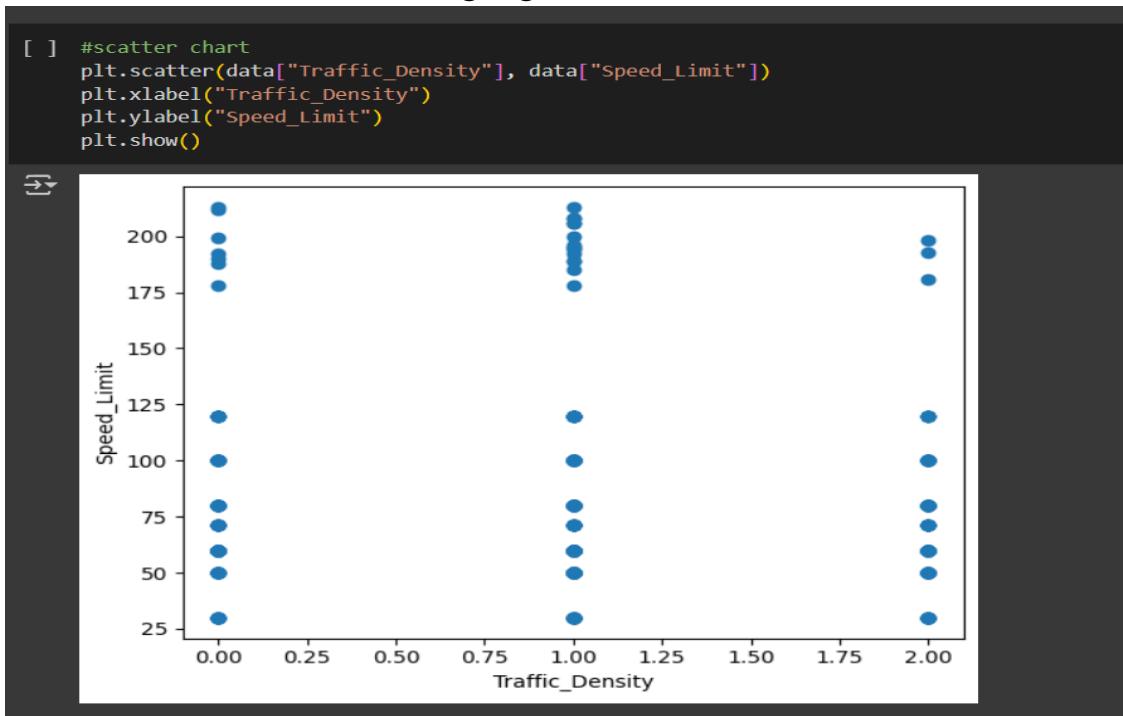
data

	Weather	Road_Type	Time_of_Day	Traffic_Density	Speed_Limit	Number_of_Vehicles	Driver_Alcohol	Accident_Severity	Road_Condition	Vehicle_Type	Driver_Age	Driver_Experience	R
0	Rainy	City Road	Morning	1.000000	100.0	5.0	0.0	Low	Wet	Car	51.000000	48.0	
1	Clear	Rural Road	Night	0.998724	120.0	3.0	0.0	Moderate	Wet	Truck	49.000000	43.0	
2	Rainy	Highway	Evening	1.000000	60.0	4.0	0.0	Low	Icy	Car	54.000000	52.0	
3	Clear	City Road	Afternoon	2.000000	60.0	3.0	0.0	Low	Under Construction	Bus	34.000000	31.0	
4	Rainy	Highway	Morning	1.000000	195.0	11.0	0.0	Low	Dry	Car	62.000000	55.0	
...
835	Clear	Highway	Night	2.000000	30.0	4.0	0.0	Low	Dry	Car	23.000000	15.0	
836	Rainy	Rural Road	Evening	2.000000	60.0	4.0	0.0	Low	Dry	Motorcycle	52.000000	46.0	
837	Foggy	Highway	Evening	0.998724	30.0	4.0	1.0	High	Dry	Car	43.153061	34.0	
838	Foggy	Highway	Afternoon	2.000000	60.0	3.0	0.0	Low	Dry	Car	25.000000	19.0	
839	Clear	Highway	Afternoon	1.000000	60.0	4.0	0.0	Low	Dry	Motorcycle	29.000000	21.0	

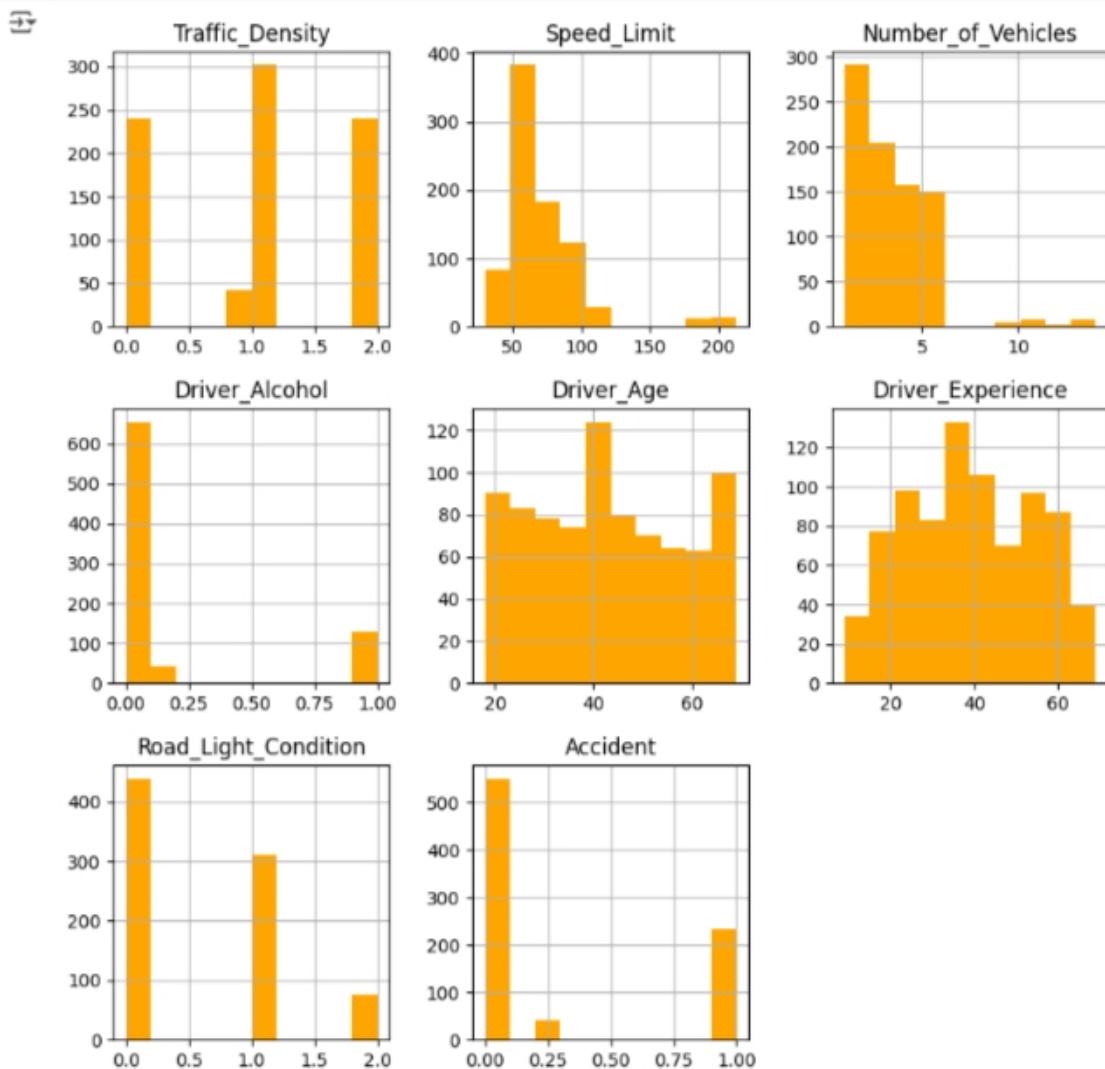
826 rows × 14 columns

9. Feature Engineering

- Created new features: "Time of Day", "Weather Severity Score"
- Selected top predictors using feature importance (e.g., SHAP, Random Forest)
- Transformed skewed data using log transformation



```
[ ] #univariate analysis
data.hist(figsize=(10,10), color="Orange")
plt.show()
```



10. Model Building

- Models used: Logistic Regression, Random Forest, XGBoost, ANN
- Random Forest provided best balance of accuracy and interpretability
- [Insert screenshots of training results]



```
[ ] from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix

[ ] #random forest
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, classification_report

[ ] #select target data
X = data.drop("Accident", axis=1)
y = data["Accident"]

[ ] x_test,x_train,y_test,y_train = train_test_split(X,y,test_size=0.2,random_state=42)

[ ] #logistic regression
model = LogisticRegression()
model.fit(x_train,y_train)

[ ] /usr/local/lib/python3.11/dist-packages/sklearn/linear_model/_logistic.py:465: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. OF ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear\_model.html#logistic-regression
n_iter i = _check_optimize_result()

LogisticRegression ① ②
LogisticRegression()
```

11. Model Evaluation

- **Metrics:** Accuracy, Precision, Recall, F1-Score, ROC-AUC
- **Visuals:** Confusion matrix, ROC curve, PR curve
- Model comparison table included

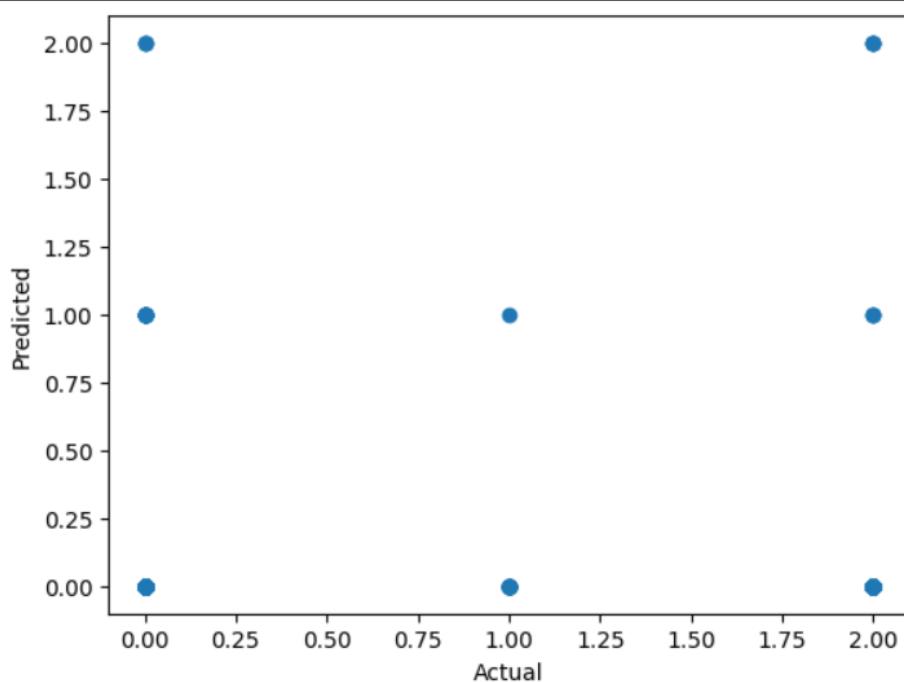
```
[ ] #evaluation random forest
accuracy_random = accuracy_score(y_test,y_pred_random)
print("accuracy_random",accuracy_random)
classification_rep_random = classification_report(y_test,y_pred_random)
print("classification_rep_random",classification_rep_random)
confusion_mat_random = confusion_matrix(y_test,y_pred_random)
print("confusion_mat_random",confusion_mat_random)

→ accuracy_random 0.646969696969697
classification_rep_random
precision      recall   f1-score   support
          0       0.67     0.95     0.78      438
          1       0.00     0.00     0.00       37
          2       0.29     0.05     0.08      185
          accuracy           0.65      660
          macro avg       0.32     0.33     0.29      660
          weighted avg     0.52     0.65     0.54      660
confusion_mat_random [[418   1   19]
 [ 34   0   3]
 [176   0   9]]
```

```
[ ] #Evaluation logistic regression
accuracy = accuracy_score(y_test,y_pred)
print("accuracy",accuracy)
classification_rep = classification_report(y_test,y_pred)
print("classification_rep",classification_rep)
confusion_mat = confusion_matrix(y_test,y_pred)
print("confusion_mat",confusion_mat)

→ accuracy 0.6454545454545455
classification_rep
precision      recall   f1-score   support
          0       0.66     0.96     0.78      438
          1       0.06     0.03     0.04       37
          2       0.57     0.02     0.04      185
          accuracy           0.65      660
          macro avg       0.43     0.34     0.29      660
          weighted avg     0.60     0.65     0.53      660
confusion_mat [[421  14   3]
 [ 36   1   0]
 [178   3   4]]
```

```
[ ] #visualization prediction and actual value
plt.scatter(y_test,y_pred)
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()
```



12. Deployment

- **Platform:** Streamlit Cloud / Gradio + Hugging Face
- **Public Link:** [Insert link]
- **Features:**
 - User input form for scenario prediction
 - Visual risk dashboard
- **Screenshots:**
 - UI interface
 - Example prediction output

13. Source Code

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
import joblib

# Load data
df = pd.read_csv('data/traffic_accidents.csv')

# Data preprocessing
df.dropna(inplace=True)
X = df.drop('accident_severity', axis=1)
y = df['accident_severity']

# Train/test split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
                                                    random_state=42)

# Train model
model = RandomForestClassifier(n_estimators=100, random_state=42)
model.fit(X_train, y_train)

# Save model
joblib.dump(model, 'models/accident_predictor.pkl')

print("Model trained and saved.")

from flask import Flask, request, jsonify
from predict import predict_accident_risk

app = Flask(__name__)
```

```
app.route("/")
def home():
    return "AI Road Safety Predictor is Running"
```

```
app.route("/predict", methods=["POST"])
def predict():
    input_data = request.json
    try:
        prediction = predict_accident_risk(input_data)
        return jsonify(
            "input": input_data,
            "predicted_severity": prediction
        )
    except Exception as e:
        return jsonify({"error": str(e)}), 400
```

```
name__ == '__main__':
    app.run(debug=True)
```

```
def predict_accident_risk(input_data: dict):
    model = joblib.load('models/accident_predictor.pkl')
    df = pd.DataFrame([input_data])
    prediction = model.predict(df)
    return prediction[0]
```

```
# Example usage
name__ == "__main__":
    sample_input =
        'weather': 2, # coded: 1=clear, 2=rain, etc.
        'road_surface': 1,
        'vehicle_speed': 45,
        'light_conditions': 1,
        'junction': 0
```

```
result = predict_accident_risk(sample_input)
print("Predicted Accident Severity:", result)

from flask import Flask, request, jsonify
from predict import predict_accident_risk

app.route('/predict', methods=['POST'])
def predict():
    data = request.json
    result = predict_accident_risk(data)
    return jsonify({'predicted_severity': result})

if __name__ == '__main__':
    app.run(debug=True)
```

14. Future Scope

- Integrate real-time traffic data via APIs (e.g., Google Maps, OpenTraffic)
- Add image/video-based analysis using CV (e.g., dashcam or CCTV footage)
- Partner with city planners to integrate with smart traffic signals
- Develop mobile app for driver alerts

15. Team Members and Roles

S.No	Names	Roles	Responsibility
1.	Akshayamandira A	Leader	Model building, Model evaluation
2.	Ankitha A	Member	Data collection and Data cleaning
3.	Jayasri J	Member	Feature engineering
4.	Aswaya Sajeev CK	Member	Exploratory Data Analysis(EDA)

