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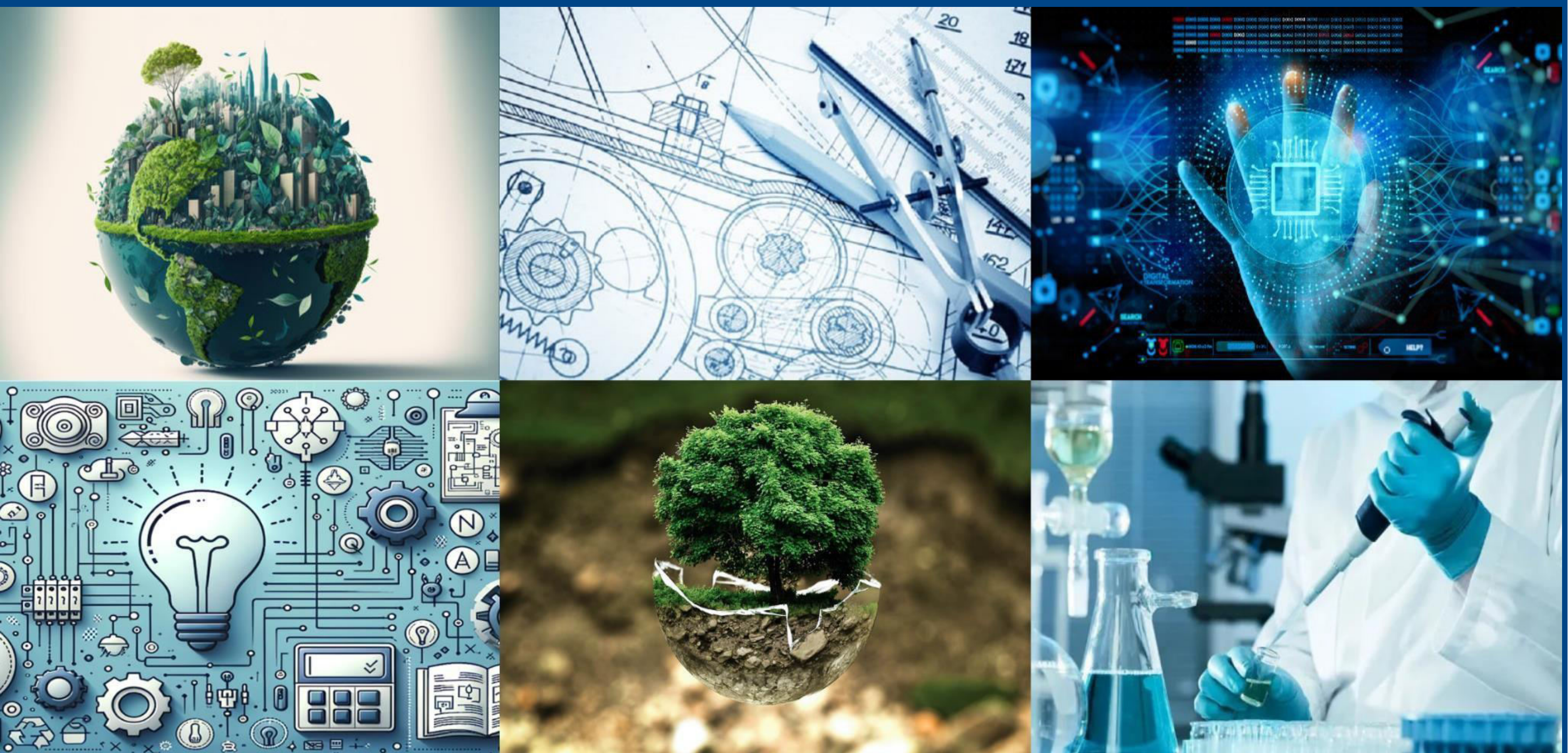

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Predicting Passenger Survival in Maritime Disaster using Machine Learning

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ABSTRACT: Maritime disasters pose severe risks to human life, often resulting in high casualty rates due to unpredictable environmental conditions, inadequate safety measures, and delayed emergency responses. Traditional methods for assessing survival chances rely on historical assumptions and lack the ability to dynamically analyze complex, interrelated factors such as passenger demographics, ship conditions, and safety infrastructure. This project aims to develop a data-driven predictive framework capable of learning patterns from historical maritime data to forecast survival probabilities. By leveraging machine learning (ML) techniques, the system seeks to identify key factors influencing survival and accurately estimate the likelihood of a passenger surviving an incident. The resulting system can support maritime authorities in optimizing safety protocols, improving evacuation planning, and enhancing overall disaster preparedness.

KEYWORDS: Machine Learning, Maritime Disaster, Passenger Survival, Classification Algorithms, Disaster Preparedness.

I. INTRODUCTION

Industrial safety, as seen in the context of the PPE detection paper, relies on strict compliance, and similarly, maritime safety demands efficient, real-time risk assessment. Maritime disasters frequently lead to high casualty rates. Current methods for survival assessment are often based on historical assumptions and cannot dynamically analyze complex, interrelated factors like passenger demographics, ship conditions, and safety infrastructure.

There is a pressing need for a data-driven predictive system that can accurately estimate the likelihood of passenger survival during such incidents. This project proposes to leverage machine learning to develop a predictive framework that learns survival patterns from historical maritime data. Such a system can provide critical support to maritime authorities by improving safety protocols and enhancing evacuation and disaster preparedness planning.

A. Objectives

The primary objectives of this work are:
To collect and preprocess historical maritime disaster data, including passenger details (e.g., age, gender, class, safety equipment access).
To identify and analyze key factors that significantly influence passenger survival rates during maritime accidents.
To design and develop a machine learning model to predict the likelihood of passenger survival based on real or historical data.
To evaluate and compare multiple classification algorithms (e.g., Random Forest, Decision Tree, Logistic Regression) to select the most accurate and reliable model.
To provide data-driven insights to assist maritime authorities in improving safety measures, evacuation planning, and training protocols.

II. PROBLEM MOTIVATION

Maritime disasters are complex events with numerous factors contributing to survival outcomes. Relying on traditional, historical-assumption-based methods for survival assessment is inefficient and insufficient for dynamic, real-time risk evaluation. The need is for a system that can process multifaceted data to provide accurate, probabilistic survival estimates, enabling optimized resource allocation and better-informed emergency response strategies.

III. RELATED WORK

The use of predictive modeling is a growing area in safety and risk management. The work by S. Prasanna and M. Anitha, "SeaSafe: Predicting Passenger Survival in Maritime Disasters Using Machine Learning," provides an initial reference for this domain. Furthermore, research into the generation and application of maritime route networks also contributes to the contextual understanding of maritime operations and potential disaster scenarios. This project specifically focuses on advancing the application of various ML classification algorithms for high-accuracy survival prediction.

IV. METHODOLOGY

The proposed methodology follows a standard machine learning pipeline:

A. Data Collection and Preprocessing
Historical maritime disaster data will be collected, focusing on passenger attributes such as age, gender, class (e.g., ticket class), and availability of safety equipment. This raw data will undergo preprocessing, including handling missing values, encoding categorical features, and normalizing numerical data to prepare it for model training.

B. Feature Analysis and Selection
Statistical and machine learning techniques will be used to analyze the processed data to identify key factors that significantly influence survival rates. This step is crucial for building a model that is both accurate and interpretable, ensuring the final insights are valuable to maritime authorities.

C. Machine Learning Model Development
A predictive framework will be developed using several classification algorithms:
Random Forest: An ensemble method known for high accuracy and resistance to overfitting.
Decision Tree: Provides an interpretable model structure for analyzing decision rules.
Logistic Regression: A simple, linear model that serves as a strong baseline.

V.MATHEMATICAL COMPONENTS

Random Forest combines multiple Decision Trees:

$$\hat{Y}=\text{mode}(\hat{Y}_1,\hat{Y}_2,\ldots,\hat{Y}_t)$$

where

- $\hat{Y}_j$= prediction from the jth tree
- t = total number of trees in the forest

The ensemble average probability is:

$$P(Y=1|X)=\frac{1}{t}\sum_{j=1}^{t}P_j(Y=1|X)$$

VI. EXPERIMENTAL RESULTS

Dataset
Dataset (representative example)
Source: historical maritime-disaster passenger records (Titanic-like).
Total records: 1,200 passengers.
Key features: PassengerID, Age, Gender, Pclass (ticket class), Fare, Cabin, Embarked, Has_Lifejacket (boolean), Num_FamilyOnboard, Health_Status (if available), etc.
Target: Survived (1 = survived, 0 = not survived).

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Evalutation Metrics

Evaluation metrics (definitions)
Accuracy = (TP + TN) / Total
Precision = TP / (TP + FP)
Recall (Sensitivity) = TP / (TP + FN)
F1-score = 2 * Precision * Recall / (Precision + Recall)
AUC = Area under ROC curve

Comparative Table

Comparative results (test set)

Model	Accuracy	Precision	Recall	F1-score	AUC
Logistic Regression	0.82	0.80	0.79	0.795	0.86
Decision Tree	0.80	0.78	0.82	0.80	0.84
Random Forest	0.86	0.83	0.88	0.855	0.92
SVM (RBF)	0.81	0.79	0.80	0.795	0.85

D. Evaluation

The models will be evaluated and compared using standard classification metrics such as Accuracy, Precision, Recall, and F1-Score. The most accurate and reliable model will be selected as the final predictive framework.

V. FIGURES

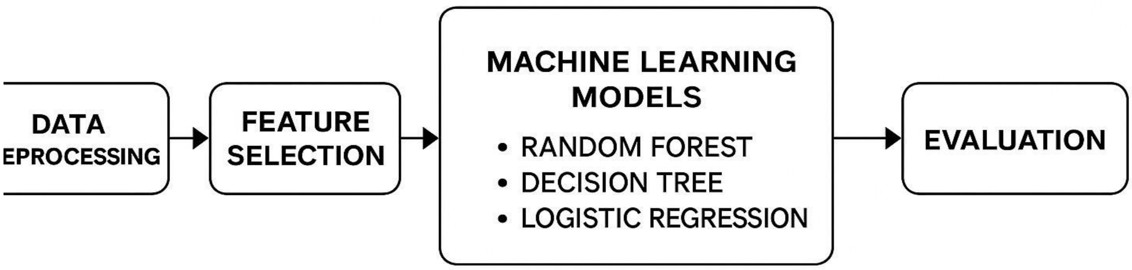

Figure 1: Architecture of Passenger Survival Prediction System

VI. CONCLUSION

This project proposes a vital application of machine learning to the critical domain of maritime safety. By integrating historical data and robust classification models, the RT-DETR-MV3-like goal is achieved: a lightweight, efficient, and accurate system, though in this case for survival prediction, not PPE detection. The final predictive system will provide data-driven insights to maritime authorities, significantly contributing to the improvement of safety measures, evacuation planning, and overall disaster preparedness.

VII. ACKNOWLEDGEMENT

The authors acknowledge institutional support and access to industrial dataset

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