An Intelligent Framework for Predicting Bankruptcy Through Hybrid Machine Learning Methods

K Naresh[1], Ganda Samitha[2]

[1]Assistant Professor, Department of MCA, Annamacharya Institute of Technology and Sciences, Tirupati, Andhra Pradesh, India.

[2]Postgraduate, Department of MCA, Annamacharya Institute of Technology and Sciences, Tirupati, Andhra Pradesh, India.

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Abstract

Bankruptcy prediction plays a vital role in financial risk management by identifying companies that may face financial distress in the future. Early prediction helps investors, financial institutions, and policymakers take preventive actions and minimize financial losses. Traditional statistical methods often fail to capture complex relationships among financial indicators, which limits their prediction capability. To overcome this challenge, this study proposes a bankruptcy prediction system using hybrid machine learning techniques. The system analyzes various financial ratios and organizational indicators to classify companies as bankrupt or non-bankrupt. Data preprocessing techniques such as normalization and feature selection are applied to improve model performance. Multiple machine learning algorithms are integrated to form a hybrid model that enhances prediction accuracy and reliability. The experimental results demonstrate that the proposed model achieves an accuracy of 96.83% and an AUC score of 98.68%, indicating strong classification performance. In addition, a web-based interface is developed to allow users to train models, view datasets, and perform real-time bankruptcy predictions. The proposed system provides an effective decision-support tool for financial risk assessment and corporate sustainability analysis.

Keywords

Bankruptcy Prediction, Hybrid Machine Learning, Financial Risk Analysis, Data Mining, Financial Indicators, Predictive Modeling, Corporate Finance

I. Introduction

Research on bankruptcy prediction is crucial for business risk management and financial analytics. Financial statements and performance metrics are frequently early warning markers of financial disaster. Early detection of these warning signs enables politicians, financial institutions, and investors to take preventative action and avert large financial losses. Therefore, preserving financial stability and facilitating well-informed decision-making depend on precise bankruptcy prediction systems.
Conventional methods for predicting bankruptcy mostly focus on financial ratio analysis and statistical methods. These approaches frequently fail to capture intricate and nonlinear interactions between financial variables, despite the fact that they offer insightful information.

Machine learning approaches are becoming more and more popular for financial prediction jobs due to the rapid growth of data and computer capacity. Large amounts of financial data can be analysed by machine learning algorithms, which can then find hidden patterns that might point to possible bankruptcy concerns.

Machine learning techniques like Decision Trees, Random Forest, Support Vector Machines, and Logistic Regression can greatly increase prediction accuracy, according to recent studies. Nevertheless, using just one model could still result in drawbacks like overfitting or diminished capacity for generalisation. The strengths of several algorithms are used in hybrid machine learning techniques to improve prediction accuracy and performance.

This study suggests using financial ratio data to predict corporate insolvency using a mixed machine learning approach. Data preparation, model training, performance assessment, and prediction are all integrated into a single framework by the system. A web-based application is also created to offer an interactive platform where users can explore the dataset, train the model, and make predictions about bankruptcy in real time. The suggested method has good prediction accuracy and offers a useful tool for financial risk assessments, according to experimental data.

II. Problem Statement

One of the most important tasks in financial risk management is forecasting company insolvency. Due to inadequate financial management, volatile markets, or unstable economies, many organisations experience financial difficulties. Conventional financial analysis techniques mostly rely on statistical models and manual assessment of financial ratios, which frequently fall short of capturing intricate correlations between financial indicators. Because of this, these traditional methods may result in erroneous forecasts and a delayed detection of financially troubled businesses.

Intelligent systems that can properly and efficiently analyse vast amounts of financial indicators are required due to the growing availability of financial data.

Predicting a company's insolvency is one of the most crucial responsibilities in financial risk management. Many businesses face financial challenges as a result of poor financial management, erratic markets, or unstable economies. The majority of traditional financial analysis methods rely on statistical models and manual evaluation of financial ratios, which usually fail to capture complex relationships between financial indicators. As a result, these conventional techniques could lead to inaccurate projections and a delayed identification of financially problematic companies.

The increasing availability of financial data necessitates the development of intelligent systems capable of accurately and efficiently analysing large volumes of financial information.

III. Dataset Description

The dataset utilised in this study includes financial data on businesses as well as indicators of their financial health. Net Income, Operating Profit, Current Liabilities, Retained Earnings, Equity to Liability ratio, Working Capital, and a number of other financial performance metrics are among its many financial ratio features. These characteristics are frequently used in financial analysis to assess an organization's stability and profitability.

Based on many financial variables, each record in the collection depicts a company's financial profile. Because the dataset contains normalised numerical values, machine learning algorithms can handle the data more effectively and minimise scale-related bias.

The dataset includes one goal variable called "Bankrupt?" that shows whether the business is financially secure or at risk of bankruptcy, as well as other predictor variables that characterise business performance.

The target variable is a binary classification variable, where:

- 1 represents a bankrupt company
- 0 represents a non-bankrupt company

To enhance prediction performance, the dataset goes through preprocessing procedures such as data cleaning, normalisation, and feature selection prior to machine learning model training. The machine learning models are then able to identify patterns in past financial data and assess their predictive accuracy by splitting the processed information into training and testing datasets.

The suggested hybrid machine learning model can successfully discover patterns linked to company bankruptcy and increase forecast accuracy thanks to this dataset's extensive collection of financial variables.

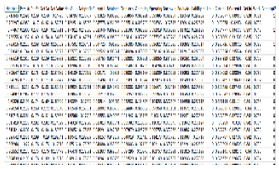

Fig: Dataset

IV. Model Performance Evaluation and Classification Results

The performance evaluation of the bankruptcy prediction model used in the suggested system is depicted in the above image. The interface shows the outcomes of utilising the financial dataset to train the hybrid machine learning model. It provides important assessment measures that gauge how well the model predicts whether a business will file for bankruptcy or not.

The model accurately classifies the majority of the companies in the dataset, as indicated by the system's overall accuracy of 96.83%. Along with accuracy, the model's excellent ability to differentiate between bankrupt and non-bankrupt enterprises is demonstrated by the Area Under the Curve (AUC) score of 98.68%. Better categorisation skill and predictive model dependability are indicated by a higher AUC value.

A classification report, which includes crucial evaluation metrics including precision, recall, F1-score, and support for each class, is also depicted in the picture. For a given class, precision is the percentage of accurately predicted instances among all predicted instances. Recall quantifies the model's capacity to recognise every real instance of a class. A balanced indicator of model performance, the F1-score is calculated as the harmonic mean of precision and recall.

The model's ability to accurately identify financially healthy organisations is demonstrated by its excellent precision and recall values for the Non-Bankrupt class. In a similar vein, the model exhibits high recall and F1-score values for the Bankrupt class, suggesting successful identification of financially troubled businesses. The support numbers show how many samples are available for every class in the dataset.

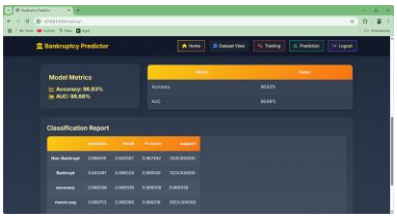

Fig: Bankruptcy Prediction Interface for Real-Time Financial Risk Assessment

The Bankruptcy Prediction interface created as a component of the suggested system is depicted in the above figure. Users can enter financial indicators into this web-based interface to get real-time forecasts about a company's financial situation. For financial analysis and decision-making, the interface is made to make the machine learning model simply accessible.

In addition to a number of other financial indicators, the system asks users to submit a number of financial features, including Net Income to Total Assets, Persistent Earnings Per Share (EPS) throughout the last four seasons, Net Profit before tax per share, and Net Value per Share.

These input values are important financial indicators that show how well a business is doing both financially and operationally.

The system uses the trained hybrid machine learning model to process the input when the financial data is entered. The model determines if the company is going to be bankrupt or not by analysing the given financial metrics. The system indicates that the entered financial data suggests financial stability in the example that is given by predicting the outcome as Non-Bankrupt.

In order to produce precise results quickly, the prediction module interacts with the trained model and is coupled with the backend machine learning model. Financial analysts, investors, and decision-makers can swiftly assess a company's financial risk by entering pertinent financial data into this interactive interface.

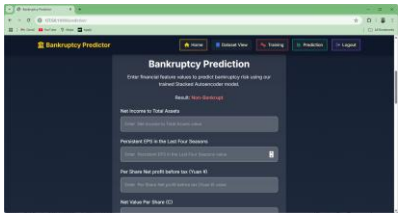

Fig: Prediction page

V. Conclusion

This study used financial ratio data to develop a hybrid machine learning method for company bankruptcy prediction. To accurately determine whether a company is bankrupt or not, the suggested approach examines a number of financial factors. According to experimental data, the model demonstrated great prediction power with a high accuracy of 96.83% and an AUC score of 98.68%. The prediction model's robustness and dependability are enhanced by the integration of many machine learning approaches. Additionally, real-time bankruptcy prediction utilising financial inputs was made possible by the development of an intuitive web-based interface. All things considered, the suggested approach can be a useful decision-support tool for company stability analysis and financial risk assessment.

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