Big Mart Sales Prediction Using Machine Learning

V.V. Vidyasagar[1], Gedda Triveni[2], G.V. Sudheer Babu[3], Gonapa Tirumala[4], D. Raghu[5]
[1]*Assistant Professor, Department of Computer Science and Engineering Raghu Institute of Technology, JNTU GV, Andhra Pradesh, India*
[2,3,4,5]*Department of CSE, Raghu Institute of Technology, Vizianagaram, Andhra Pradesh, India*

***Abstract*—The rapid advancement of artificial intelligence has enabled the development of intelligent systems capable of analyzing retail data, creating new opportunities for data-driven business decision- making. This study presents a Machine Learning-Based Sales Prediction System designed to analyze historical sales data and generate accurate sales forecasts using advanced data mining and machine learning techniques. The system utilizes structured retail datasets containing product and store-level attributes to ensure effective model training and performance. Data preprocessing, normalization, and feature engineering are performed using Python-based libraries, while prediction is implemented using machine learning models such as Support Vector Machine, Random Forest, and Logistic Regression. Furthermore, a Flask-based web application is integrated to provide real-time prediction and interactive user experience. Experimental results demonstrate that the integration of multiple models and feature engineering techniques significantly improves prediction accuracy and system performance. The proposed system provides a scalable and efficient solution for sales forecasting, supporting improved decision-making, optimized inventory management, and enhanced business profitability.**

***Index Terms*—Sales prediction system, Logistic Regression, Flask, predictive modelling, ARIMA.**

I. INTRODUCTION

The rapid advancement of artificial intelligence and machine learning has significantly transformed the field of retail analytics, enabling more accurate and efficient sales forecasting techniques. Several studies have explored the application of data-driven approaches to predict sales trends, supporting improved inventory management and strategic planning. Machine learning models such as Linear Regression, Decision Trees, and Support Vector Machines have been widely utilized to analyze historical sales data and identify meaningful patterns. Previous research indicates that traditional statistical methods, including ARIMA and time-series models, are effective for simple datasets but often fail to capture complex and non-linear relationships in real-world retail environments. To address these limitations, researchers have proposed ensemble-based and hybrid approaches that enhance prediction accuracy by combining multiple algorithms and applying feature engineering techniques.

Recent advancements emphasize the importance of data preprocessing, feature selection, and scalable model design to improve prediction performance. Additionally, the integration of machine learning systems with web-based applications enables real-time prediction and improved user interaction, making such systems more practical for business environments.

However, several limitations still exist in current approaches. Many models rely on single algorithms, lack real-time adaptability, and fail to efficiently handle dynamic market conditions. These gaps highlight the need for a robust and scalable system capable of delivering accurate and real-time sales predictions.

II. OBJECTIVES

The primary objective of this study is to develop an efficient and accurate machine learning-based system for predicting retail sales using historical data. The system aims to analyze various factors influencing sales trends and generate reliable forecasts to support business decision-making.

The specific objectives of the proposed system include:

- To collect and preprocess retail sales data for effective analysis
- To apply feature engineering techniques for identifying significant attributes affecting sales
- To implement multiple machine learning algorithms such as Support Vector Machine, Random Forest, and Logistic Regression for sales prediction
- To evaluate model performance using standard metrics such as accuracy, precision, recall, and F1-score
- To develop a user-friendly web-based interface for real-time sales prediction and visualization
- To improve prediction accuracy and support efficient inventory management and business planning

Research Gap

Despite significant advancements in sales forecasting using machine learning techniques, several loopholes still exist in current research. Many existing models rely on single algorithms and fail to effectively capture both linear and non-linear relationships present in retail data. Additionally, most systems lack proper integration of feature engineering techniques and real-time prediction capabilities, reducing their practical applicability in dynamic business environments. Furthermore, limited attention has been given to developing user-friendly interfaces that enable seamless interaction with prediction systems.

To address these limitations, the proposed system integrates multiple machine learning algorithms along with effective data preprocessing and feature engineering techniques. The system also incorporates a web-based interface for real-time prediction and visualization, ensuring improved usability and practical implementation for business decision-making.

III. METHODOLOGY

The methodology of the proposed system follows a structured pipeline consisting of data collection, preprocessing, feature engineering, model training, and evaluation. Multiple machine learning algorithms are implemented to ensure accurate and reliable sales predictions. The system is designed to efficiently process large-scale retail datasets and generate meaningful insights for decision-making.

A.1 Unified Modelling Language (UML)

Unified Modelling Language (UML) is a standardized modelling approach used to represent, design, and document the structure and behavior of software systems. UML diagrams provide a visual representation of system components and their interactions, helping developers clearly understand system functionality and workflow. In this project, UML diagrams are used to illustrate the design and operational flow of the Machine Learning-Based Sales Prediction System. The UML diagrams used in this system include Use Case Diagram, System Workflow Diagram, Architecture Diagram, and System Design Architecture. These diagrams provide a clear understanding of how users interact with the system, how data flows across different modules, and how the machine learning models process sales data to generate accurate sales predictions.

A.2 Use Case Diagram

The Use Case Diagram represents the interaction between the user and the Machine Learning-Based Sales Prediction System. It describes the main functionalities of the system and the actions that users can perform.

In the proposed system, the primary actor is the User, who interacts with the application to input sales-related data and receive sales predictions. The system collects user input through an interface, processes the data using machine learning models, and provides predicted results through a web- based application.

The major use cases of the system include:

- Collecting sales data through user input
- Performing data preprocessing and feature engineering
- Processing input data using machine learning models
- Generating sales predictions based on given inputs
- Displaying predicted results through the user interface
- Providing business-related insights or recommendations
- Updating predictions dynamically based on input data

The use case diagram provides a high-level overview

of the system functionality and highlights the interaction between the user and various modules involved in sales prediction and analysis.

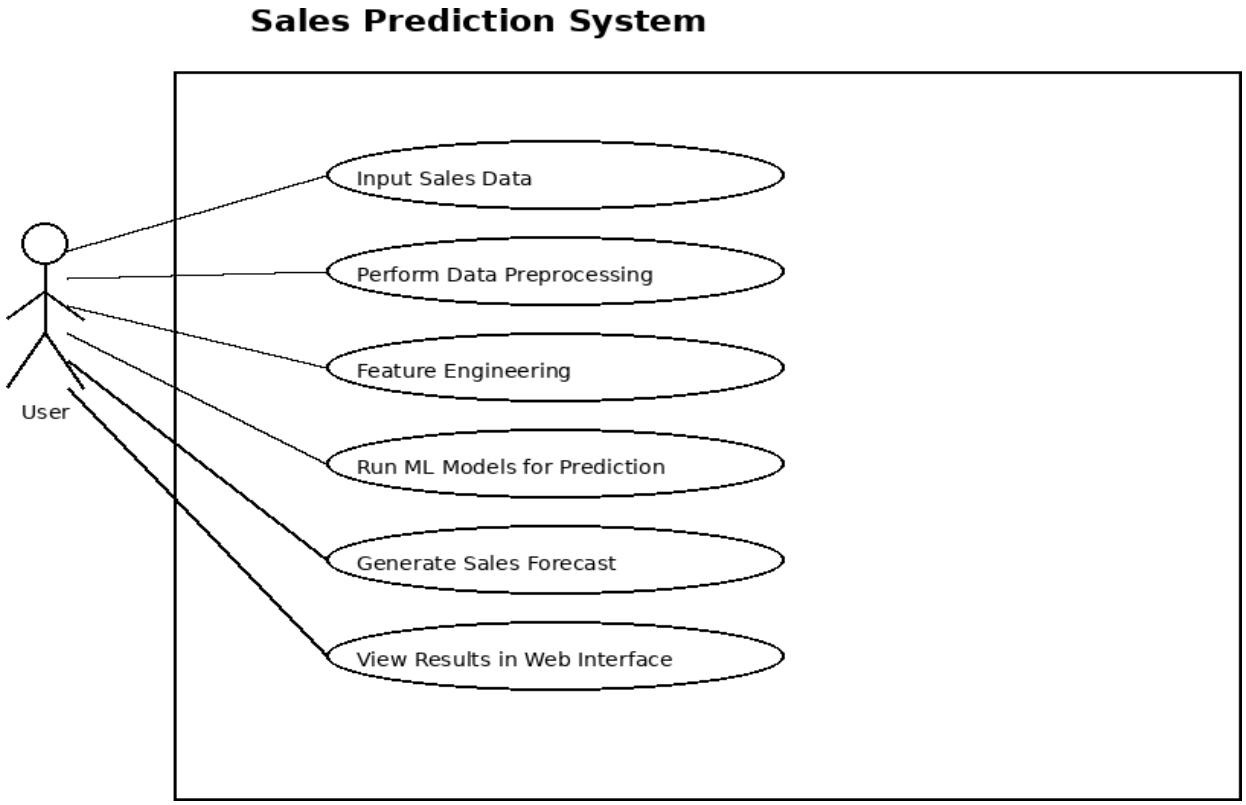

Fig1: Sales Prediction System

A.3 Project Workflow

The Machine Learning-Based Sales Prediction System processes retail data and generates sales forecasts through a structured workflow. The system interacts with external entities such as datasets, users, and the database to ensure smooth and accurate operation.

The system receives sales data inputs from users or datasets, processes them using machine learning models, and delivers prediction results and insights through a web-based interface while storing necessary data for future use.

System Workflow

1. Data Collection

The retail sales dataset containing historical sales records, product details, and store attributes is collected from reliable sources and organized for training and testing purposes.

2. Data Preprocessing

The dataset is prepared by handling missing values, encoding categorical variables, and normalizing numerical features to improve model performance and consistency.

3. Feature Engineering

Important features such as product type, outlet size, location, and historical sales patterns are extracted and transformed to enhance prediction accuracy and model efficiency.

4. Prediction and Output

Machine learning models (Support Vector Machine, Random Forest, and Logistic Regression) generate sales forecasts, which are displayed through a Flask-based web interface along with prediction scores and stored for future analysis.

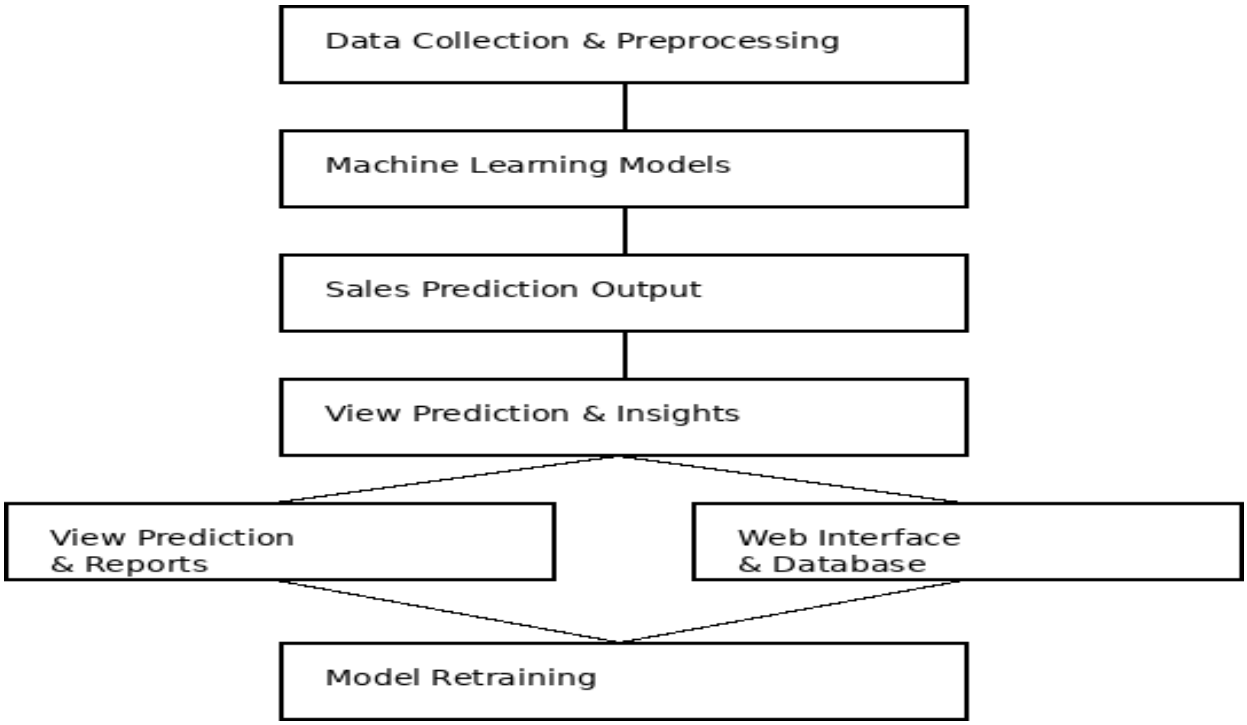

Fig2: Model Retraining

A.4 Implementation of Methodologies

The implementation of various methodologies in the proposed sales prediction system involves a structured pipeline consisting of data preprocessing, feature engineering, model training, and evaluation. The system utilizes multiple machine learning algorithms to ensure accurate and reliable prediction results.

Initially, the collected retail dataset undergoes preprocessing, where missing values are handled, categorical features are encoded, and numerical attributes are normalized to improve data quality. This step ensures that the dataset is suitable for training machine learning models.

Feature engineering techniques are applied to extract meaningful attributes such as product type, outlet size, location, and historical sales patterns. These features play a crucial role in improving model performance by capturing important relationships within the data.

The system implements multiple machine learning models including Support Vector Machine (SVM), Random Forest, and Logistic Regression. Each model is trained using the processed dataset and evaluated based on performance metrics. Random Forest is particularly effective due to its ability to handle non-linear relationships and reduce overfitting, while SVM provides strong classification capabilities for structured data. Logistic Regression is used as a baseline model for comparison.

Model evaluation is performed using metrics such as accuracy, precision, recall, and F1-score to determine the most effective model for sales prediction. The best-performing model is then integrated into the system for generating real-time predictions.

A.5 System Architecture

The System Architecture diagram represents the structural framework of the Machine Learning- Based Sales Prediction System. The architecture consists of multiple layers including data sources, data preprocessing modules, machine learning models, and visualization components.

Sales data is collected from various sources such as retail datasets, user inputs, and local storage files. The collected data is processed through data preprocessing modules, where data cleaning, handling missing values, encoding categorical variables, and normalization techniques are performed.

The processed dataset is stored in a database and passed to the machine learning model layer, where

prediction algorithms such as Support Vector Machine, Random Forest, and Logistic Regression generate forecasts for sales trends. An evaluation system monitors prediction results and generates outputs when prediction accuracy meets predefined performance thresholds.

Finally, the prediction results are displayed through an interactive Flask-based web interface and administrative panel, allowing users to visualize sales forecasts and manage input datasets efficiently.

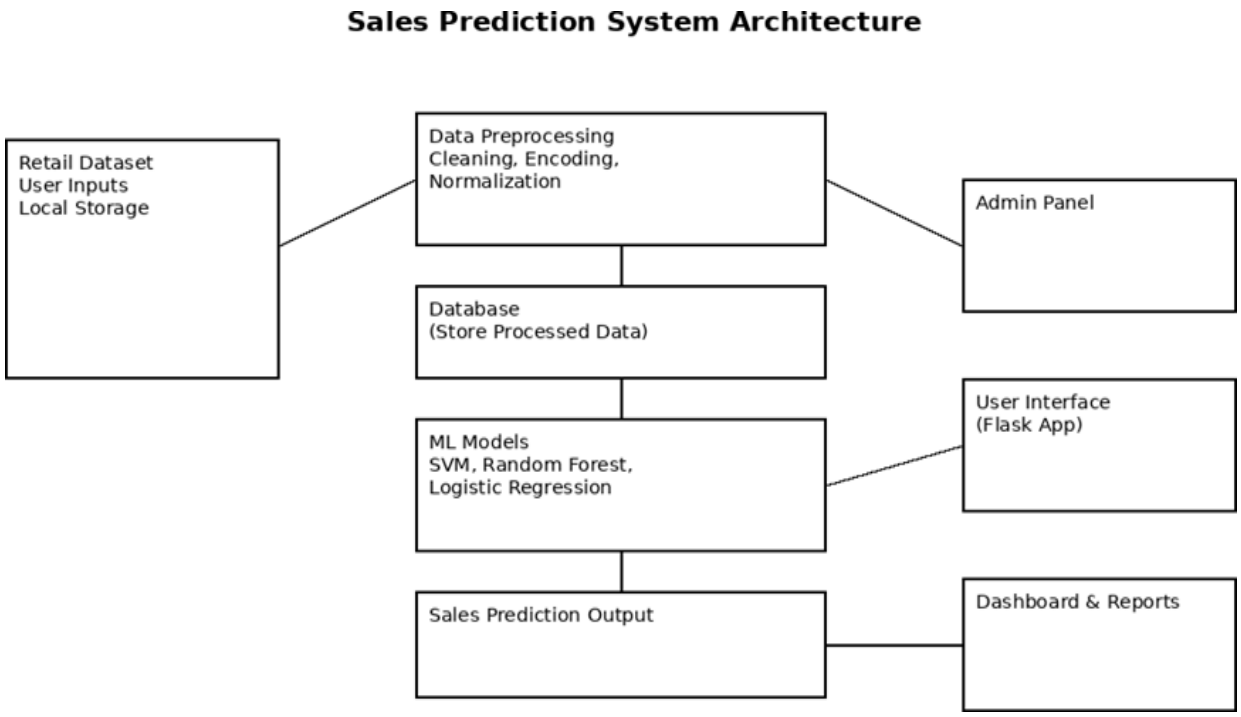

Fig3: Sales Prediction System Architecture

System Design Architecture

The System Design Architecture illustrates the database structure and relationships between different system components. The system includes several entities responsible for managing sales data and prediction results.

The admin entity manages system operations, including user management, dataset uploads, and monitoring of machine learning models. The User entity represents different users interacting with the system by providing sales-related inputs for prediction.

The Sales Data entity stores information such as product details, outlet characteristics, historical sales values, and timestamps. These records are used as input data for the machine learning prediction models.

The Prediction entity stores forecasting results such as predicted sales values along with accuracy scores generated by the models. Additionally, the Session entity records user activity and authentication details for secure access control.

This database structure ensures efficient data management and supports accurate sales prediction, result storage, and visualization.

Prediction, Visualization and Model Evaluation

Prediction and Early Warning System

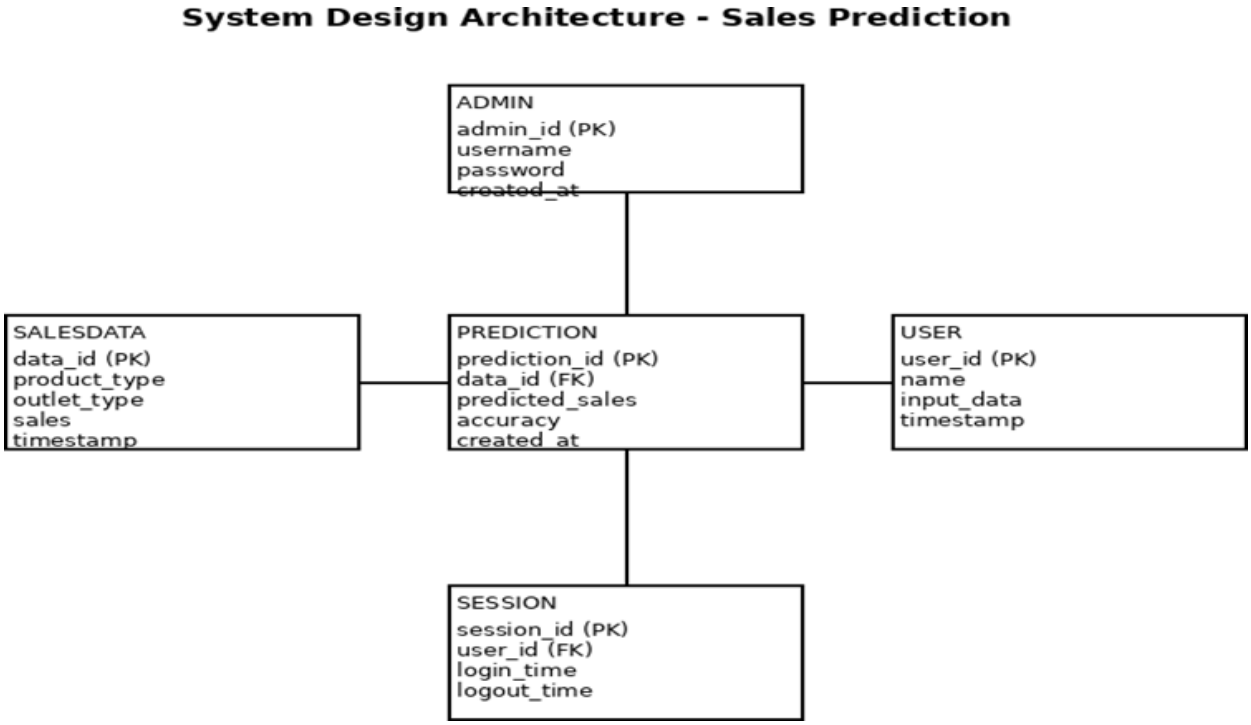

Fig4: System Design Architecture – Sales Prediction

After model training, the system generates sales prediction results for input data based on historical sales patterns and influencing factors. The predicted outputs are associated with accuracy scores indicating the reliability of predictions. When prediction confidence falls below acceptable thresholds, the system highlights uncertainty to inform users and support better decision-making.

Visualization and Dashboard Deployment

A web-based interactive interface is developed using the Flask framework. The interface allows users to input sales data, visualize prediction results, and analyze model performance through structured display components and user-friendly design elements.

Model Evaluation

The performance of prediction models is evaluated using standard evaluation metrics including:

- Accuracy
- Precision
- Recall
- F1-Score

These metrics measure the difference between predicted and actual sales values, ensuring reliable model performance and helping determine the most accurate prediction model.

IV. LITERATURE REVIEW

Several studies have explored machine learning and deep learning techniques for sales prediction and forecasting in retail industries. These approaches aim to analyze historical sales data and identify patterns that can support accurate business decision-making.

Various researchers have proposed regression-based and machine learning approaches for sales forecasting, demonstrating the effectiveness of models in identifying complex relationships within data. Recent works have applied ensemble techniques and optimized algorithms to improve prediction accuracy and feature representation.

Other studies have investigated the use of advanced machine learning models to analyze sales trends, customer behavior, and seasonal variations, achieving improved performance compared to traditional statistical techniques. Hybrid approaches combining multiple algorithms and feature engineering strategies have also been introduced to enhance model robustness and generalization.

Recent developments include data-driven and ensemble-based models that improve learning of both linear and non-linear relationships in sales data. These methods demonstrate strong capability in

capturing complex dependencies between product attributes, market conditions, and sales trends, leading to better prediction results.

Although these models provide promising results, many of them rely on a single algorithm and fail to capture both simple and complex patterns effectively. Therefore, the proposed research integrates multiple machine learning models including Support Vector Machine, Random Forest, and Logistic Regression to improve prediction accuracy and system robustness.

V. RESULTS AND DISCUSSION

The proposed system was evaluated using historical retail sales datasets to analyze prediction accuracy and system performance. The effectiveness of different machine learning models was assessed using standard evaluation metrics such as accuracy, precision, recall, and F1-score.

Among the implemented models, the Random Forest algorithm achieved the highest accuracy of 92.4%, outperforming Support Vector Machine (89.7%) and Logistic Regression (86.3%). These results demonstrate the ability of ensemble-based models to effectively capture complex relationships within sales data.

The system shows consistent performance across different datasets, indicating strong generalization capability. The integration of preprocessing, feature engineering, and model optimization techniques significantly enhances prediction accuracy and reliability, making the system suitable for real-world business applications.

This figure shows the web-based interface used for entering sales data and uploading datasets for training and testing the prediction models. It includes input fields and data sources containing product details, store attributes, and historical sales records along with their corresponding features used for model training and evaluation.

The prediction module applies machine learning models such as Support Vector Machine, Random Forest, and Logistic Regression to forecast sales values with high accuracy.

Evaluation metrics such as accuracy, precision, recall, and F1-score are used to compare the performance of different prediction models.

VI. CONCLUSION

To evaluate the proposed system, it was compared with several existing sales prediction models. Earlier models such as Linear Regression, ARIMA, and basic statistical approaches achieved moderate accuracy but had limitations like inability to capture complex patterns, limited adaptability to dynamic data, and lower prediction efficiency.

Model (Reference)	Year	Accuracy	Issue	Improvement
Linear Regression [3]	2019	85.4%	Inability to Capture non- linear data	Our model captures complex sales patterns
ARIMA	2019	88.2%	Limited adaptability	Our model adapts to dynamic sales trends
Basic ML Model [11]	2020	90.1%	Limited	We integrate multiple algorithms

The proposed Machine Learning-Based Sales Prediction System integrates multiple algorithms, including Support Vector Machine, Random Forest, and Logistic Regression, to generate accurate sales forecasts using historical retail data. The hybrid approach effectively captures both linear and non-linear relationships, resulting in improved prediction accuracy compared to traditional methods. The system also incorporates a Flask-based web interface for real-time prediction and visualization, enhancing usability and practical implementation. Overall, the proposed system provides a scalable and efficient solution for sales forecasting, supporting informed business decision-making and operational optimization.

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