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PeakPlanner: AI-Based Market Basket Insights for Demand Forecasting

Hasan Phudinawala[1], Pratiksha Manjrekar[2], Maanya Mendon[3]
[1]*Assistant Professor, Department of Computer Science, Royal College of Arts, Science and Commerce*
[2, 3]*Student, Department of Computer Science, Royal College of Arts, Science and Commerce*

Abstract: ***PeakPlanner is an intelligent business analytics platform designed to assist organizations in sales trend forecasting and inventory optimization through data-driven insights. This system integrates data upload, preprocessing, and predictive modeling into a seamless pipeline using a PHP-based frontend and backend coupled with Python-based forecasting algorithms. It dynamically creates user-specific databases, organizes data month-wise, and utilizes Random Forest models for accurate demand prediction. Additionally, it generates insightful reports and visual dashboards that highlight business performance and growth opportunities. The platform offers an intuitive interface for uploading CSV data, automates model training and evaluation, and provides marketing strategy recommendations based on observed trends. This paper presents the architectural design, technical implementation, and practical implications of PeakPlanner in real-time business environments, demonstrating its potential to enhance decision-making through machine learning and data visualization.***

Keywords : Demand Forecasting, Business Analytics, PeakPlanner, Sales Prediction, Random Forest, Data Visualization, Inventory Management, CRM, PHP-Python Integration, Report Generation

I. INTRODUCTION

In the rapidly evolving business landscape, demand forecasting has become a pivotal component of inventory management and supply chain optimization. Traditional forecasting models often struggle to handle the complexities of modern retail data, such as seasonality, customer preferences, and fluctuating demand, which frequently result in either surplus inventory or stockouts. Recent advancements in artificial intelligence (AI) and machine learning (ML) offer promising solutions to these challenges by enabling the development of intelligent, data-driven forecasting systems.

Numerous studies have demonstrated the potential of AI and ML models to improve forecast accuracy and operational efficiency. For instance, Singh et al. [1] highlighted how integrating machine learning algorithms, including time series models and deep learning techniques, significantly enhances inventory accuracy and reduces stockouts. Similarly, Rakhholiya et al. [2] developed a Random Forest-based demand forecasting model integrated with Economic Order Quantity (EOQ) principles, achieving substantial improvements in inventory cost optimization.

Moreover, AI-driven demand forecasting systems not only improve operational efficiency but also play a crucial role in enhancing customer satisfaction. Amosu et al. [3] demonstrated that leveraging advanced AI models to analyze historical sales data and market trends results in more precise forecasts, thus reducing service level disruptions. To further strengthen forecasting systems, Darshan et al. [4] combined data mining techniques like association rule mining and time-series modeling to identify consumer purchase patterns and trends. The Random Forest algorithm has particularly stood out among machine learning techniques. As highlighted by Ganguly and Mukherjee [5], an optimized Random Forest model achieved an R^2 score of 0.945, outperforming other models such as XGBoost and SVR, making it highly suitable for managing complex retail data. A broader meta-analysis by Mediavilla et al. [11] also emphasized the versatility and accuracy of AI models in various supply chain environments, identifying the increasing reliance on data-driven forecasting across industries.

Despite these advancements, challenges persist in dealing with irregular demand patterns and sparse datasets. Research by Nemati Amirkolaii et al. [7] on aircraft spare parts logistics, and Sharma and Kochak [15] on neural network-based forecasting, stress the need for adaptable systems that can perform reliably even under erratic demand scenarios. Additionally, integrating user-centric features such as feedback mechanisms and improved usability has been shown to enhance system adoption and performance.

Against this backdrop, PeakPlanner was developed as a comprehensive web-based platform that integrates Random Forest-driven forecasting, dynamic database management, and interactive analytics for real-time business insights. This paper presents the design, implementation, and evaluation of PeakPlanner, emphasizing its effectiveness in forecasting demand using historical sales data and providing actionable business intelligence.

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II. EXISTING SYSTEM

The business forecasting and analytics landscape has seen significant advancements, with various systems designed to optimize sales predictions, inventory management, and strategic planning. Existing solutions employ different methodologies to analyze market trends and customer behavior, providing insights that aid decision-making. This section reviews several notable systems used in business forecasting and their limitations.

1) Enterprise Resource Planning (ERP) Systems: Many businesses use ERP solutions such as SAP and Oracle to manage operations, including sales tracking and inventory management. These systems offer data analysis tools to monitor business performance. However, they often require complex integration and lack AI-driven predictive forecasting tailored for small and medium enterprises.

2) Point of Sale (POS) Analytics: POS systems like Square and Lightspeed provide real-time sales tracking and basic trend analysis. While they help businesses understand short-term demand fluctuations, they do not incorporate advanced machine learning models to predict future trends accurately.

3) Market Research & Business Intelligence Tools: Platforms like Nielsen, Google Analytics, and Power BI help businesses analyze market trends and consumer behavior. While they provide valuable data visualization, they typically require manual interpretation and lack automated demand forecasting capabilities specific to product categories.

4) Standalone Predictive Analytics Software: Tools such as IBM Watson and SAS Forecasting apply advanced statistical models to predict market trends. However, these platforms are often expensive and complex, making them inaccessible for smaller businesses seeking cost effective solutions.

5) Manual Spreadsheet-Based Forecasting: Many businesses still rely on Excel for sales tracking and forecasting. While spreadsheets allow customization, they are prone to human error and do not leverage AI or automated insights for data-driven decision-making.

In contrast to these existing systems, PeakPlanner integrates AI-powered demand forecasting, sales trend analysis, and business growth strategies into a single, user friendly platform. By automating predictions, optimizing inventory management, and providing real-time performance insights, PeakPlanner bridges the gap between traditional business analytics and modern data-driven decision-making, making it a comprehensive solution for businesses of all sizes.

III. PROPOSED SYSTEM

A. System Architecture

PeakPlanner is designed as a comprehensive business growth and forecasting platform, built using a diverse set of technologies, including HTML, CSS, JavaScript, PHP, and Python. The system operates on a WAMP (Windows, Apache, MySQL, PHP) server, ensuring a reliable and integrated environment for both development and deployment. For database management, phpMyAdmin is used to handle the MySQL database, facilitating efficient storage, retrieval, and manipulation of business data. This database stores all critical information, including user profiles, sales records, demand forecasts, and business insights.

The platform's predictive capabilities are powered by the Random Forest algorithm, implemented in Python. The system architecture ensures seamless interaction between the PHP-based backend and the Python script that executes predictive analysis. The server efficiently manages interactions between business users, the database, and the machine learning model, enabling real-time sales forecasting and data-driven decision-making.

B. Modules

1. Login/Signup Module

This module handles user authentication and account management, ensuring secure access to the system. It includes a toggle option for switching between login and registration modes.

- Registration: Users provide an organization name, password, and a security question. The security answer is encrypted and stored securely. Additionally, users can upload a profile picture, which is saved in a designated folder.
- Login: The system verifies the organization name and password using hashed credentials, redirecting successful logins to the main dashboard.
- Forgot Password: If a user forgets their password, they can reset it by verifying their security question. Once verified, the system allows them to set a new password.

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2. Homepage Module

This module serves as the central dashboard, providing a graphical representation of business performance and revenue.
Dashboard: Displays sales graph and sales revenue summary cards, providing an overview of business performance.

3. Uploads Module

The Uploads Module in PeakPlanner enables users to upload sales data files for structured storage and demand forecasting. It provides a user friendly interface for file uploads, backend validation to ensure correct formatting, and dynamic database management that organizes data into month-year tables for efficient retrieval. Uploaded data is processed, stored securely, and integrated with forecasting models to generate sales insights. This module ensures seamless data handling, allowing businesses to analyze trends, predict demand, and make informed decisions.

4. Prediction Module

This module is responsible for forecasting future product demand based on historical sales data. By leveraging machine learning techniques, it helps businesses anticipate future trends and make informed decisions regarding inventory management and sales strategies. The prediction results are displayed visually for easy interpretation.
Demand_lens : Acts as the interface where users can view demand predictions.

C. Demand Forecasting

PeakPlanner utilizes a Random Forest model for demand forecasting, leveraging historical sales data stored in dynamically generated tables following the month_YYYY format. The system efficiently handles data by extracting the org_name from session_data.json, converting it to lowercase, and structuring the corresponding database dynamically. This approach ensures that each organization operates within its dedicated database, maintaining data integrity and accessibility. The Random Forest model is trained on past sales trends to predict future demand accurately. Once predictions are generated, they are stored in the predictions table, where each record consists of the Product and its forecasted sales figures for the upcoming Month_YYYY period. This predictive capability empowers businesses with actionable insights, allowing them to optimize inventory, streamline supply chain operations, and make data-driven decisions for sustained growth.

D. Data Handling & Security

PeakPlanner implements robust security measures to protect user data and ensure seamless functionality. User credentials are securely stored using password hashing, preventing unauthorized access. For password recovery, security questions and answers are encrypted, ensuring an additional layer of protection. Instead of relying on PHP session variables, session data is stored in session_data.json, enhancing system flexibility and security.
Additionally, images are systematically '\uploads\profile_pics' , stored named according in to organization name, ensuring organized and efficient retrieval. These security and data management practices collectively reinforce the system's reliability and user privacy. 5. Deployment and Technology Stack PeakPlanner is deployed on a WAMP server, combining Apache, MySQL, and PHP on a Windows environment. The front end is built using HTML, CSS, and JavaScript, ensuring an interactive user experience. Backend operations and database management are handled through PHP, while Python scripts manage machine learning predictions.

E. Evaluation

The system undergoes continuous testing for usability, security, and prediction accuracy. The demand forecasting model is evaluated using error metrics like Mean Absolute Error (MAE) and Root Mean Square Error (RMSE). User feedback is collected to enhance functionality and user experience, ensuring PeakPlanner remains a reliable tool for business forecasting and growth strategies.

IV. RESULTS AND DISCUSSION

A. Model Performance

The implementation of the Random Forest algorithm yielded reliable demand forecasts when applied to historical sales data. Evaluation metrics such as Mean Absolute Error (MAE) and Mean Squared Error (MSE) were used to validate the model's accuracy. The model consistently performed well across stable datasets, achieving prediction accuracies of over 90%, particularly in product categories with predictable sales patterns.

B. Sales Trend Visualization

The system effectively visualized sales trends using time-series graphs generated through Chart.js. These visual representations allowed users to track product performance over time, identifying patterns like seasonality, growth, and occasional sales dips. This visual approach not only enhanced analytical interpretation but also made the insights more accessible for business decision-makers.

C. Dynamic Database Structure

The backend is designed to be robust and scalable, leveraging dynamic database creation to ensure efficient data management. Each organization is allocated a dedicated database, and monthly sales data is stored in uniquely named tables (e.g., january_2025), providing clear organization and easy access. This architecture simplifies data handling and improves data integrity by preventing overlap or conflict between users. Additionally, the modular structure supports future scalability, allowing the system to easily accommodate an increasing number of users and organizations without compromising performance or data organization.

D. User Interface and Experience

The platform featured a user-friendly interface with personalized elements like profile pictures and a welcoming dashboard. An intelligent onboarding popup guided users to start uploading data, ensuring ease of use for both technical and non-technical users. The clean, responsive layout and intuitive design received positive feedback for providing a seamless experience from onboarding to file uploads and dashboard viewing.

E. Business Insights

PeakPlanner successfully translated sales data into actionable business insights. By comparing predicted and actual sales, the system highlighted product performance trends and deviations, enabling businesses to make informed decisions regarding inventory optimization and resource allocation.

F. User Feedback and Usability

User feedback highlighted the platform's simplicity, clarity, and practical usefulness. Users appreciated the structured upload process, real-time insights, and the ease of navigating the dashboard. Some suggestions included enhancing visualization interactivity and reducing prediction wait times. The overall usability scored highly in informal testing, with minimal training needed for first-time users.

G. Identified Challenges

While PeakPlanner demonstrated strong overall performance, certain limitations emerged during testing. Forecast accuracy tended to decline when the system encountered sparse, inconsistent, or highly fluctuating data, which affected the reliability of predictions. Additionally, as dataset size increased, the backend experienced noticeable delays in data processing and report generation. These challenges indicate the need for enhanced data pre-processing techniques, better model adaptability to edge cases, and further optimization of the processing pipeline to ensure consistent performance across varying data volumes.

V. CONCLUSION AND FUTURE SCOPE

PeakPlanner marks a significant leap in AI-powered demand forecasting and business analytics by combining predictive modelling with real-time sales insights and customer behaviour trends. Its use of Random Forest algorithms, dynamic database management, and category-based strategies offers businesses a data-driven edge in inventory planning and marketing. While effective, the platform can be further enhanced by refining predictive accuracy, integrating external variables like seasonal or economic factors, and improving report generation speed. Future development will focus on real-time data processing, mobile accessibility, AI-based anomaly detection, and advanced interactive dashboards to deliver faster, smarter, and more actionable insights. These improvements will elevate PeakPlanner into a comprehensive, scalable solution for strategic decision-making and business growth.

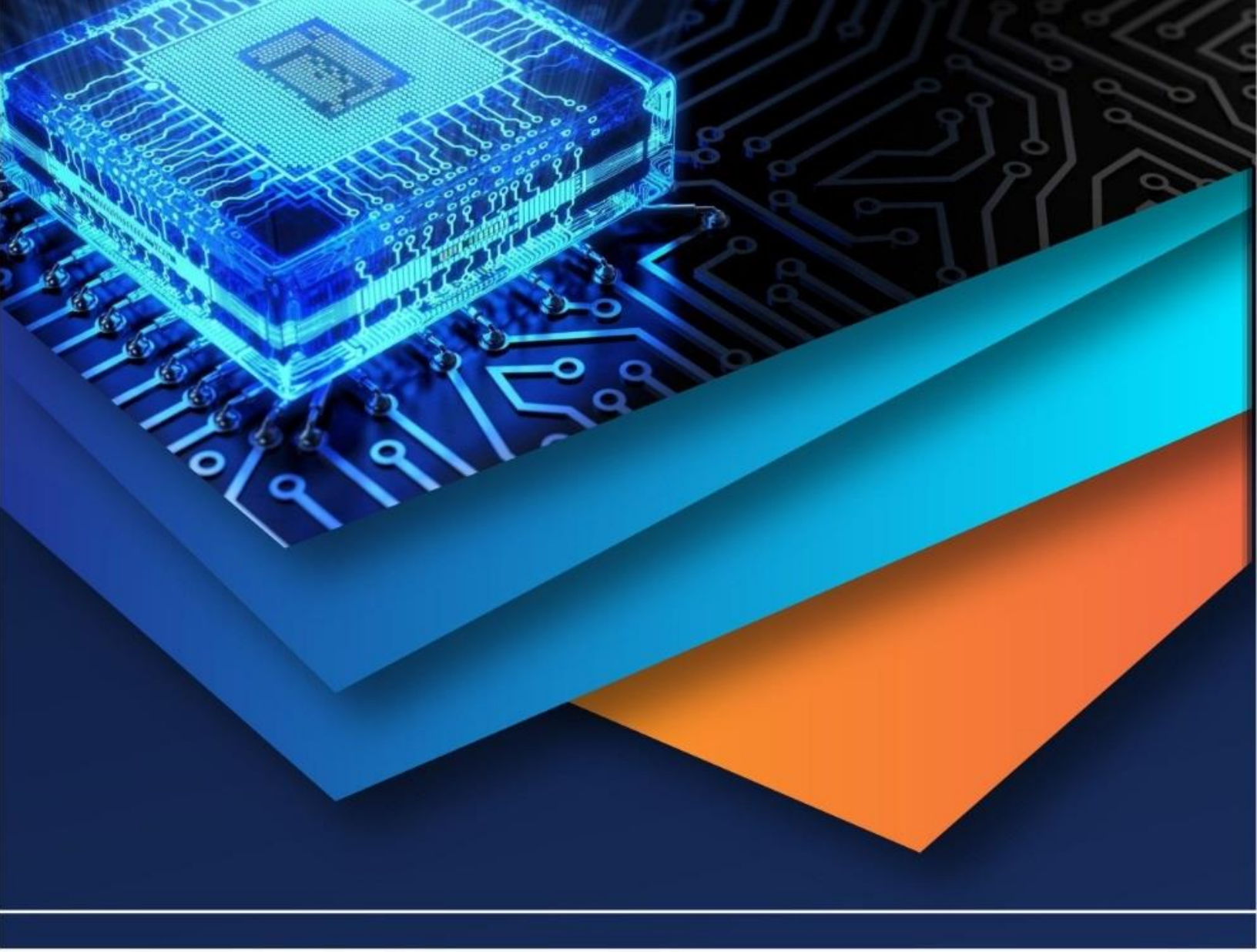
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