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Journal of Behavioral Informatics
Digital Humanities & Development Research
Vol 11, No 2, June 2025 Series

Enterprise Application for Real-Time Stock Control and Predictive Analytics Using Machine Learning

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ABSTRACT

Enterprise applications for inventory management and prediction of market trends using Long Short-Term Memory (LSTM) based deep learning to improve inventory accuracy. The system integrates real-time data from various sources to ensure timely and accurate tracking of goods and services. The developed enterprise application comprises real-time tracking, demand forecasting, and predictive analytics to ensure data-driven systems. The system provides small and medium-scale enterprises with tools to optimize inventory, improve operational efficiency, and enhance customer satisfaction.

Keyword: Enterprise Application, Real-Time Stock Control, Predictive Analytics, Using Machine Small and Medium Scale Enterprises, Learning

Journal Reference Format:
Ogbu Nwani Henry & Ignatius Nwoyibe Ogbaga (2025): Enterprise Application for Real-Time Stock Control and Predictive Analytics Using Machine Learning. Journal of Behavioural Informatics, Digital Humanities and Development Rese Vol. 11 No. 2. Pp 1-18.
https://www.isteams.net/behavioralinformaticsjournal dx.doi.org/10.22624/AIMS/BHI/V11N2P1

1. INTRODUCTION

Small and medium-sized enterprises (SMEs) are privately owned companies with assets, capital, and workforce levels that range from 10 to 49 employees, depending on national guidelines (Taiwo, 2016). The viability of SMEs operations determines the level of growth and development that a nation can achieve, so SMEs are important for nation-building because they provide jobs, act as a platform for effective training that allows the nation especially Nigerian entrepreneurs to flourish, and help workers and youth acquire new skills (Dias et al., 2022; Papadopoulos et al., 2020; Taiwo, 2016).

The funding sources for SMEs include banks (microfinance, commercial, and merchant banks), owner's savings, government agencies, cooperative societies, local governments, moneylenders, friends, family, partners, and business associates. Specialized funding facilities included the National Economic Reconstruction Fund (NERF), the Bank of Industry (BOI), and the World Bank Loan Scheme (WBLS) for SMEs(Taiwo, 2016).

Enterprise systems (ES) have become a vital tool for business start-ups and the development of SMEs. An enterprise system is essentially a collection of digital tools that many businesses use to facilitate and support a cross-functional, company-wide communication system to accomplish its stated objectives, vision, and initiatives (Arora, 2021; Ekman, 2015). The ES includes supply chain management (SCM), enterprise resource planning (ERP), and customer relationship management (CRM). This shows how powerful a corporate information system can be when implemented across the entire organization (Muangmee et al., 2022; Shapel, 2023). The use of these technology-driven tools reduces data duplication, gives employees access to potential customers' knowledge, and boosts overall organizational productivity (Arora, 2021). These tools present a high potential for business growth in these countries through the integration of people, products, companies, and business processes (Shehu et al., 2023).

Monitoring the financial flow and operations of SMEs requires the implementation of enterprise applications and real-time financial and stock prediction. Enterprise application is a set of digital applications utilized by organizations to achieve set goals, visions, and initiatives. The applications support cross-functional, and business-wide communication systems(Arora, 2021; Ekman, 2015). Enterprise applications support business tasks such as customer relationship management, supply chain, and enterprise resource planning that aid company employees gain in-depth knowledge, prevent data duplications, and increase organizational productivity (Muangmee et al., 2022). Enterprise application implementation in business has become an integral part of business success, improved productivity, and market trend forecasting.

Market trends forecasting (MTF) determines the direction of the price of goods and services over time (Wulandari, 2023). The essence of market trend forecasting is to help traders and/or investors identify potential shifts in the market, which they can forecast or speculate, and require the implementation of machine learning to extract relevant features from the market data, identify patterns and relationships within the data and predict trends (Nweke et al, 2024). In recent times, deep learning an aspect machine that automatically extracts relevant characteristics from market data has been widely utilized for market trend forecasting (Law et al., 2019). Deep learning consists of neural networks organized in layers for effective feature extraction.

Various models of deep learning have been developed for various tasks ranging from image recognition, cancer detection, and market trend forecasting (Sarker, 2021). These deep learning models include convolutional neural networks, long short-term memory, autoencoder, generative adversarial networks, and restricted Boltzmann machines. In this research, the long short-term memory (LSTM) method was implemented for stock and market trends prediction due to its ability to handle vanishing gradients, especially for complex forecasting problems(Rathipriya et al., 2023).

In addition, long short-term memory-based deep learning methods have been deployed for drug demand forecasting, stock market prediction, and asset price forecasting. For instance, A recent study by Rathipriya et al., (2023) deployed a Long Short Term Memory (LSTM) model to forecast drug demand in pharmaceutical companies to improve sales, demand, and distributions.

Nabipour, et al., (2020) used LSTM deep learning methods to predict the stock market using 10 technical indicators. The shows LSTM with the highest fitting ability. Other studies that have utilized LSTM models for time series data, historical data, etc. in stock or asset price forecasting in the market include (Suresh et al., 2022; Zaar et al., 2023). Nonetheless, some of these studies implemented standalone Long Short-Term Memory models without integration into the enterprise applications. The integration of a deep learning model into the enterprise application would improve the prediction model using constant business and customer data.

In this paper, we propose the development of an enterprise application system for real-time stock management and market trend prediction by integrating the system with a deep learning model. The contribution of this paper to the body of knowledge are:

- Implementation of enterprise application systems for real-time stock management;
- Propose long short-term memory-based deep learning model for stock and market trend prediction using alcoholic beverages;
- Extensive experimental settings to evaluate the proposed method using a large alcoholic beverages dataset.

The rest of the paper is organized as follows: Section 2 discusses the methodology which includes the implementation of the enterprise systems, long short-term memory, and interface design. Section 3 highlights the enterprise system design. Section 4 discusses the result of implementation. We conclude and outline the direction for future research in Section 5.

2. METHODOLOGY

In this study, two main methods were utilized during the research. These include the method for software design and the method for data gathering. The research adopted an object-oriented methodology for the implementation of the proposed enterprise application for real-time stock management and prediction using a machine learning method. The object-oriented approach applies object modeling to analyze the functional requirements of the systems, and further produce the conceptual model information. To gather relevant data from stakeholders and industry experts, the research utilized various approaches ranging from interviews, questionnaires, review of relevant documents, and observation. These methods enable the researchers to obtain important information and characteristics on small and medium-scale enterprises, human resources, workforce size, supply chain approach, and inventory management.

2.1 Architecture of enterprise application and stock prediction

Nigeria's small- and medium-scale enterprise system has been developed to manage different organs of the business venture. Therefore, enterprise systems developed as vital tools for business start-up development, helping businesses achieve their goals and information communication. Various components of enterprise systems are developed to handle the operations of small and medium-scale enterprises. These include customer relationship management, accounting and finance, stock management, inventory control, and human resource management. The enterprise systems aim to implement integrated, modular, and off-the-shelf systems to control key product delivery in the supply chain.

Therefore, in this study, we developed a comprehensive enterprise application system integrated with the deep learning-based system that continuously predicts market trends and stock for small and medium-scale enterprises. The system will effectively collect data on stock sales and product information from alcoholic drinks. The essence of developing enterprise applications for real-time financial reporting and forecasting of market trends is to enable small and medium-scale enterprises in Nigeria to have access to real-time information and forecast market trends and stock for decision-making. With the developed system, Business owners and developers would register products, access product information, and collect large amounts of real-time data using the enterprise application.

The system is composed of two main components as shown in Figure 1, product registration and market forecasting. The product registration collects real-time information on alcoholic drinks and the information collected includes item numbers, date of purchase, store numbers, address of the seller, item description, etc. In the market trend forecasting, a deep learning model was implemented to forecast the market trends of alcoholic beverages. Here, long short-term memory algorithms were developed to ensure real-time forecasting of various stocks. Figure 8 shows the diagram of the proposed system that comprises the product information and market trend forecasting components.

2.2 Stock product information system

The real-time enterprise applications and inventory management system is made up of the following modules:

- Stock product information registration: the components register information about all products/items in the store. These include the brand name of the alcoholic drink, category, wholesale price, unit price, packaging type, and total unit available.
- Staff registration: The component is used to collect detailed information about the staff working in the company or retail stores. The information includes names, gender, date of birth, type of staff, address of the staff, department, and remuneration.
- Stock/package information: This contains information on the user's market preference selection of a particular brand of alcohol.

2.3 Market Trends and Stock Prediction Systems

The market trends and stock prediction system are composed of different phases that enable accurate forecasting of stocks and market trends. The phases include data collection, preprocessing, feature extraction, prediction system training, performance evaluation, and decision making as explained below.

1. **Data collection**: The data collection process involves the capturing of relevant data required for market trends forecasting. The system utilizes alcoholic drink sales activity. The important dataset information for training the market trends forecasting systems include consumption rate, most popular mix beer, distribution region, and prices.
2. **Data preprocessing:** The information collected from customers, products, and sales is affected by noise, duplication anomalies, and some missing information. Accordingly, data preprocessing methods are used to remove anomalies and data duplication in the data. In addition, inputting missing values using an average of each column is also an important

method to ensure improved performance of the disease prediction system. Here, the missing values were replaced with the mean of each data.

3. **Feature Extraction**: During the implementation of the proposed enterprise application for real-time financial reporting and forecasting of market trends for SMEs using deep learning algorithms, we identified various discriminate attributes and features, including invoice number, date of purchase, store number, store name, address, city, zip code, store location, state number, state, categories, category name, vendor number, vendor name, item number, item description, pack, bottle volume, and product cost
4. **Market trend forecasting**: After identifying the most discriminative features to develop the market trend forecasting system, the feature will be converted into a master feature vector and deployed to the machine learning models for real-time market trend forecasting. In this thesis, we utilized a deep learning algorithm that automatically extracts relevant features from raw stock information. Specifically, the thesis implemented long short-term memory. Long short-term memory is a recurrent neural network (RNN) architecture designed to handle sequential data.
5. **Prediction performance evaluation:** the performance of the proposed market trend forecasting was assessed using various performance metrics utilized to assess forecasting algorithms. The performance metrics utilized include root mean square errors, mean absolute percentage, and mean accuracy. The root mean square error (RMSE) measures the average difference between the important market trend features and compares the models regarding the ability to follow the direction of the trends and predict directional changes. The equation for computing root means square errors is as shown in eq (1). Mean absolute percentage error (MAPE) defines the forecasting ability of long short-term memory of each entry data and measures the average deviation between the forecasted values and actual values. This is depicted in eq (2). While accuracy computes the rate of correctly defined data points out of the total data point in the prediction samples. The formula for computing these performance metrics is explained below:

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y}_i)^2} \quad (1)$$

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \bar{y}_i}{y_i}\right| \quad (2)$$

$$\text{Accuracy} = \frac{1}{N}\sum_{i=1}^{N}\frac{(TP+TN)_i}{(TP+FP+TN+FN)_i} \quad (3)$$

3. ENTERPRISE SYSTEM DESIGN

The enterprise application is made up of various modules. These modules include a login module, workers management module, inventory module, and market trends and stock prediction modules.

3.1 input module

The input design contains all the necessary input forms for sales forecast data capturing/entering that are organized for the proposed system. These include login, stock, package, staff details, department, etc. Login form design: This is the form that contains the sign/sign up form for new/existing users in the proposed system as shown in Figure 1.

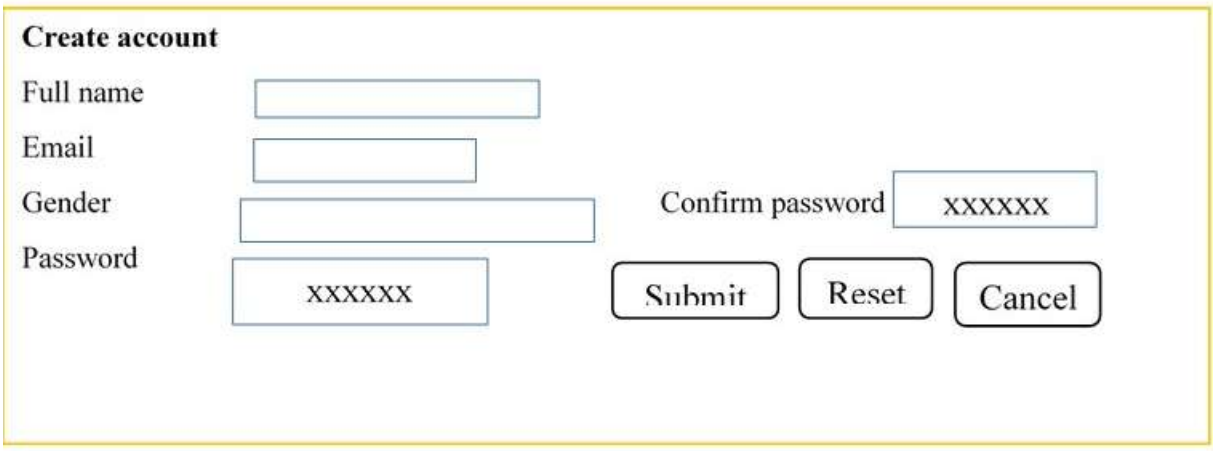

Figure 1: Login Form Design

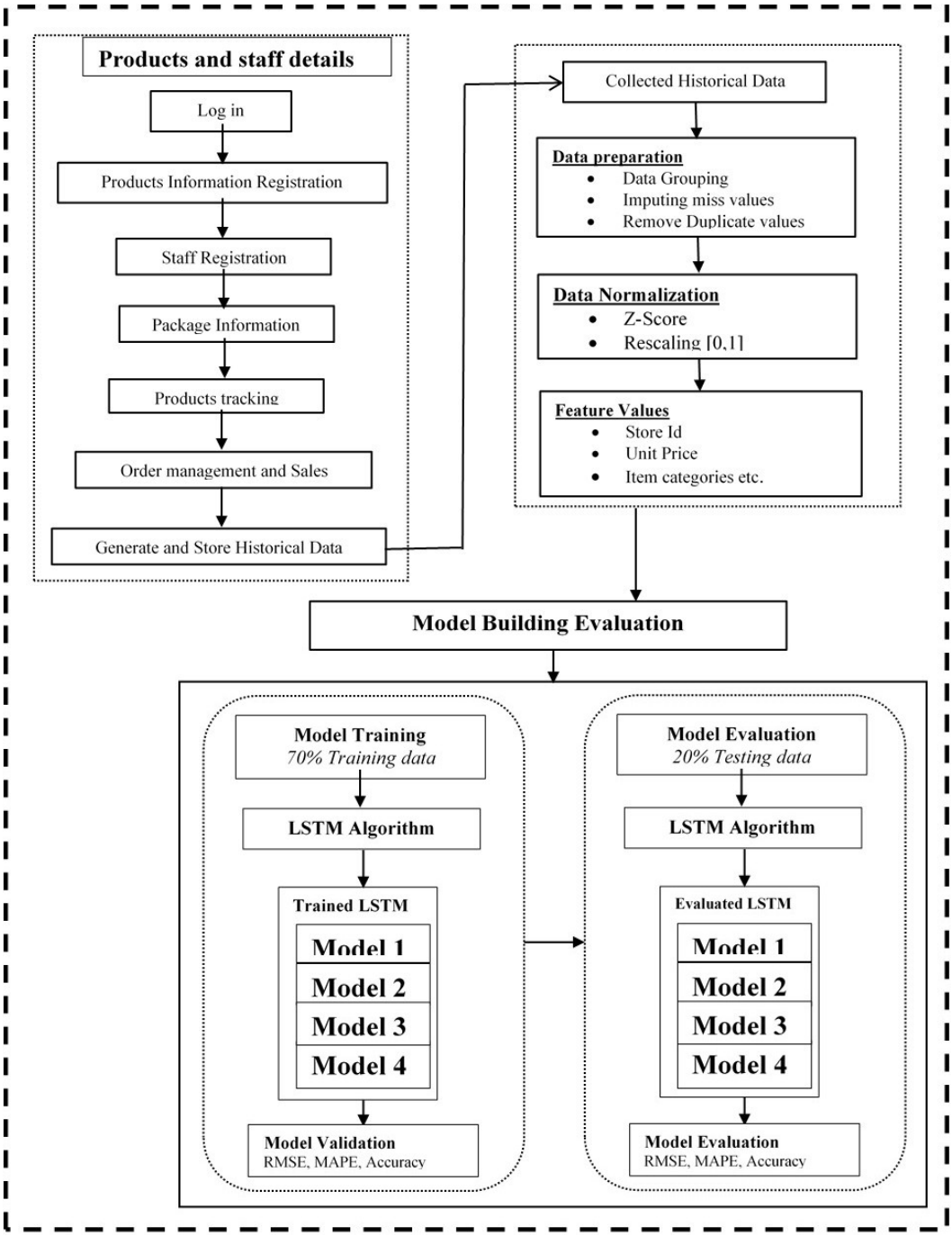

Figure 2: Architecture of the Enterprise Applications And Stock Prediction System

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Stock Registration Form Design: This form is used to enter stock details as shown in Figure 3

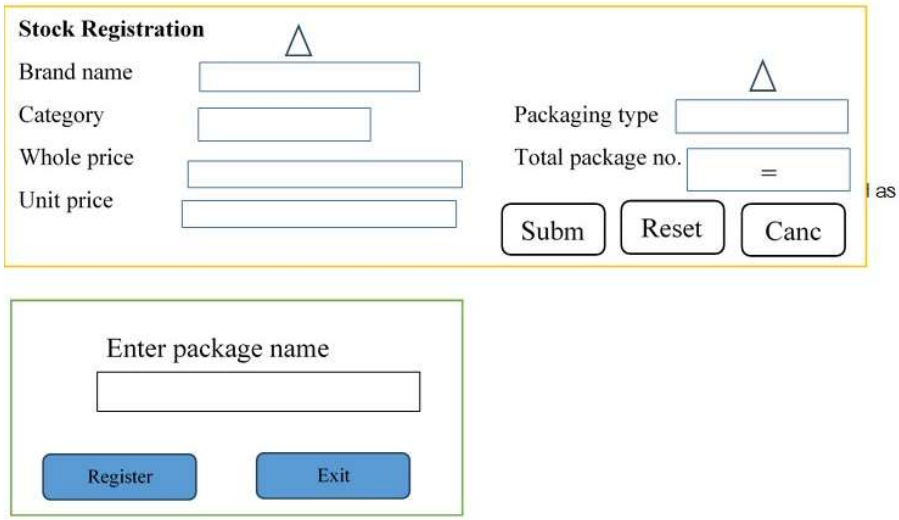

Figure 3: Package Registration Form Design

Staff Registration Form Design: This form is used to capture the staff details in the proposed as shown in Figure 5

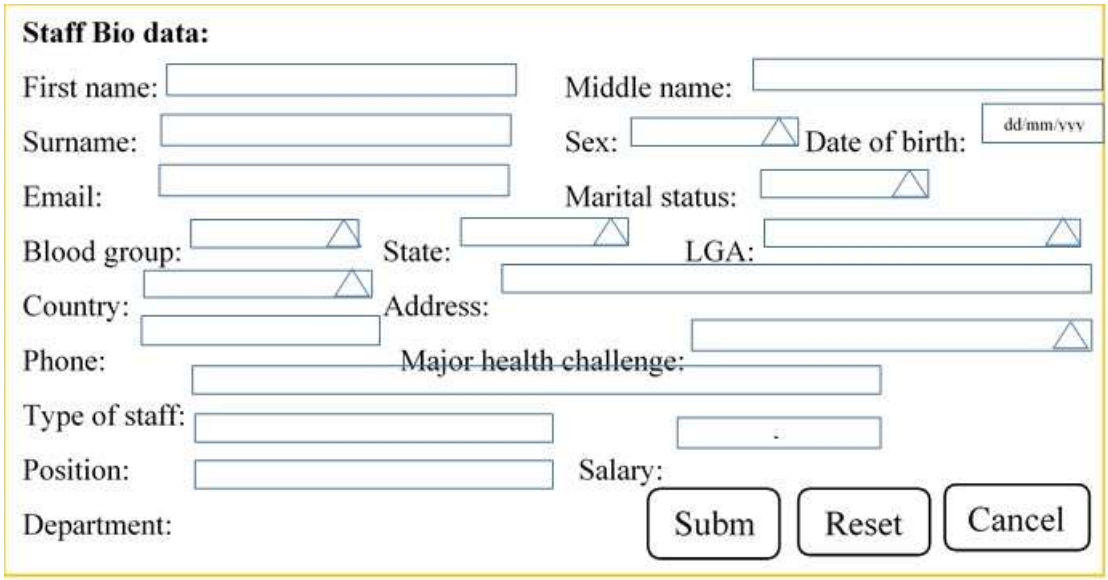

Figure 4: Staff Registration Form Design

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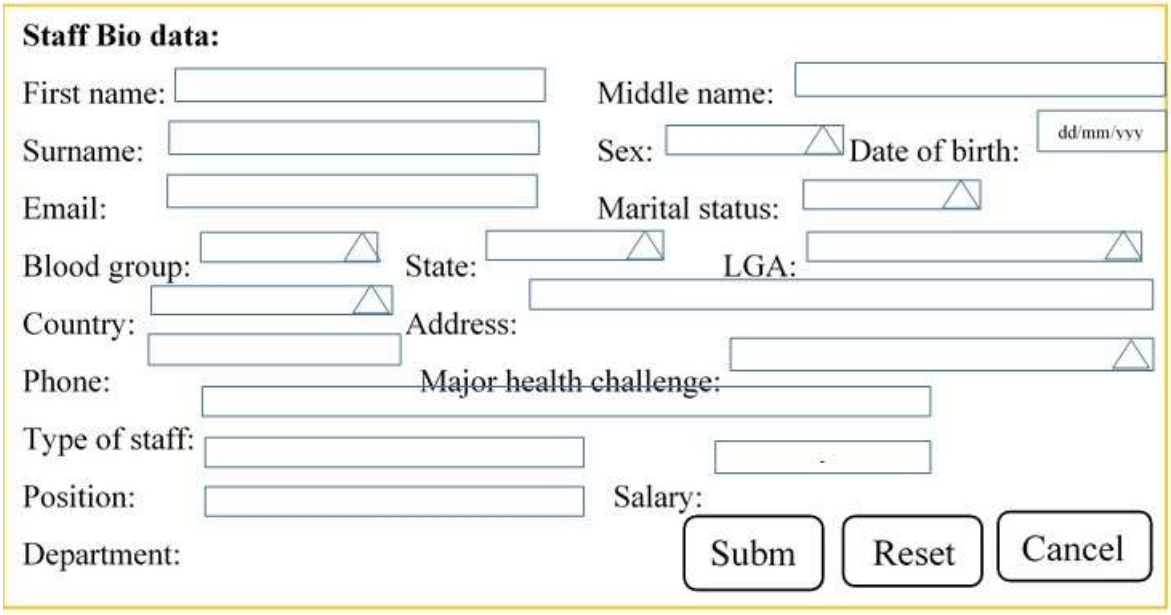

Figure 5: Staff Registration Form Design

Store department registration form design: This form is used to enter the store department details in the proposed as shown in Figure 6

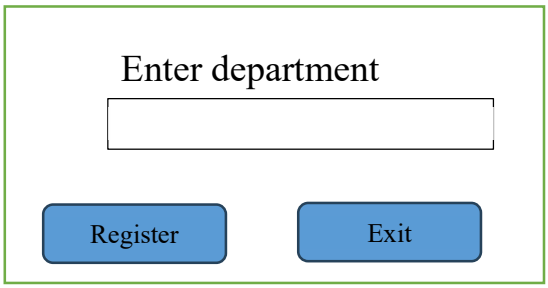

Figure 6: Store Department Registration Form Design

3.2. Database Design

This involves the database table of the system which helps to model the different objects such as stock, package registration, payroll, and data for forecasting market trends. Each object has predictive variables (attributes) on which prediction can be based therein. The database specifies the column name, data type, data size, and description of each utilized table in the designed system. Some of the tables are as explained below.

a. Users: This table specifies the operators or the system user such as the manager, sales representative, and secretary. The specification for the database is presented in Table 2.

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Table 2: Users

Column Name	Data Type	Data Size	Description
Id	Big Integer	20	Auto increment identity number
Username	Varchar	18	Username
Password	Varchar	120	User Password
First_name	Varchar	75	First name
Last_name	Varchar	75	Surname
Email	Varchar	50	Electronic mail
Active	Bit	1	Active user

b. Stocks**:** This table stores the stock's information based on the user's market preference selection and entry into the market. The stock is presented in Table 3.

Table 3: Stocks

Column Name	Data Type	Data Size	Description
Id	Integer	11	Identification number
brand	Varchar	100	Brand of the product
category	Varchar	250	Category of the product
packagingType	Varchar	100	The type of package for the product
wholePrice	Double		The whole price of the package
unitPrice	Double		The unit price of each package
totalQtyInPackType	Double		The total quantity in the package type
date	Date		The transaction date

c. Staff: This table describes the staff details for the sales forecast. The staff details are presented in Table 4.

Table 4: Staff

Column Name	Data Type	Data Size	Description
fname	Varchar	155	Full name
email	Varchar	100	Electronic mail
address	Varchar	200	Staff Address
dateOfBirth	Date		Date of birth
gender	Varchar	50	Staff gender
position	Varchar	50	Staff position
department	Varchar	50	Department of the staff
staffType	Varchar	50	Staff type
contractEndDate	Date		Contract end date
amount	Double		Amount
image	BLOB		Binary large object for image
date	Date		Date

d. Position: This table stores the details of the position of the user of the sales forecast. The position is presented in Table 5.

Table 5: Position

Column Name	Data Type	Data Size	Description
name	Varchar	100	Name of the position
date	Date		Date

e. Payroll: This table describes the payroll details of workers of the sales forecast. The payroll is presented in Table 6.

Table 6: Payroll

Column Name	Data Type	Data Size	Description
staff	Varchar	100	Name of the staff
position	Varchar	100	Staff position
workerSalary	Double		Worker's salary
workerAllowance	Double		Worker's allowance
status	Varchar	55	Status of the payment
date	Date		Date

f. Package: This table stores the details of the package of the stock of the sales forecast. The package is presented in Table 7.

Table 7: Package

Column Name	Data Type	Data Size	Description
packagingType	Varchar	100	The type of the package
date	Date		Date

g. Department: This table stores the details of the departments in the sales forecast market. The department is presented in Table 8.

Table 8: Department

Column Name	Data Type	Data Size	Description
departName	Varchar	100	Department name
date	Date		Date

3.3. System Implementation

System implementation involves transforming the design system into a working model for the development of a stock forecast framework available to the end-users (deployment) and positioning ongoing support and maintenance of the system within the performing entity. The enterprise application components were implemented as web browsers with Node.js, and MongoDB while the deep learning components were developed using Python programming, Scikit learn, and Keras

platforms. These platforms are open-source and cross-platform, and enable the implementation of scalable systems.

3.4 Market Trends and Stock Prediction

The implementation of the market trends and stock forecasting with the collection of appropriate datasets. The dataset used for the implementation is an integration of a public dataset with customer information. It contains alcoholic sales activities and includes the number of alcohols sold, brand, consumption rate, distribution region, and prices. Specifically, the implementation used the Lowa sales dataset collected between 2022 and 2024. After the collection of appropriate datasets, the data were cleaned by removing duplicate values noise, and errors. then, the data was saved as comma-separated values (CSV) for feature analysis. the features used for the implementation of the deep learning-based model are shown in Table 9.

Table 9: Dataset Attributes.

Attributes	Definition	Types
Invoice/Item Number	Number to identify the item on the invoice	String
Date	Date Item of item purchase	Date
Store Number	Unique identifies of stores	Integer
Store name	Name of stores	String
Address	Address of each store	String
City	Identifies of a city where the store is situated	String
Zip code	Identifies unique regions	Integer
Store Location	Location of the store	String
County Number	Identifies unique county	Integer
County	Name of a unique county	String
Category	Number assigned to categories of alcoholic drinks	Integer
Category Name	The types of drinks such as cocktails, dry gin, or blended whiskies	String
Vendor Number	Identifies unique vendor	Integer
Vendor name	Unique name of a particular alcoholic vendor	String
Item number	Identifies unique stores	Integer
Item Description	Identifies a unique brand of alcoholic drink	String
Pack		Integer
Bottle volume (ml)		Integer
State Bottle Cost		Float
State Bottle Retails		Float
Bottle sold	Provide the quantity of information on bottles sold	Integer
Sale (Dollars)	Amount of each bottle	Float
Volume Sold (Liters)	Average volume of alcohol sold in liters	Float
Volume Sold (Gallons)	Average volume of alcohol sold in gallons	float

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4. RESULTS AND DISCUSSIONS

This presents the results obtained from the implementation of an enterprise application for stock management and market trends forecasting using the Long short-term memory (LSTM) model.

4.1 Enterprise application for stock management.

These show the interfaces of the implementation of the enterprise applications. Interfaces include the main menu, stock registration, package registration, department registration, and staff registration as shown in Figures 4 to 8. Figure 4 shows the main menu of the enterprise application systems. The main menu comprises the dashboard, staff management, alcoholic inventory, login, etc.

Figure 7: Main Menu Of The Enterprise Application

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Stock registration form implementation: This form is used to enter stock details as shown in Figure 8

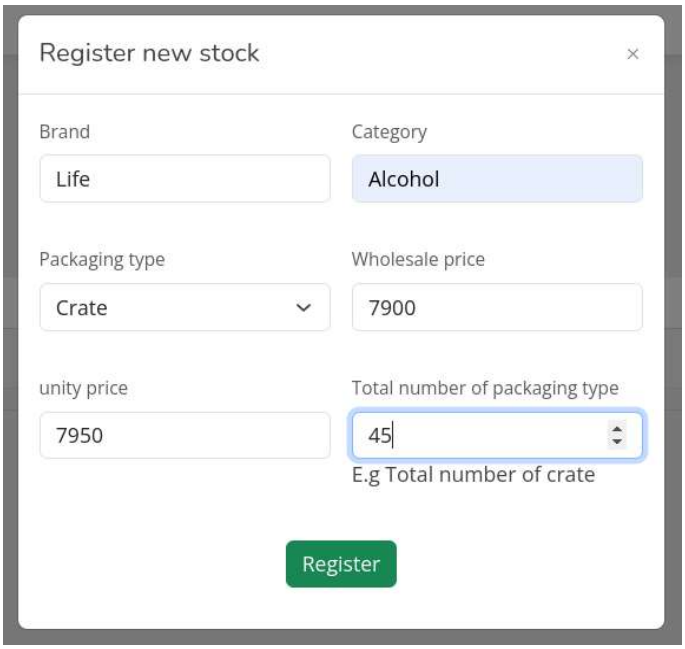

Figure 8: Stock Registration Form Implementation

Package form registration implementation: This form is used to enter the package name in the proposed as shown in Figure 9.

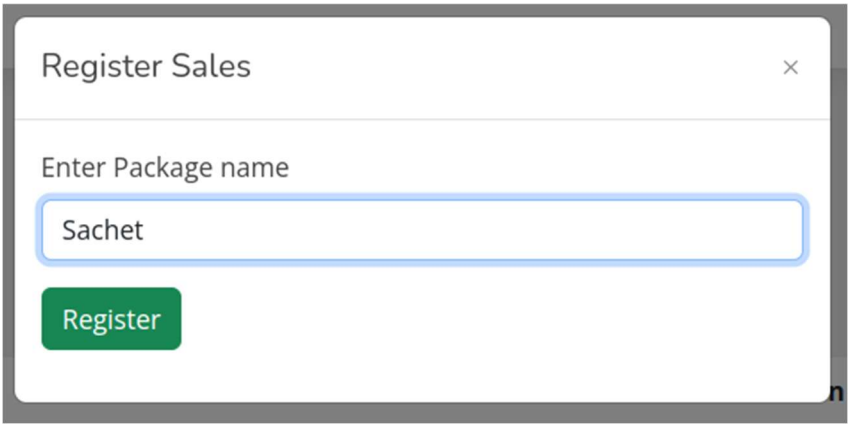

Figure 9: Package registration form implementation

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Department registration form implementation: This form is used to enter the department details in the proposed as shown in Figure 10.

Figure 10: Department Registration Form Implementation

4.2 Results obtained from the data analysis

This section of the thesis presents the results of the implemented enterprise application for real-time financial reporting and forecasting of market trends. The results obtained using the long short-term memory are shown in Figures 11 and 12.

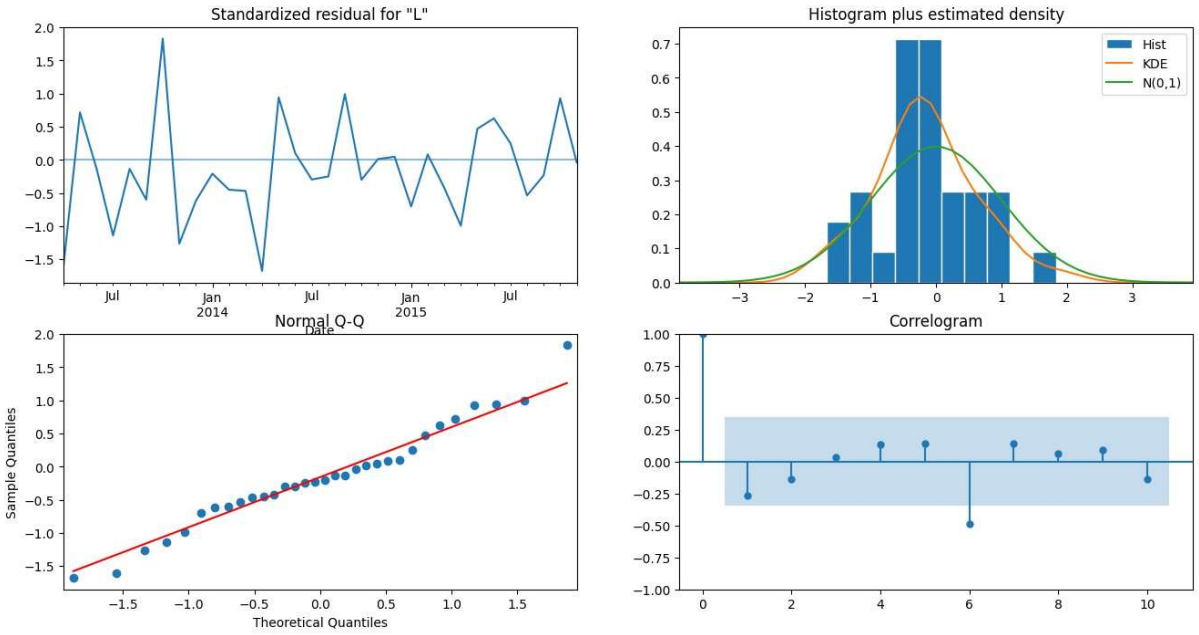

Figure 11: Performance Results Obtained Using Long Short-Term Memory

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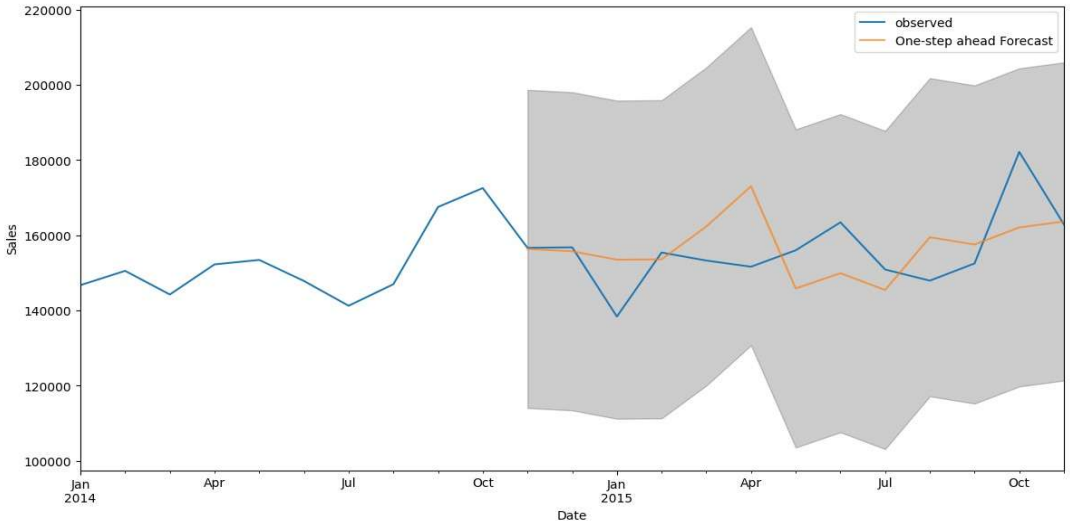

Figure 12: Validation Of The Market Trend Forecast Using Long Short-Term Memory.

Other performance results obtained during the implementation of the proposed system is shown in Figures 13 and 14.

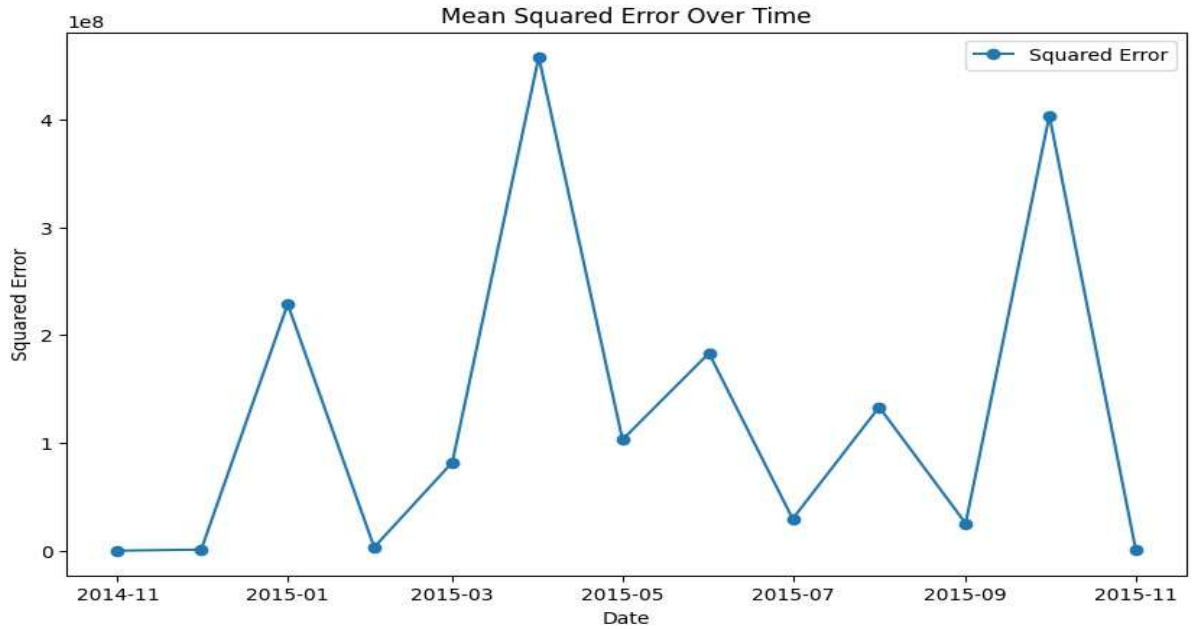

Figure 13: Root Mean Square Obtained Using The Deep Learning Algorithm

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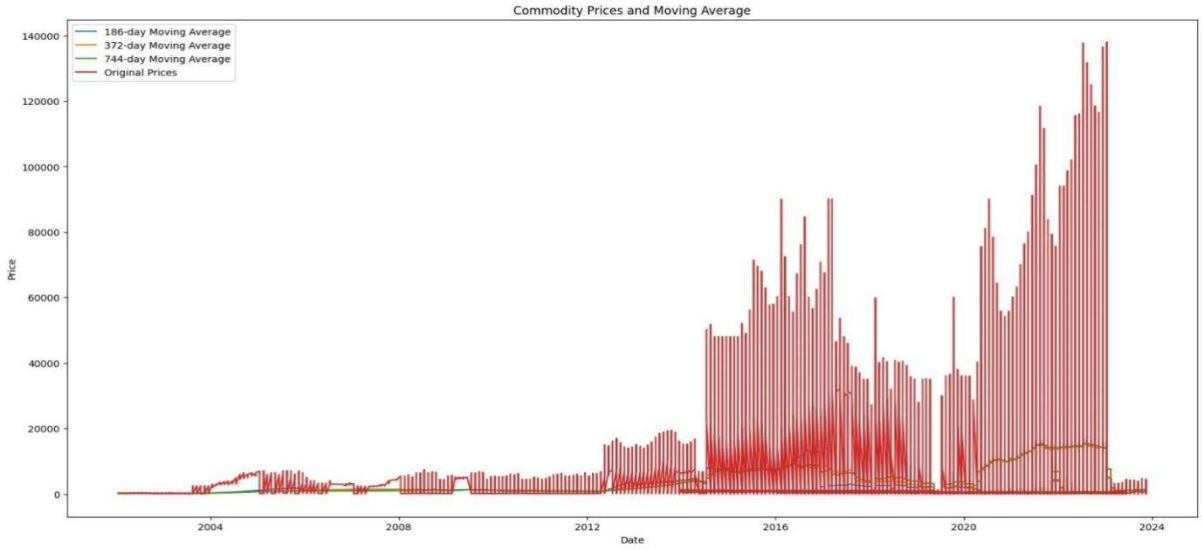

Figure 14: Moving Average Of The Alcoholic Beverage Showing The Fluctuation In Stock Price

5. CONCLUSION

Enterprise applications for real-time financial reporting and forecasting of market trends for small and medium-scale enterprises using deep learning algorithms will improve the market uptrend and downtrend challenges. We modeled the real-world scenarios of the proposed system using Object Oriented Methodology (OOM) that uses the Rapid Application Development (RAD) – based sequence of Software Development Life Cycle (SDLC) phases. This study effectively investigated enterprise systems and deep learning methods to identify pressing areas that require improvement to achieve efficient forecasting of market trends. We provided an interactive user-friendly platform that enables real-time financial reporting and forecasting of market trends for SMEs. In the future, the study will implement the integration of cloud platforms and collect large datasets to improve real-time data analysis.

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