Applying Deep Learning for the Prediction of Retail Store Sales

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Abstract

When it comes to brick-and-mortar retailing and E-Commerce, anticipating demand accurately is one of the most important aspects in minimizing loss (through unavailability of items) and maximizing profit for any time period. This literature review aims to pursue a deeper understanding in founding a prediction model for forecasting retail sales by using deep learning techniques. The researchers gathered various papers from reputable publishers and institutions and sorted those that dealt with the use of deep learning techniques and machine learning techniques. The researchers found that the most frequent techniques used are Long-Short Term Memory and Random Forest for deep and machine learning respectively. Thus, the researchers proposed a model using LSTM with learning features inherited from common features observed through the related studies gathered and Random Forest as the proposed comparator or baseline model.

Keywords
Deep Learning, Machine Learning, Sales Prediction, Baseline model, E-Commerce.

1. Introduction
Store sales are a fundamental aspect of retail. Administrators critically examine the most reliable models to aid in predicting future sales. Predicting store sales can assist in foreseeing future fluctuations or increase in sales to prepare decision-making based on past and current data. Through accurate prediction, this will aid in guiding companies or merchants in acquiring higher profits and improving customer experience through understanding sales patterns and trends. Using deep learning and machine learning techniques in predicting retail store sales provide high accuracy due to its basis and training on previous data.

This paper presents deep learning and machine learning techniques, specifically Random Forest and Long Short-Term Memory, which will be examined through various methods to determine the most accurate algorithm in retail sales prediction based on the twenty (20) papers collected from 2017 to 2021.

1.1 Objectives
Add research objectives here. Make sure to fulfil all the research objectives at the end and articulate in the conclusion. Focus on key unique research contributions.

2. Methods

The online databases used for this study are Association for Computing Machinery (ACM), ScienceDirect, MDPI and other publishers. In finding related papers, certain filters were added, such as a narrow range of publication dates between 2017 and 2021 (Bohanec et al. 2017) and dealing specifically in the application for forecasting sales, demand, or stock preparation (Elmasdotter and Nyströmer 2018).]. Then, the documents are analyzed to determine the most relevant documents to our study as well as its popularity and listed in the table of chosen studies (Table 1) (Liu et al. 2019).

2.1 Selection Technique

From a total of 46 research papers gathered, the researchers' selected the relevant studies in a two-step filtering process. First, they observed which machine learning and deep learning techniques were most used and accurate based on the results of the gathered papers. Then, the researchers eliminated papers that didn't utilize the most used deep learning and machine learning techniques that have led to a total of 20 selected studies.

Table 1. List of Published Papers After Selection

Title of Study	Source of Study	Deep/Machine Learning Techniques Used	Number of Citations
Explaining machine learning models in sales predictions (Bohanec et al, 2017)	ScienceDirect	Support Vector Machines (SVM), Random Forest (RF)	52
Crop yield prediction using machine learning: A systematic literature review. Computers and Electronics in Agriculture. (Van Klompenburg et al, 2020)	ScienceDirect	Linear Regression (LR), Long-Short Term Memory (LSTM), Convolutional Neural Network (CNN), and Deep Neural Network (DNN)	48
An optimized model using LSTM network for demand forecasting. (Abbasimehr et al, 2020)	ScienceDirect	Long-Short Term Memory (LSTM), Autoregressive Integrated Moving Average (ARIMA), Artificial Neural Network (ANN), and Recurrent Neural Network (RNN)	47
Feature Generation by Convolutional Neural Network for Click-Through Rate Prediction. (Liu et al, 2019)	Association for Computing Machinery	Convolutional Neural Network (CNN)	30
Demand forecasting with color parameter in retail apparel industry using artificial neural networks (ANN) and support vector machines (SVM) methods (Güven and	ScienceDirect	Artificial Neural Network (ANN), Support Vector Machines (SVM)	11

Şimşir, 2020)			
Retail sales forecasting with meta-learning. (Ma and Fildes, 2020)	ScienceDirect	Dual-Channel Convolutional Neural Network	11
Short-term stock market price trend prediction using a comprehensive deep learning system. (Shen and Shafiq, 2020)	SpringerLink	Long-Short Term Memory (LSTM)	7
A Deep Neural Framework for Sales Forecasting in E-Commerce. (Qi et al, 2019)	Association for Computing Machinery	Recurrent Neural Network (RNN)	6
LSTM Response Models for Direct Marketing Analytics: Replacing Feature Engineering with Deep Learning. Journal of Interactive Marketing. (Sarkar and De Bruyn, 2021)	ScienceDirect	Long-Short Term Memory (LSTM)	5
Scalable Causal Graph Learning through a Deep Neural Network (Xu et al, 2019)	Association for Computing Machinery	Deep Neural Network (DNN)	3
On the platform but will they buy? Predicting customers' purchase behavior using deep learning. (Chaudhuri et al, 2021)	ScienceDirect	Deep Neural Network (DNN), Decision Tree (DT), Random Forest (RF), and Artificial Neural Networks (ANN).	1
Statistical and Machine Learning-based E-commerce Sales Forecasting. (Dong et al, 2019)	Association for Computing Machinery	Incentive Auto-Regressive Integrated Moving Average (I-ARIMA), Long Short-Term Memory (LSTM), Artificial Neural Network (ANN)	0
A Convolutional Neural Network-based Model for Sales Prediction. (Buyar and Abdel-Raouf, 2019)	Association for Computing Machinery	Convolutional Neural Network (CNN)	0
Predicting Sneaker Resale Prices using	ScienceDirect	Linear Regression(LR), and Random Forest (RF)	0

Machine Learning. (Raditya and Hanafiah, 2021)			
Future-Aware Trend Alignment for Sales Predictions. (Liu et al, 2020)	MDPI	Recurrent Neural Network (RNN), Long Short-Term Memory (LSTM), and Artificial Neural Network (ANN)	0
A comparative study between LSTM and ARIMA for sales forecasting in retail. (Elmasdotter and Nyströmer, 2018)	Dublin Business School	Long Short-Term Memory (LSTM), Autoregressive Integrated Moving Average (ARIMA)	N/A
Using Machine Learning Approaches to Improve Long-Range Demand Forecasting. (Nowadly and Jung, 2020)	MIT Libraries	Support Vector Machine (SVM), Random Forest (RF), Artificial Neural Network (ANN), Linear Regression (LR)	N/A
A Big Data Approach to Black Friday Sales. (Javed Awan et al, 2021)	Others	Linear Regression (LR) and Random Forest (RF)	N/A
Predicting Book Sales Trend using Deep Learning Framework. (Feng et al, 2020)	The Science and Information (SAI) Organization	Convolutional Neural Network (CNN)	N/A
A Prediction Model For Automobile Sales In Turkey Using Deep Neural Networks. (Kaya and Yildrim, 2020)	Others	Deep Neural Network (DNN), Artificial Neural Network (ANN), and Random Forest (RF)	N/A

2.2 Study Filtering

From the selection process, a total of forty-six (46) studies were gathered. Of these studies, only 20 papers were deemed qualified to support the study. The distribution of sources for the chosen studies are as follows: ACM = 5, MDPI = 1, ScienceDirect = 8, Other publishers and sources = 6. A total of 20 papers.

3. Results and Discussion

The paper aims to identify the deep learning techniques and machine learning techniques relevant to predicting retail store sales. These methods are as follows (1) The usage of deep learning techniques and machine learning techniques considered in sales prediction, (2) The overview of testing the accuracy of choosing a deep learning prediction model, (3) Deep Learning and Machine Learning technique that has been utilized in the study. The filtered studies collected have the publication year of 2020 as the highest number of studies. Year 2017 (One (1) paper with reference number of Bohanec et al (2017)); Year 2018 (1 paper with reference number (Elmasdotter and Nyströmer, 2018)) (Table 2).

3.1 Deep Learning and Machine Learning Analysis

Deep Learning is a set of algorithms that are used to study and learn complex prediction models. Although Machine Learning also uses algorithms in interpreting and analyzing data, deep learning is more accurate in analyzing large data and preferable in terms of performance and output

Table 2. Usage of Deep Learning Techniques considered in Prediction of Retail Store Sales

Deep Learning Techniques	Number of Papers	Reference Studies
Long Short-Term Memory (LSTM)	7	Elmasdotter and Nyströmer (2018), Qi et al (2019), Abbasimehr et al (2020), Shen and Shafiq (2020), Raditya and Hanafiah (2021),
Artificial Neural Network (ANN)	6	Qi et al (2019), Abbasimehr et al (2020), Nowadly and Jung (2020), Liu et al, 2020), Sarkar and De Bruyn (2021), Ma and Fildes (2020)
Convolutional Neural Network (CNN)	4	Xu et al (2019), Buyar and Abdel-Raouf (2019), Van Klompenburg et al (2020), Shen and Shafiq (2020)
Recurrent Neural Network (RNN)	3	Abbasimehr et al (2020), Liu et al (2019), Sarkar and De Bruyn (2021)
Deep Neural Network (DNN)	4	Xu et al (2019), Shen and Shafiq (2020), Liu et al, 2020), Ma and Fildes (2020)

It is shown in Table 2 that the utilized deep learning techniques based from the related studies are Long Short-Term Memory (LSTM), Artificial Neural Network (ANN), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), Deep Neural Network (DNN) with LSTM being the most used deep learning technique in sales forecasting. The primarily used machine learning techniques in the 20 papers gathered are shown in Table 3. These machine learning techniques are Random Forest (RF), Linear Regression (LR), Decision Tree (DT), Support Vector Machine (SVM), Auto-Regressive Integrated Moving Average (I-ARIMA), Extreme Gradient Boosting (Xgboost), and Gradient Boosting Machine with RF being the most utilized machine learning from all the techniques mentioned.

Table 3. Usage of Machine Learning Techniques considered in Prediction of Retail Store Sales

Machine Learning Techniques	Number of Papers	Reference Studies
Random Forest (RF)	8	Bohanec et al. (2017), Nowadly and Jung (2020), Güven and Şimşir (2020), Feng et al (2020), Raditya and Hanafiah (2021), Kaya and Yildrim (2020), Liu et al, 2020), Ma and Fildes (2020)
Linear Regression (LR)	4	Güven and Şimşir (2020), Feng et al (2020), Shen and Shafiq (2020), Kaya and Yildrim (2020),
Decision Tree (DT)	3	[6], Güven and Şimşir (2020), Ma and Fildes (2020)
Support Vector Machine (SVM)	3	Bohanec et al. (2017), Nowadly and Jung (2020),
Auto-Regressive Integrated Moving Average (I-ARIMA)	2	Elmasdotter and Nyströmer (2018), Qi et al (2019), Abbasimehr et al. (2020),
Extreme Gradient Boosting (Xgboost)	1	Bohanec et al. (2017),

3.2 Deep Learning and Machine Learning in Sales Prediction

Sales prediction is a method of analyzing prediction models that aim to predict a business' marketing sales**.** Forecasting and predicting sales are relevant and allow the company or the business to predict the profit that may come in and their anticipated expenses. This can contribute to the success of the business in terms of formulating business decisions and developing data-driven strategies. Predictive models can use both machine learning techniques and deep learning techniques. However, deep learning techniques are preferable when handling a large

number of data and features related to anticipating sales demand. With this, various algorithms are utilized to predict future trends and sales demand. Through deep learning and machine learning techniques, patterns learned from the provided data are used to generate sales predictions accurately. Several deep learning and machine learning techniques were used in prediction sales from the gathered studies. A depiction of the conceptual illustration of the deep learning techniques and machine learning techniques employed in the studies included in this paper are shown in Figure 1.

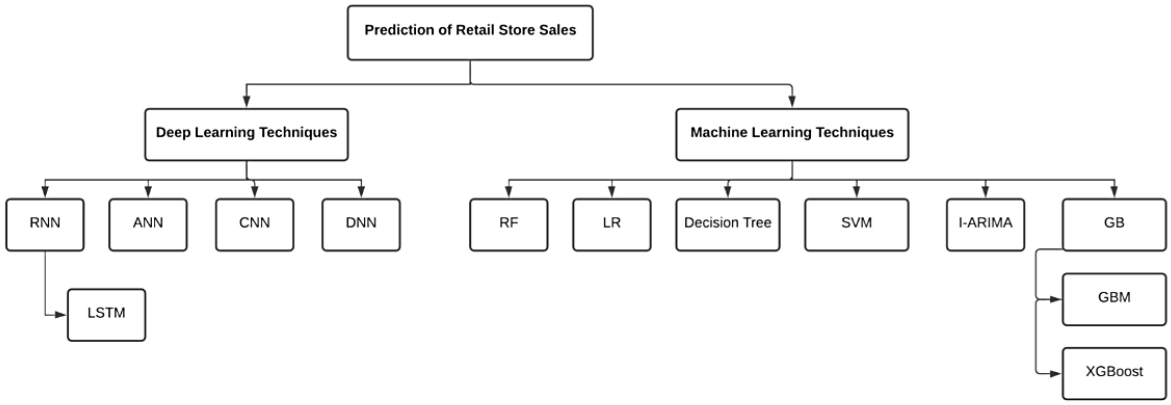

Figure 1. Schematic representation of various deep learning and machine learning techniques that are primarily used in the paper's related studies

The general overview of the steps involved in determining the accuracy of the Long Short-Term Model (LSTM) model by predicting retail shop sales is presented in Figure 2. The studies presented in this review undergo the following steps in testing the accuracy of the two models, LSTM and ARIMA. The researchers obtain predictive models through the use of research papers that are available online. Upon testing the models extracted from the predictive models, the baseline model of Random Forest (RF) is implemented to get the model with better and higher accuracy. In model assessment, the evaluation measures begin to compare the performance of the two models, LSTM and ARIMA, using the Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). Then, the T-Test to validate the result performance of the models and determine which model is better.

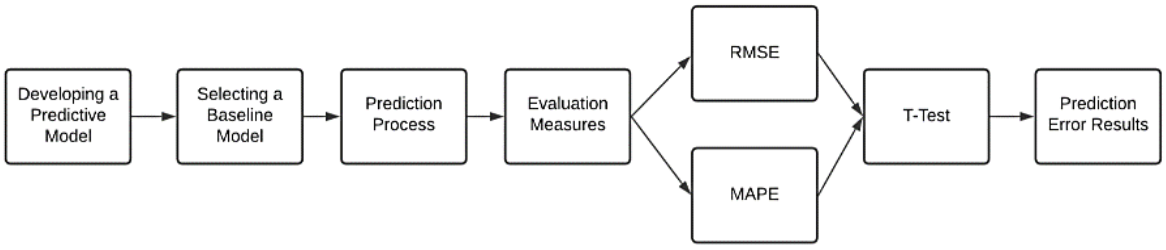

Figure 2. General overview of testing the accuracy of a chosen deep learning prediction model

3.2.1 Predictive Models

The prediction model seeks to predict future sales in retail sales by analyzing patterns that are likely to forecast future results. Prediction models through deep learning provide the possibility of getting more accurate retail store sales predictions even with big data (Elmasdotter and Nyströmer, 2018). There are two comparable models in deep learning and machine learning; LSTM and ARIMA are known models to form a major architecture for sales

forecasting accuracy (Elmasdotter and Nyströmer, 2018). ARIMA is a machine learning model that has been popular in forecasting retail sales and problems accuracy. However, ARIMA has limitations in forecasting, and it can only perform better within a short period of time, unlike Elmasdotter and Nyströmer (2018) LSTM, an artificial recurrent neural network (RNN) architecture model used in deep learning. It learned when to allow read and write information from the previous steps. Thus, when predicting retail store sales for an extended period of time, the LSTM model showed better and higher accuracy performance.

3.2.2 Evaluation Measures

In model assessment, the evaluation measures are used to test and compare the performance of the two models, LSTM and ARIMA, using the Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) (Elmasdotter and Nyströmer, 2018). A lower number for both measures indicate greater accuracy. The following are the definitions of RMSE and MAE:

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{t=1}^{n}(A_t - F_t)^2}{n}}$$

$$\mathrm{MAE} = \frac{\sum_{t=1}^{n}|A_t - F_t|}{n}$$

Previous research (Elmasdotter and Nyströmer (2018), Xu et al (2019), Liu et al (2019), Qi et al (2019), Buyar and Abdel-Raouf (2019), Abbasimehr et al (2020), Güven and Şimşir (2020), Javed Awan et al (2021), Van Klompenburg et al (2020), Shen and Shafiq (2020), Raditya and Hanafiah (2021), Sarkar and De Bruyn (2021), Chaudhuri et al (2021)) has used the evaluation measures of RMSE and MAPE to measure the prediction performance of various models, as well as LSTM and ARIMA [2, 5, 6, 8, 10, 13, 14, 17, 18], indicating that they are efficient.

3.3 Selected Deep Learning and Machine Learning Techniques

3.3.1 Long Short-Term Memory (LSTM)

Long Short-Term Memory networks are classified as a Recurrent Neural Network (RNN), used for prediction regarding time series analysis due to its capability of retaining and preserving information [2, 5, 8]. An LSTM network functionality is similar to a computer's memory as it uses cells to keep and accumulate information. LSTM can be used to predict the sales of a specific item with minimal previous data through the data sales of similar items (Qi et al, 2019). LSTM models are often used in retail sales prediction due to its high prediction accuracy [2, 5, 8].

3.3.2 Random Forest (RF)

Random Decision Forest, also known as Random Forest (RF), is a decision tree-based machine learning technique model wherein it utilizes many trees during its decision and training process. The process of the decision tree structure comprises of creating a branch for each decision and a leaf for the result, wherein through the repetition of this process creates a tree (Raditya and Hanafiah, 2021). Each attribute is chosen through the algorithm by the use of the attribute selection measure or ASM. The process of Random Forest is often used in prediction and aggression due to its high accuracy in forecasting through the use of decision trees and its capability of handling large data (Raditya and Hanafiah, 2021).

4. Proposed System

The proposed system of this study focuses on predicting sales in retail stores that adopted four-stage approaches to prepare the dataset to improve the predictive accuracy. The proposed system will take into account five (5) feature categories: these categories are static, date, user behavior, purchasing, and promotion features (Liu et al, 2019). The model will be tested for accuracy based on the Root Mean Square Error (RMSE) and Mean Absolute Percent Error (MAPE). Previous research presented in the review took this approach; however, most previous studies used datasets to analyze customer purchase behavior. The most similar studies to the solution is from the study Chaudhuri et al. 2021.

4.1 Feature Gathering

The proposed system will take into account five (5) feature categories: these categories are static, date, user behavior, purchasing, and promotion features (Liu et al, 2019). These features are described as in Table 4.

Table 4. Features to be collected and inputted to the proposed system.

Category	Sub features	Type
Static	Item Classifier (SKU)	Nominal
	Item Name	Nominal
	Item Category	Nominal
Date	Was the period a weekday?	Discrete/Binary
User Behavior	The number of favorites/bookmarks on the item.	Continuous
	The number of page views on the item.	Continuous
	The number of unique viewers on the item.	Continuous
	Purchase conversion rate	Continuous
	Average page views of other items in the same category	Continuous
Purchasing	The price of the item	Continuous
	Sales volume of the item	Continuous
	Average sales volume of the items in the same category	Continuous
Promotion	Was there a promotion for the item?	Discrete/Binary
	Grade of the promotion	Discrete
	Days after the promotion began	Discrete
	Days before the promotion began	Discrete

4.2 Long Short-Term Memory

The proposed system will take advantage of the efficacy of Long Short-Term Memory (LSTM) when dealing with time-series data to forecast sales based on the study of Chaudhuri et al. 2021. Predictions will be made in a daily (1st day) and weekly (7th day) manner and will be implemented using the Keras Python library (Elmasdotter and Nyströmer, 2018).

4.3 Data Set

The data used shall be sourced from Kaggle and processed to fit the features present in Figure 3. The data set shall be cleaned from noise such as unnecessary data (seller name, product added date, tags). The data set will be separated into a training set and testing set such that the training set would not underfit nor overfit the model (Chaudhuri et al, 2021). For this, 80% of the data set shall be allocated as the training set, with the remaining 20% as the testing set (Elmasdotter and Nyströmer, 2018).

4.4 Model Criteria and Selection

The model shall be tested for its accuracy based on the Root Mean Square Error (RMSE) and Mean Absolute Percent Error (MAPE) as prevalently used in multiple referenced papers (Liu et al, 2019), Qi et al (2019), Buyar and Abdel-Raouf (2019), Abbasimehr et al (2020), Güven and Şimşir (2020). MAPE shall also be used to compare the LSTM model against another machine learning technique (Random Forest) whose results are neck-and-neck with LSTM Bohanec et al (2017), [6], Nowadly and Jung (2020), [10], Javed Awan et al (2021), Feng et al (2020), Kaya and Yildrim (2020), Liu et al, 2020), Ma and Fildes (2020).

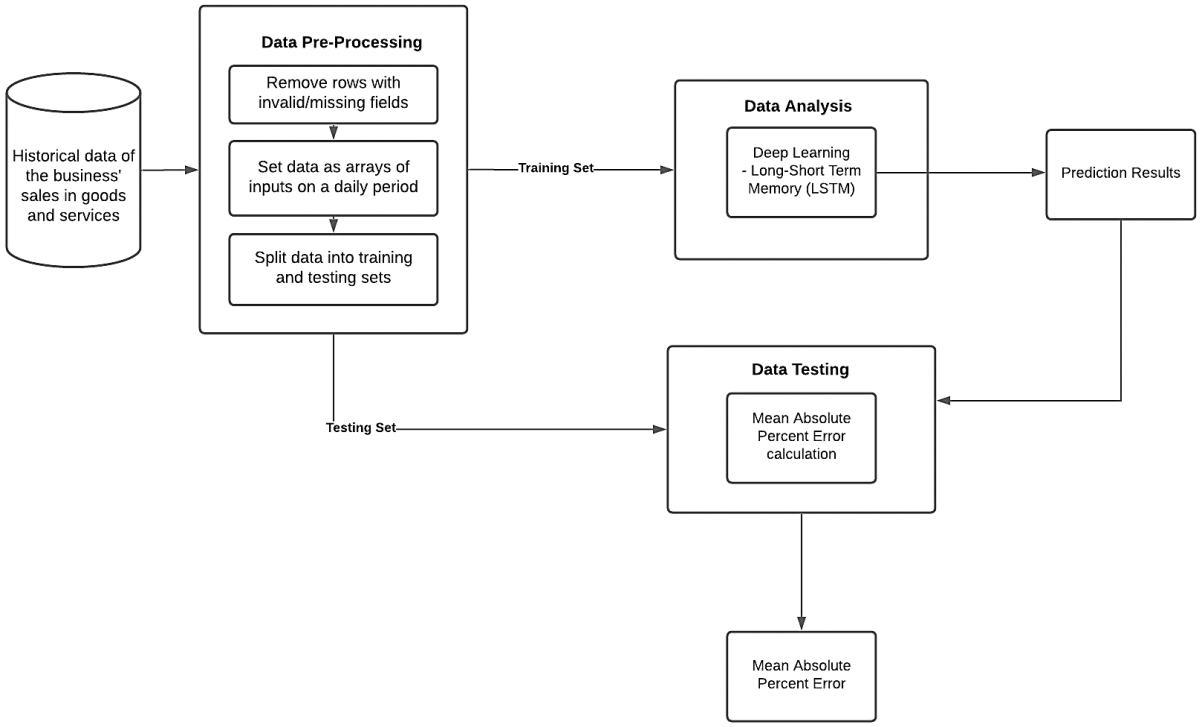

Figure 3. The conceptual framework of the proposed system.

5. Implication and Conclusion

In conclusion, the systematic literature review of this paper has been successful in terms of determining the deep learning techniques and machine learning techniques utilized in the chosen studies and their methods in implementing specific algorithms in testing the accuracy of the chosen prediction models as well as determining which technique has the greatest precision in forecasting and projecting future sales prediction. The study was based on 46 gathered research studies from reputable sources that have been thoroughly filtered. After the two-step filtering process, this has led to 20 relevant studies in which the set of deep learning techniques and machine learning techniques applied were considered. The filtered papers are related to our study about sales prediction with the application of deep learning techniques. Based on the 20 filtered studies, it has been identified that the most predominant deep learning technique used is the Long Short-Term Memory (LSTM) and the Random Forest (RF) for the machine learning technique. The researchers came up with a proposed system that primarily utilized the algorithms of the Long Short-Term Memory (LSTM) when dealing with time-series data to forecast sales and used the algorithms in the Random Forest (RF) as a baseline of the study to compare with the applied prediction model in the proposed system. The conclusions of this study's research can be utilized as a reference in the future for research that will incorporate the usage of deep learning models for sales prediction.

6. Limitation and Future Research

The limitations of the study will be assessed and improved upon by future researchers in related studies. It is recommended to improve the proposed system to a more enhanced and developed design. The researchers also suggest that future researchers increase the number of studies selected to widen the study's scope and conduct further analysis in applying deep learning to predict retail store sales better.

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