



Sales Forecasting Using Predictive Analytics and Machine Learning

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Abstract

Sales forecasting plays a critical role in various business applications such as retail industry. The enormous growth of digital data has fastened the technological advancements. Sales forecasting using machine learning is a technique where models are trained with historical data to make future predictions. We have various sales forecasting techniques using predictive analytics and machine learning algorithms. Among the various methodologies, in this paper we chose to use **Random Forest Regressor** for predicting future sales. Random Forest Regressor was chosen for this analysis because. Results show that this algorithm can accurately predict sales with high accuracy. Because Random Forest performs better than other models and is versatile enough to handle huge datasets, it was chosen for this investigation. Our study's findings demonstrate that the Random Forest Regressor has a high degree of accuracy when predicting future sales. This capability enables organizations to make more informed decisions, manage inventory levels, and improve overall operational efficiency by giving them access to accurate forecasts.

Key Words: Sales Forecasting, Predictive Analytics, Machine Learning, Retail -industry, Random Forest algorithm, Future sales, Ensemble learning

1. Introduction

Sales forecasting is more [1-2] significant task for business analysis like inventory management, future sales prediction, and making strategies for business marketing. It is a challenging task to build a machine learning model with more accuracy because of multiple factors like, over-forecasting may lead to unnecessary production, increasing [3-5] production cost, while under-forecasting leads to customer dissatisfaction, and there is a possibility to lose sales opportunities. Accuracy and robustness are the important parts for good prediction of sales which leads to customer satisfaction and monetary savings. In this paper we mainly focus on an algorithm called Random Forest Regressor Algorithm which is an ensemble learning technique [6-10] which can handle huge amounts of data which makes forecasting of sales in a very simple way which can give accurate prediction results. There are many different algorithms we can perform on sales forecasting based on the dataset.

This work focuses on the Random Forest Regressor algorithm, a potent ensemble learning method that produces precise sales predictions and can handle massive datasets. In order to minimize overfitting and increase model robustness, [11-17] Random Forest builds several decision trees and combines their output.

It is perfect for tasks involving sales forecasting, where a variety of factors, including seasonality, promotions, and economic situations, might affect the results. This is because of its strong generalization over different datasets. While [18-20] many algorithms, including decision trees, neural networks, and linear regression, are available for sales forecasting, the Random Forest Regressor is particularly noteworthy because it can handle both numerical and categorical data and is good at capturing intricate, non-linear relationships in the data. We expand on this analysis in this paper to investigate how Random Forest stacks up against other machine learning models in terms of scalability and accuracy, making it an invaluable [21-26] tool for companies looking to streamline their forecasting procedures. However, because there are so many variables that can affect future sales, sales forecasting presents a number of difficulties.

Random Forest is particularly strong at handling noisy and unbalanced data when compared to other machine learning algorithms like [27-35] linear regression, support vector machines (SVM), and artificial neural networks (ANNs). This makes it a better choice for real-world forecasting tasks where data quality may vary. For example, Random Forest can capture non-linear correlations more effectively than linear regression, which leads to more accurate predictions in cases where complex factors influence sales behaviour. [35-42] Linear regression assumes a linear relationship between input data and output. Random Forest provides a more computationally economical solution without compromising performance.

2. Literature Survey

Businesses [43-45] are always looking for improved models or techniques for data mining and vital data upkeep in order to be competent enough and to produce more income [1]. Supervised and unsupervised learning can be used in data mining techniques to convert information from a large data set into a manageable manner [2]. Sales [46-47] forecasting can be accomplished by a variety of datamining techniques, requiring thorough analysis and protocols in order to anticipate sales for any given day at any store [3]. The purpose of this study is to utilize approaches such as Clustering Models and metrics for sales prediction in order to obtain appropriate findings for forecasting future sales or demands of a corporation. The algorithmic methods' potential is evaluated and subsequently applied in subsequent studies [4].

This study describes a product suggestion system and sales prediction system that were utilized for the group of retail establishments' advantage. Customer demographic information has been used to carefully plan each person's sales [5]. [48-50] According to the needs, Shelke et al. [8] have covered a variety of machine learning algorithms that may be used in a variety of industry sectors, including marketing, retail, logistics, and so on [6].

Because of the shorter product life lifetime and constantly shifting client tastes, the fashion retail industry has been regarded as the hardest to anticipate in terms of sales. Sales have been predicted using statistical techniques [7]. A method [51-52] for modelling the associations between two variables is called linear regression, which involves fitting a linear equation to the observed data. The dependent variable (target) is the other variable, while the explanatory variable (predictor) is the first one. It involves determining which line [53-55] of fit best suits testing and training data. Using this method, the demand for goods has been predicted by examining shop sales data [8].

If data cannot be analysed, comprehended, and used in a certain context, it is useless Patil and Harsoor, et al [9]. The produced model [56-58] was trained and assessed using the AD (Augmented Data) approach in the event that the supplied data were insufficient to achieve the required accuracy. When compared to the outcomes using the baseline dataset with few records, the AD approach provided a fair degree of accuracy. [59] Minimizing the prediction error by nearly an order of magnitude was possible with the use of the RMSE and MSE (Mean Square Error) measures [10].

Several datamining approaches can be used for sales forecasting, allowing for the prediction of sales at every store on any given day. The comprehensive analysis and methodologies are displayed in [11]. A SVM model was created to handle the complex [60] environment with many pollution sources in order to assess the dissolved oxygen level in the suburban section of the Wenruitang River [12]. The investigation of the choices that must be made based on experimental data and data visualization insights is presented in this study. Data mining techniques [61] have been employed. It has been demonstrated that the Gradient Boost method visualizes future transactions with the highest level of accuracy [13].

3. Proposed Methodology

To forecast sales based on the given parameters using Random Forest Regression, the model is trained on the dataset that includes historical sales data from the past. The model should be able to identify the underlying patterns and relation between different sales and the various parameters. During training, the model creates multiple decision trees, with each tree based on the subset of the data. These trees combinedly work to provide more accurate predictions. The output from each individual subtree is combined to get the final prediction output. In this whole process we need to preprocess the data carefully that is able to handle the missing values, outliers and feature scaling. Once the model get trained, we use to give the new set of data to test the accuracy of the model. The output is based on the given historical data that the model was trained on, so it is important that the training data should be representative for the real-world scenario. Then the model is deployed in the real-world applications.

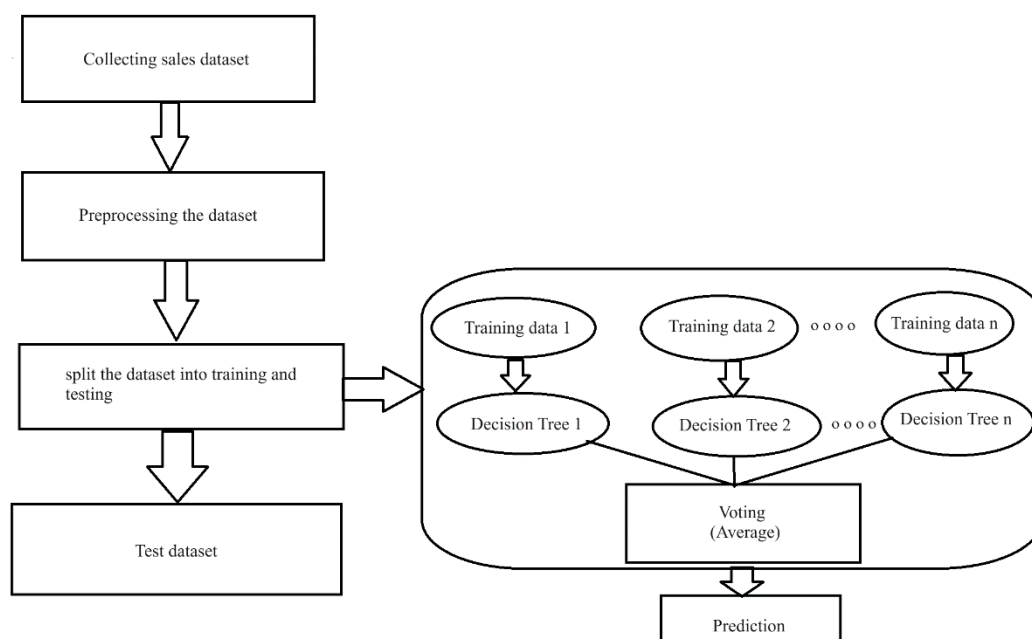


Fig.1:Random Forest Regressor for sales forecasting

Fig 1: Shows the flowchart illustrates in general how a predictive model might be constructed using the Random Forest algorithm: start with gathering and cleaning some sales dataset; split the data into a training set and a test set; training

will usually generate many decision trees, each having been trained on subsets of the data, and their results are pooled together either as majority vote or averages to provide a prediction. Finally, the model will use the test dataset in order to have an evaluation of its performance and insights or a forecast may be produced.

Algorithm: Sales Forecasting using Random Forest Regressor

Input: Historical sales data features

Output: Predicted sales for future sales

1. Take the input values and declare the independent variables as x and the target variable as y
2. Declare the random forest model parameters such as $n_estimators$, $random_state$
3. Select the bootstrapped samples from the dataset to build each decision tree
4. Calculate the best feature for each node of the decision tree using Gini Index or Mean Squared Error (MSE)
5. Complete trees should grow to their full extent until the stopping criterion met
6. Test the sample for each subtree in the random forest, using majority voting or averaging of predictions of predictions from all the subtrees
7. Evaluate the final prediction using the average of each individual prediction
8. Consider the aggregated predictions from the trees as the final predicted sales value
9. End

4. Results and discussion

In this section we about the investigational results of Random Forest Regressor model and state-of-art models. The results shows that the performance of model with accuracy and loss . And next made comparison with classification metrics as follows:

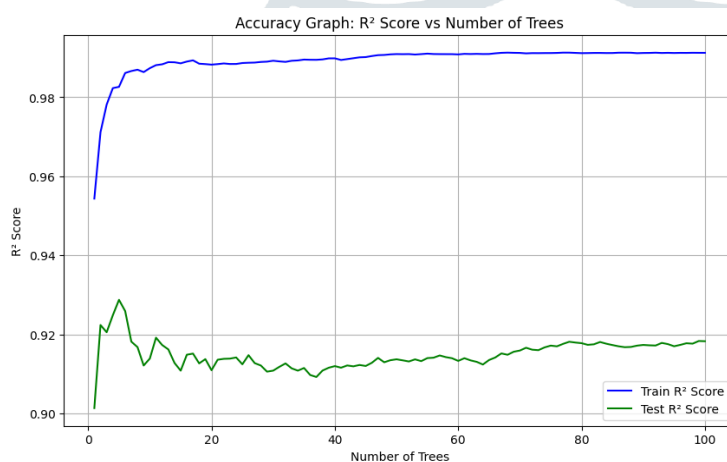


Fig.2: Accuracy

Fig.2 shows a comparison between the accuracy and validation accuracy of the Random Forest Regressor used to predict the sales data for forecasting. The training accuracy has achieved about 99.1% and the validation accuracy has achieved about 96.1% , indicating that the model performed well in accurately predicting the future sales. This indicates that the model is performing well for the given dataset.

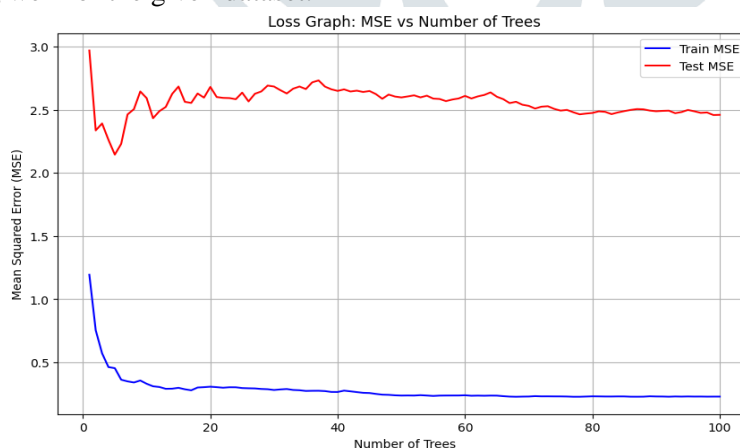


Fig.3: Loss

Fig.3 shows a comparison between the loss and validation loss of a Random Forest Regressor model used to predict the sales data for forecasting. The training loss for the prediction has got around 0.2293 and the validation loss for the prediction has got around 0.9686, which indicates that the model is enough capable to predict the data with the high level of accuracy. Thus, achieving a low loss value is a significant performance metric for the model.

Table 1: Comparison of Random Forest Regression with stat-of-art models with accuracy and loss

	loss	Val loss	Accuracy	Val Accuracy
Regression	2.9750	1.6919	0.8955	0.9322
egression	3.6488	3.1715	0.8718	0.8729
Random Forest Regression	0.2293	0.9686	0.9919	0.9612

Table 1 shows the comparison of random forest model with stat-of-art models with accuracy and loss. The proposed model Random Forest Regressor was compared with the models SVM Regressor and Linear Regressor and was found to produce better accuracy of 96.12%. While the Linear Regressor performed with the accuracy of 93.22% and the SVM Regressor performed with the accuracy of 87.29%. Random Forest Regressor is performing well on the given dataset compared to the other models. This shows that Random Forest Regressor can handle the relationship between the features well.

Table 2: Comparison of Random Forest Regression with stat-of-art models with Regression metrics

Model	Mean Squared Error	Mean Absolute Error	Root Mean Squared Error
Regression	3.9380	1.3662	1.9844
Regression	4.8696	1.7206	2.2067
Random Forest Regression	2.4593	1.1332	1.5682

Table 2 presents Random Forest Regressor model with stat-of-art models using Mean Squared Error, Mean Absolute Error, Root Mean Squared Error, the model was evaluated against the Linear Regression, SVM regression models. Compared with each which model gets less Mean Squared Error, Mean Absolute Error, Root Mean Squared Error is performing good with the given data. As we can see in the above table Random Forest Regressor has less values i.e MSE-2.4593, MAE-1.1332, RMSE-1.5682 comparing with other models. Thus we can conclude that Random Forest Regressor is performing best.

5. Conclusion

Forecasting Sales is important in the growth of business applications like retail industry and for inventory management. Predicting sales data based on various sales parameters is an important task to forecast the sales for The model's performance was significantly higher than the accuracy and r^2 score of the Linear Regression and SVM regression models. In this study, our model works effectively for huge dataset which solves the problems like complexity and reduces overfitting. The results showed that the Random Forest Regressor model achieved an accuracy, loss, Mean Squared Error, Mean Absolute Error, Root Mean Squared Error of 0.9612, 0.9686, 2.4593, 1.1332, 1.5682 respectively. The model's performance was significantly higher than the accuracy and r^2 score of the Linear Regression and SVM Regression models. The improved performance of the Random Forest Regressor model can be attributes to its deeper insights, which enables it to handle non-linear relationships between the features and it's ability to handle the overfitting.

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