Regression Analysis: Walmart Sales Forecasting

ECE 9063 Data Analytics Foundations
Yaozhuo Wang
251009638
ywan3223@uwo.ca

1 Problem Description

Walmart sales Forecasting Dataset provides historical sales data from more than 100 departments of Walmart stores located in different regions. As one of the leading retail stores in the US, Walmart, each store has a large number of departments. The historical sales data includes the basic situation of every week from 2010 to 2013. Additionally, Walmart hosts several promotional markdown sales all year round. These reductions occur before significant vacations. There are four largest markdowns which are Super Bowl (February), Labor Day (September), Thanksgiving (November), and Christmas (December). [1]

Predicting the department-wide sales for each store is the goal of the project. Unforeseen demand is a hurdle for the company, and occasionally stock runs out because of a bad machine learning system. Modelling the effects of markdowns on these vacation periods in the absence of complete/ideal historical data is one of the challenges given by this forecasting problem. The perfect machine learning algorithm will precisely estimate demand and consider variables like the CPI, unemployment rate, and other economic situations.

Training a suitable data model to forecast department-wide sales for each store is our forecasting challenge. Data need to be explored and cleaned to understand the attributes. Determine the relevance of the attributes to weekly sales by compiling and understanding the data and making the feature selection to determine the retention or deletion of data. After developing the framework, the cleaned dataset needs to be evaluated by three algorithms. To measure the accuracy of the algorithms, results will be compared by hold-out validation using the appropriate metrics for the forecasting problem. [1]

2 Data for modelling

The goal of the problem is to predict the sales of Walmart stores with the historical sales data. This historical information includes weekly sales from February 5, 2010, to July 26, 2013. The dataset is from the Kaggle dataset “Walmart Store Sales Prediction - Regression Problem” [1]. The dataset contains 6745120 data that have been categorized using 16 variables.

TABLE I. DATA DICTIONARY

Variable	Variable Explanation
Store	ID of the store
Dept	ID of Department in the stores
Date	Date of the start of accurate week
IsHoliday	whether the week is a special holiday week 1 – Holiday week 0 – Non-holiday week
Type	A to D, four types of stores
Size	Size of the store

Temperature	Temperature of the day of sale
Fuel Price	Average fuel price of the week
Unemployment	Prevailing unemployment rate
Markdown1	Five different types of markdowns
Markdown2	
Markdown3	
Markdown4	
Markdown5	
CPI	Prevailing consumer price index

There are four holiday events during every year. The time of the holiday also effect the weekly- sales.

TABLE II. HOLIDAY TIME

Super Bowl	12-Feb-10, 11-Feb-11, 10-Feb-12, 8-Feb-13
Labour Day	10-Sep-10, 9-Sep-11, 7-Sep-12, 6-Sep-13
Thanksgiving	26-Nov-10, 25-Nov-11, 23-Nov-12, 29-Nov-13
Christmas	31-Dec-10, 30-Dec-11, 28-Dec-12, 27-Dec-13

Because the size of the dataset is too large, the historical sales data of the first store will be chosen for the regression analysis and to solve the forecasting problem. After cleaning the data, I drop some of the samples with Nan values. It includes 3657samples and 16 variables in the training dataset and 2783 samples in the test dataset. isHoliday is the binary attribute. While there is no holiday, the value will be '0'. Otherwise, the value will be '1'. And other data types are integer and float.

3 Background

Since the Walmart sales Forecasting problem is a regression problem, I choose three algorithms which are Linear Regression, Random Forest, and Support Vector Machine to train the data.

Linear regression: To minimize the residual sum of squares between the observed targets in the dataset and the targets predicted by the linear approximation, Linear Regression fits a linear model with coefficients w = (w1..., wp). When fitting a linear regression model to a set of data, it is important to pay close attention to the data's range. When attempting to forecast numbers outside of this range using a regression equation, it is frequently unsuitable and may provide astonishing results. Extrapolation is the term for this method. [2]

Random forest: A huge number of distinct decision trees work together as an ensemble in a random forest. The class with the highest votes becomes the prediction made by our model. The random forest's trees each spit forth a class prediction. The best results come from a large number of very uncorrelated models (trees) working together as a committee. [3]

Support Vector Machine (SVM): A group of supervised learning techniques used in machine learning are called support vector machines. It works well in high-dimensional spaces and when there are more dimensions present than there are samples. Additionally, it is a flexible approach that is specified for the decision function using various Kernel functions. Both dense and sparse sample vectors are acceptable inputs for scikit-support lean's vector machines. An SVM must fit on sparse data to be used to make predictions for such data. [4]

4 Methodology (Algorithms)

- Cleaning data

Before modelling, the dataset needs to be cleaned up to reduce the error. Original train dataset needed to be collected by merging feature.csv and store.csv to train.csv. All the attributes need to be in one data frame to proceed to fix NaN values and oth help to explore the specific data without going through the specific files. Due to the high dependencies on the date, all features will be kept in the training dataset. All the Nan values need to be filled with related numerals to keep the modelling running properly. For Temperature, Fuel price and Unemployment, Nan values will be filled by the average to keep the training dataset more reasonable than filled in with zero. Other Nan values in Markdown will be filled with zero. After that, all the zero values will be dropped to delete the extreme values to keep the clean dataset. Repeat the same operation to test.csv to get the test dataset.

- Algorithms applied

The following stage is to use an algorithm with the ideal parameters to achieve the results after analyzing, cleaning, and preparing the data. First, split data into 4 sets (x_train, x_test, y_train, y_test). In the process of splitting data, x_train is the weekly sales of the train data, and y_train is other attributes. And x_test is the data from the test dataset.

Three models have the same preparation and data split process. Use three estimators (Linear regression, Random Forest, Support Vector Machine) in sklearn.linear_model to train the data. The algorithm splits the samples and selects one characteristic. We can select and pass as a parameter the function that will be used to evaluate the quality of a split. fit( ) method is used to train and analyze the data in the code. pre() method is the model consisting of the model parameters calculated by fit(). The value of pre() is obtained by making predictions on the explanatory variables.[5]

- Evaluation procedure

Using hold-out validation to evaluate the three models. In the dataset of the Walmart historical sales data, the dataset has already split up into train and test set. The test set is used to evaluate how well the model works on data that has not yet been seen, whereas the training set is used to train the model.

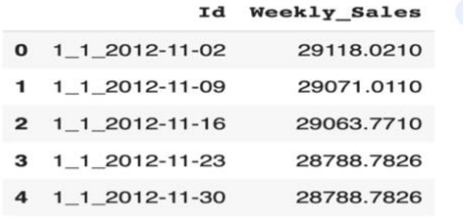
5 Results Comparison

Mean absolute error (MAE) is a measure of mistakes between paired observations describing the same phenomenon. The MAE is determined by dividing the total absolute errors by the sample size [6]. In the comparison of results obtained with three different algorithms, MAE is used to determine whether the model is suitable. Due to the size and reality of the original dataset, it is difficult to get an accurate model for the dataset. Although MAE is too big, it is easy to know that RANDOM FOREST is the best model. And there is a predicted value for the weekly sales in 2012 with the model of random forest.

TABLE III. ALGORITHMS' MAE

Algorithms	MAE
Linear regression	46859.845032294004
Support Vector machine	46326.78357465562
Random forest	35980.95243674864

FIGURE I. PREDICTED WEEKLY SALES



```
               Id   Weekly_Sales
0  1_1_2012-11-02     29118.0210
1  1_1_2012-11-09     29071.0110
2  1_1_2012-11-16     29063.7710
3  1_1_2012-11-23     28788.7826
4  1_1_2012-11-30     28788.7826
```

Reference

[1] M. Y. H, “Walmart dataset,” *Kaggle*, 26-Dec-2021. [Online]. Available: https://www.kaggle.com/datasets/yasserh/walmart-dataset. [Accessed: 19-Oct-2022].

[2] O. O. Aalen, “A linear regression model for the analysis of Life Times,” *Statistics in Medicine*, vol. 8, no. 8, pp. 907–925, 1989.

[3] “Support Vector Machine,” *Machine Learning*, pp. 137–150, 2016.

[4] L. Breiman, *Machine Learning*, vol. 45, no. 1, pp. 5–32, 2001.

[5] Z. H. I.-H. U. A. ZHOU, *Machine learning*. S.l.: SPRINGER VERLAG, SINGAPOR, 2022.

[6] T. Chai and R. R. Draxler, “Root mean square error (RMSE) or mean absolute error (mae)? – arguments against avoiding RMSE in the literature,” *Geoscientific Model Development*, vol. 7, no. 3, pp. 1247–1250, 2014.