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RESEARCH ARTICLE

Optimized Warehouse Management of Perishable Goods

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ABSTRACT

In recent years, food wastage becomes the major problem of the world and researchers indicate that 20-60% of the total production is lost in the food supply chain.[1] Due to perishable nature and the cost of the products fresh food companies face more challenges throughout the supply chains. An order proposal is generated for all the products for a time period of a week by the integration of Machine Learning and loud and also taking into supply chain with some barriers such as supplier delivery times and also the maximum and minimum number of orders. The whole process of prediction is done using Random Forest Regression algorithm. This paper focuses particularly on perishable goods and analyzed based on the accuracy of the training and testing data.

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Introduction

As the population increases at a rapid rate the necessity to feed them, there is a requisite to reduce the tones of perishable waste.[2] About one third of global fresh fruits and vegetables (FFVs) are thrown away due to their quality. The particular aspect that must be considered in the competitive management of fresh food supply chains is concern for the deterioration in product quality. Maintaining high food quality standards is important for product market value, customer happiness and in turn for the long term reputation of the organization.[3]

It has been a formidable task to handle the perishable food supply chains due to its short lifespan and the possibility of spoilage of the product due to its deterioration nature.[4] All these components can cause a substantial amount of shortage of food items and retail loss.

With the use of Machine Learning and its algorithms we have created a way for the optimization of the goods so that the wastage of perishable goods can be minimized to a maximum level. Machine learning and cloud both integrated together taking into account supply chain constraints, minimum or maximum order quantities can be predicted. This suggests for the required amount of perishable food products to be stored in the warehouse by the retailer for better sales.

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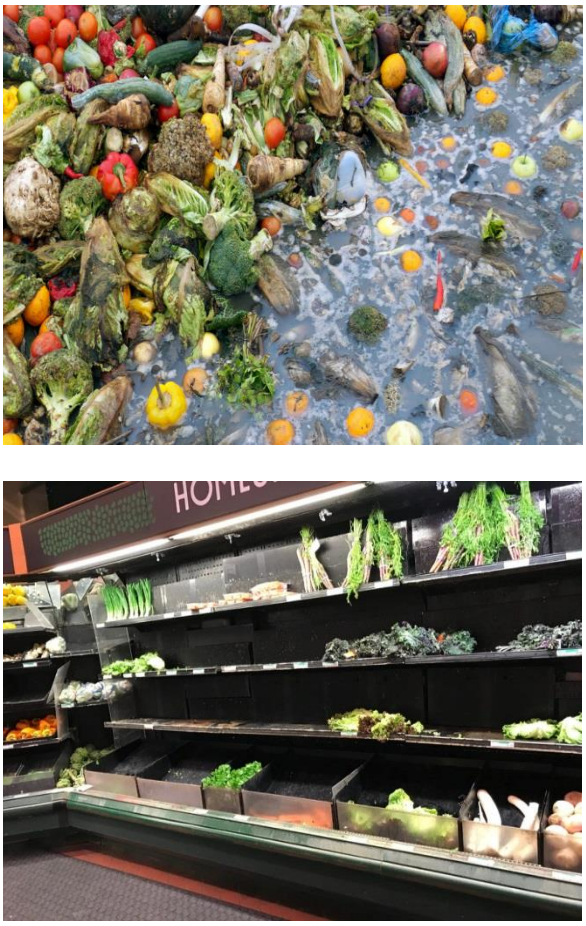

Fig. 1. Current Scenario of how the foods are being wasted due to lack in management of the warehouse

Literature Review

First-expired-first-out (FEFO) was the approach for a supply chain management that was first in the late 1980s. The basic concept is to implement stock rotation in such a way that the leftover storage time of each item is best matched to the remaining transport duration options, to reduce product waste duration transportation and provide product continuity at the store.

Fresh food supply chain management and deep frozen foods have a rise in the number of researchers. Ahumada and Villalobos (2009) presented an overall study of agro-food supply chain.[5] LAbuza (1982) reviewed the significance of preserving and maintaining the freshness of food products in industry and academic sectors.[6] Rong et al. (2011) introduced an approach that integrates food quality in decision making, production and distribution in a food supply chain. They also determined product deterioration by time and temperature. Few scholars took customer satisfaction into consideration. If the customer was not convinced, a penalty cost would be generated from the spoilt food.

Methodology

The solution to this problem we have proposed concentrates on both Cloud for collecting dataset and Machine Learning though Python to predict the amount of goods to be ordered in a range of one week. This is possible by collecting and storing the data of each order a customer makes for a range of one year in Google Cloud Database and then processing this data using Random Forest Regressor algorithm to predict the quantity of goods to be ordered in the next week and also for the consecutive ten weeks.

With the outreach of online shopping and the advancement in the delivering services many customers started to buy perishable products on business to customer platforms. Thus we have implemented and integrated this idea of webpage for online shopping and machine learning and cloud based services.

By doing so, we will be able to predict the demand of products for the following week, buy and store only the required amount of perishable goods in the warehouses so that the wastage of food and money can be avoided at the same time.[7] Thus, this helps both the retailer and customer in a way that the loss for retailers will be minimized with customer satisfaction as the customers get good quality food products.

Theoretical Analysis

The expansion in the volume of data and its diversity is the result of the bigger dataset. To manage and evaluate these new and potential valuable data sets, new methods and application have been developed in the form of predictive analytics. One of these methods is Machine Learning (ML). ML has helped us to predict the amount of goods the retailer needs to store in his warehouse so that his perishable goods do not deteriorate. This was possible as a prediction is ideal for mobile applications, websites and other applications that use results interactively.

A. Block Diagram

The below block diagram shows the schematic representation of the process that takes place.

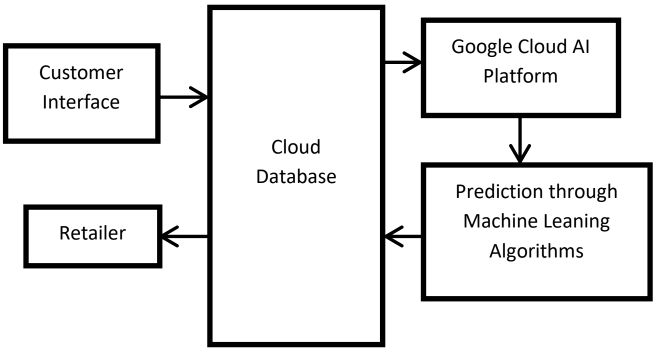

Fig. 2. Block Diagram showing the flow of work and modeling of the process

From the user the data is collected and is stored and processed and then sent to Google Cloud AI Platform where the prediction is done for the following week and next ten weeks from the previous history of data and the predicted value is stored in cloud which is later on the retailer.

B. Software Designing

The data set required to predict the amount of goods will be purchased during the next full week by machine learning is done by getting the data from the customers. This is made possible by creating a website for the retailer where he will showcase all the goods available in his warehouse.

Each time a customer makes an order, the data of goods and its quantity is sent to the cloud where they are stored. After a time span of one week the data set collected is sent to the Google Cloud AI Platform, where machine learning is applied for prediction. The retailer can easily understand and makes a profit by ordering a correct amount and selling them without any deteriorated food left.

Experimental Investigations

The data was collected from Kaggle platform as the work hasn't come into play. The entire dataset was used to predict using different algorithms. The dataset consists of 913000 rows and 7 columns namely store number, item number, year, month, day of the week, week of the year. There were totally 50 items and 10 stores.

The table 1 shows the prediction accuracy of the entire dataset (in percentage) using various algorithm and their remarks was noted. It is clear from the table that SVR regression takes a lot of time to produce an output since the dataset was huge.

Table 1. Accuracy for the entire dataset

Algorithms	**Training Accuracy**	**Testing Accuracy**	**Remarks**
Linear Regression	9.386	9.314	Has a very low accuracy
Polynomial Regression (degree 2)	18.43	18.5	Has a very low accuracy
Polynomial Regression (degree 3)	18.67	18.76	Has a very low accuracy
Support Vector Regression (kernel = rbf, C= 9)	There was no output for a runtime of 1-day	There was no output for a runtime of 1-day	Takes too long to produce output
KNN (C = 7)	51.12	34	Comparatively high accuracy and takes less time
Decision Tree Regression (Criterion = mae)	27.98	27.92	Has a nearly 50% accuracy only and also takes time
Random Forest Regression	46.3	45.76	Has a higher accuracy than other models

As the database was huge with nearly 913000 rows, which will be similar to the real-time data, it did not perform well both in time competency and as well as in accuracy determination. Thus the database was filtered and predicted with each item number and also with each store number.

The below table, table 2, shows the prediction accuracy of the dataset filtered shop wise (in percentage) using various algorithm. It is clear from the table that all the algorithms gives very low accuracy in the range of 10 to 50% which will not be suitable for a large-scale company.

Table 2. Accuracy for each Store number

Store No. / Algorithm	**Linear Regression**		**Polynomial Regression (degree 2)**		**Polynomial Regression (degree 3)**		**Support Vector Regression (kernel = rbf, C=9)**		**KNN (C = 7)**		**Decision Tree (Criterion = mae)**		**Random Forest Regressor (Criterion = mae)**	
	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test
1	11.37	10.58	21.94	21.58	22.19	21.9	32.67	31.24	43.11	23.79	32.25	31.42	48.24	46.95
2	11.49	10.86	22.33	22.22	22.59	22.57	33.09	31.83	43.87	24.73	31.9	31.28	49.29	48.39
3	11.45	10.71	22.19	21.89	22.46	22.23	32.93	31.72	43.52	24.47	33.19	32.66	48.67	48.05
4	11.39	10.63	22.01	21.84	22.27	22.2	32.7	31.58	43.49	24.15	32.9	32.09	48.36	47.55
5	10.96	10.34	21.35	21.36	21.6	21.64	31.8	30.78	42.46	23.25	32.19	31.84	47.6	46.81
6	10.94	10.26	21.36	21.28	21.63	21.59	31.93	30.77	42.85	23.47	31.42	31.07	47.59	46.85
7	10.91	10.23	21.27	20.92	21.52	21.2	31	30.75	42.32	23.03	31.64	31.15	46.8	46.01
8	11.49	10.74	22.19	22.09	22.46	22.43	33.05	31.82	43.77	24.51	33.44	32.51	48.83	47.75
9	11.39	10.84	22.07	22.03	22.32	22.38	32.72	31.73	43.33	24.5	33.02	32.31	48.83	47.92
10	11.3	10.83	22.1	22.05	22.37	22.38	32.93	31.67	43.67	24.23	33.43	32.68	48.41	47.79

So the prediction of item wise was also carried on, which is given in the table 3. This shows the prediction accuracy (in percentage) for various algorithms tested for first ten item numbers alone.

Table 3. Accuracy for each Item Number

Item No. / Algorithm	Linear Regression		Polynomial Regression (degree 2)		Polynomial Regression (degree 3)		Support Vector Regression (kernel = rbf, C=9)		KNN (C = 7)		Decision Tree (Criterion = mae)		Random Forest Regression (Criterion = mae)	
	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test
1	19.16	16.66	38.17	35.91	38.65	36.61	62.42	60.22	67.87	55.71	48.92	48.21	63.47	60.8
2	23.33	23.13	46.51	45.95	46.87	46.5	76.39	75.29	80.13	72.1	59.14	58.84	77.04	75.49
3	21.94	20.18	42.73	42.26	43.24	42.72	70.39	68.67	74.67	64.7	54.46	53.16	70.98	68.51
4	18.09	18.26	37.79	37.14	38.33	37.64	62.11	59.91	67.67	54.81	48.63	48.13	63.85	61.18
5	18.43	17.35	36.64	33.94	36.93	34.28	58.96	55.93	65.18	50.46	45.23	43.3	60.96	57.33
6	23.58	22.5	47.02	46.27	47.63	46.56	76.8	74.99	80.6	72.01	59.18	59.09	76.52	74.38
7	23.31	21.91	46.84	46	47.47	46.52	76.3	75.14	80.28	71.63	58.48	59.04	76.16	75.82
8	24.55	23.5	48.34	47.68	49.01	48.25	79.05	78.02	82.59	74.77	61.16	61.38	78.80	78.25
9	23.01	21.74	45.53	45.63	46.06	46.15	74.26	73.97	78.35	70.25	58.26	57.57	73.71	72.18
10	24.61	23.16	48.16	47.39	48.82	47.8	78.82	77.35	82.18	74	60.74	60.81	79.01	78.04

It is clear from the above both tables that Decision Tree gives low accuracy when compared to other three algorithms for this type of dataset. From the above two tables the accuracy was poor while predicting for each store when compared to the item number prediction accuracy. So the item number was considered as the key filter for the prediction of the number of goods needed for the next or the following week. Among KNN and SVR, SVR consumes more time than KNN. But Random Forest Regression is more accurate and satisfying algorithm for this problem. So this model was opted for Random Forest algorithm.

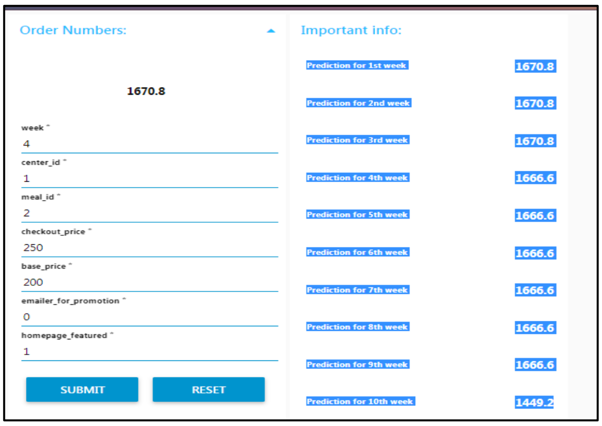

Fig. 3. User Interface Fig 4: Prediction page for retailer

Fig 3 depicts the design of the products page designed for the customers in which the buyer information is stored in the cloud as a dataset. Fig. 4 shows how the retailers give the input (on the left side), the predicted value for the next ten weeks (on the right side). In this way the retailer will be informed of the trend of the upcoming weeks.

Results and Discussions

The development of the model was done on standard conditions for the purpose of testing. The website works in the same way a normal online shopping website works, but with an extra advantage of storing all the user information and also their buying information in the cloud. The payment page is developed with highly secured.

The model is deployed in such a way that when the retailer requests the prediction for the start of the week, he gets the predicted value for that particular item and for that item he can also improve the sales through promotion so that he gets a greater profit. There is two separate logins for the retailers and customers separately where, when the customers login then they get to buy the items and when the retailer logins, then he gets a different page where he can see the demand of the various items for the previous week and also the predicted value for the following week in numerical for all the items present in the store

The web page accessed by both the customers and the retailers is programmed with node.js, JSON and HTML languages. The prediction of the amount of goods to be ordered for the following week is done with Python 3.6. Prediction using Machine Learning can be done with various programming languages, but the reason for choosing python for this project is that it is a high level interpreting programming language and it is easily readable by everyone.

The prediction was accurate with an accuracy of approximately 75%. This depicts that it can be used in real-time and will surely help the retailers manage the buying and selling of their goods with a profit, by making all the goods to be sold out without any deterioration of the goods in the warehouse.

Conclusion

This project not only concentrates for the benefit of retailers, but also customers. The retailers will know how much quantity of goods they must need to store in the warehouse and reduce the wastage of goods which in turn reduces their loss.[8] At the same time, there will not be any shortage of goods to sell to the customers. The customers will also get good quality food products as the retailers buy the products as per the needs of the customers.

This will also improve the customer-retailer relationship and will be a profit for both of them, in terms of money spent by on goods and quantity of food products. This model will enhance the sales thus this project will help and gives benefit both the retailers and customers. The prediction is highly reliable and it prevents wastage of valuable perishable food products. Similarly the UI is also user friendly. For more accuracy we may also use AI technology with Time Series Analysis which will use Weather Forecasting Algorithm for prediction. This will have an extension and depends on the parameters like geographical, season, etc.

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