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A Project Phase 1 Report on

“FOOD DEMAND FORECASTING USING MACHINE LEARNING”

Submitted in partial fulfilment for the award of the degree of

BACHELOR OF TECHNOLOGY IN COMPUTER SCIENCE AND ENGINEERING

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CERTIFICATE

This is to certify that the project work titled “**Food Demand Prediction Using Machine Learning**” is carried out by **Vikash Kumar (19BTRCS105), Vishal Vijay Kirit Kumar (19BTRCS118)**, a bonafide students of Bachelor of Technology at the Faculty of Engineering & Technology, Jain Deemed-to-be University, Bangalore in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science & Engineering, during the year 2022-2023.

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DECLARATION

We, **Vikash Kumar (19BTRCS105), Vishal Vijay Krit Kumar (19BTRCS118)** are students of seventh semester B.Tech in **Computer Science & Engineering**, at Faculty of Engineering & Technology, **Jain Deemed to-be University**, hereby declare that the project titled **“Food Demand Prediction Using Machine Learning Algorithm”** has been carried out by us and submitted in partial fulfilment for the award of degree in **Bachelor of Technology in Computer Science & Engineering** during the academic year **2022-2023**. Further, the matter presented in the project has not been submitted previously by anybody for the award of any degree or any diploma to any other University, to the best of our knowledge and faith.

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Signature of Students

ABSTRACT

“Demand is an economic principle referring to a consumer's desire to purchase goods and services and willingness to pay a price for a specific good or service”

Demand Forecasting is a process by which an individual or entity predicts the how much the consumer or customer would be willing to buy the product or use the service. Without Proper Demand forecasting it becomes impossible for any business to function. Improper Demand forecasting. would result in heavy loss. Different industry or company has different methods to predict the demands. In case of food industry, it is at most important that the demand needs to be on bulls’ eye since the food materials gets perished easily and has the fixed time frame to be used. So, the daily and weekly demand needs to be precise to avoid wastage which would otherwise increase the operating cost.

Key words: Cross-sectional forecasting, demand forecasting, Machine Learning, clustering

TABLE OF CONTENTS

	Page No
Abstract	i
Table of Contents	ii
Chapter 1	01
1. INTRODUCTION	01
Chapter 2	02
2. Literature Survey	02
Chapter 3	04
3. Objective and Methodology	04
3.1 Objective	04
3.2 Methodology	05
3.3 Feature Engineering	07
3.4 Data Transformation	07
3.5 Evaluation Metric	07
Chapter 4	08
4. System Usage	08
4.1 Applications	08
4.2 Need	08
4.3 Risk Identified & Risk Management Approach	09
Chapter 5	11
5. Hardware and Software requirement	11
5.1 Hardware requirement	11
5.2 Software requirement	11
Chapter 6	12
Conclusion	12
Chapter 7	13
References	13

Chapter 1

INTRODUCTION

Retail food delivery is a courier service in which a restaurant, store, or independent food-delivery company delivers food to a customer. An order is typically made either through a restaurant or grocer's website or mobile app, or through a food ordering company. The delivered items can include entrees, sides, drinks, desserts, or grocery items and are typically delivered in boxes or bags. The delivery person will normally drive a car, but in bigger cities where homes and restaurants are closer together, they may use bikes or motorized scooters.

A food delivery service has to deal with a lot of perishable raw materials which makes it all, the most important factor for such a company is to accurately forecast daily and weekly demand. Too much inventory in the warehouse means more risk of wastage, and not enough could lead to out-of-stocks - and push customers to seek solutions from your competitors. The replenishment of majority of raw materials is done on weekly basis and since the raw material is perishable, the procurement planning is of utmost importance, the task is to predict the demand for the next 10 weeks.

Chapter 2

LITERATURE SURVEY

This research study was conducted following the principles of a systematic literature review approach. This approach allows to ease the process of collecting data and analyzing it. With respect to the classical narrative review Tranfield and al. (2003), systematic approach overcomes the narrative review weaknesses. With the purpose of analyzing the methodologies and summarizing the findings, systematic review approach produces a new comprehension to the field, evaluates its quality and synthesizes the study using an adequate strategy. Based on the five-step process introduced by Denyer and Tranfield (2009), we conducted the literature search to achieve a better understanding of the existing literature.

John McCarthy invented the term artificial intelligence (AI) in 1956, defining it as “the science and engineering of creating artificial intelligence machines.” That which we refer to as the simulation of human intelligence that is processed by machines is what we are talking about today. Cortana, Siri, and Google Assistant are the most prevalent artificial intelligence systems that we encounter in our daily lives. Since its inception, AI has undergone a significant transformation. Previously, AI has been able to do this through developing robots and machines that have been employed in a variety of disciplines, including robotics, space exploration, marketing, and healthcare. AI is also involved in the development of business analytics software, among other things. We often think of artificial intelligence as a robot or machine that performs our daily tasks, but we do not realise that it has always been present in our lives. For example, the Google search engine that we use is an example of AI that provides accurate search results even if we input something that is related to our desired output. Because they share a common application, AI, ML, and DL are frequently confused as being the same thing. AI is the science of teaching machines to mimic human behaviors, ML is the subset of AI that makes decisions based on the data fed into it, and DL is the subset of ML that uses neural networks to solve difficult problems. These three are frequently seen working together to solve algorithmic and data-driven problems. AI has a variety of beneficial effects on a company’s overall operations, and management and business investment in AI will improve the company’s long-term viability and market leadership [1]. In their existence, artificial intelligence (AI) poses new hazards, which must be minimised to an acceptable degree in order to preserve their overall well-being [2]. Artificial intelligence encompasses a wide range of topics such as object identification, natural language processing, expert systems, and robotics. There are three categories of artificial intelligence, which are artificial narrow intelligence, artificial general intelligence, and artificial superintelligence. From a commercial standpoint, artificial intelligence (AI) allows us to automate human decision-making. As a result, we can reduce expenses and waiting times while simultaneously increasing revenue and profit margins [3].

In 1980, a Japanese AI-based drone was utilised for agricultural dusting. Nowadays, most firms use agricultural AI and aerial technologies to monitor crop health [4]. The company’s main goal is

to reduce expenses and increase the agricultural yield. Users preprogram the drone's path and then connect it. Then, the computer vision will take photographs for analysis.

Artificial intelligence (AI) leverages information from previous records to analyze it using AI-enabled techniques, allowing trade outcomes to be anticipated for a given period of time. AI primarily benefits food producers and merchants by assisting them in greater understanding of their clients. Organizations will discover the likes and preferences of their customers, which will aid them in forecasting potential sales patterns for their goods. With supply chain management proving to be a big challenge for many food and beverage (F&B) businesses, AI can help deliver insight into the way businesses operate by successfully managing inventory. By increasing the productivity and using different algorithms for sales projections, artificial intelligence combined with data science can enhance the efficiency of cafes, delivery service restaurant chains, hoteliers, and dining establishments [5]. They make smart managerial decisions and deliver products without excess inventory by studying how consumers react to digital marketing activities and incentives [6].

AI is taking care of recruitment, training and development, pay and benefits, compliance, sales, consumer behaviour forecasts, customer support, and a slew of other tasks and responsibilities. The use of artificial intelligence in corporate management is very beneficial since it makes it possible to assess and forecast crucial factors with more efficiency and lower cost in a timely manner [7]. AI admissions in digital data help in this coordination, resulting in company benefits throughout the course of the phase. In this food business model, the company will be in charge of retaining a recurring subscription [8].

With the rise of artificial intelligence, low-level employment will undoubtedly become obsolete, since AI can complete a task in a couple of seconds and provide the most precise results. Nevertheless, more jobs will be introduced to humans for the design of artificial intelligence as a programmer in the future, which will benefit the education sector by increasing the number of AI educators. At the same time, food industries will be developed that provide artificial intelligence applications that compete against one another to see who can complete the task the fastest. Currently, we cannot truly state that artificial intelligence is intelligent since no AI can have intelligence comparable to that of a person. When developing artificial intelligence software, it is still necessary to include education and safeguards [9,10]. There is still plenty of time for humans to develop artificial intelligence that is much more powerful than humans.

Superior and useful analysis may be completed in a short period of time with the necessary understanding of procedures and a plan of action for processing massive volumes of data. The visualisation and structuring of data in a more intuitive and reasonable pattern are the major focuses of business intelligence. There are many specialists that are working on this specific feature, and the strategy of replacing it from a choice to a must is well known in this industry. The BI has developed over a period of time that has been quite fruitful. The IBM researcher "Hans Peter Luhn," who was subsequently regarded as the "Father of Business Intelligence," produced a paper in 1958 that is considered to be a critical tool that should be employed in the twenty-first century.

It has been discovered in numerous businesses that artificial intelligence is not only aiding food-processing industries in generating various flavour amalgamations, but it is also guiding buyers in selecting novel essences [10]. Sales forecasts are created using artificial intelligence [11] and may be generated by using several fitting algorithms. In the food sector, finding an appropriate fitting

algorithm for the sales forecast, whether it is for a five-month sales prediction or a fourteen-month sales prediction, takes a significant amount of time and consistent work to complete. In [12], the data acquired from a retail shop are examined and predictions of future store management strategies are made based on the information gathered from the business. The impacts of numerous sequences of events, such as weather conditions and vacations, may really affect the status of various departments, and so, they also analyse these effects and assess their influence on the bottom line of the company. The purpose of this study [13] is to get appropriate findings for forecasting future sales or needs of a company by using approaches such as clustering models and metrics for sales forecasts. The potential of algorithmic approaches is assessed, and the results are employed in future study. In [14], a sales forecast system and a product suggestion system are described, which were both implemented for the benefit of a group of retail outlets in the United Kingdom. Consumer demographic information has been utilised to tailor the sales of each person to their own needs and requirements.

Chapter 3

OBJECTIVE AND METHODOLOGY

3.1 Objective

In the food industry, planning and execution of supply chains are essential to meet demand. However, in most cases, due to the lack of accurate demand forecasting, food inventories are overstocked and lead to food wastage.

Companies and businesses in the food industry allocate a higher amount of their budget towards maintaining an excess of food inventory. This is done to ensure that there is always sufficient inventory to meet demand at any given time. Currently, managers estimate demand largely through experience and intuition, which results in inaccurate spending on inventory.

Grocery stores and supermarkets maintain a large range of products in high volumes to cater to diverse consumer demands. However, the demand for all products is not the same and some are subject to seasonality and fluctuations in demand. Apart from these, unscheduled events and other external factors negatively impact stock levels. Additionally, these problems also affect small-scale food companies, such as restaurants.

The main aim of this project is to create an appropriate machine learning model to forecast then number of orders to gather raw materials for next ten weeks. To achieve

this, we should know the information about of fulfilment center like area, city etc., and meal information like category of food sub category of food price of the food or discount in particular week. By using this data, we can use any classification algorithm to forecast the quantity for 10 weeks. A web application is built which is integrated with the model built.

The dataset consists of three individual datasheets, the first dataset contains the historical demand data for all centers, the second dataset contains the information of each fulfilment center and the third dataset contains the meal information.

3.2 Methodology

Data Dictionary:

Weekly Demand data (train.csv):

Contains the historical demand data for all centers. The Train dataset consists of 9 variables and records of 423727 unique orders. test.csv contains all the following features except the target variable. The Test dataset consists of 8 variables and records of 32573 unique orders.

Variable	Definition
id	Unique ID
week	Week No
center_id	Unique ID for fulfillment center
meal_id	Unique ID for Meal
checkout_price	Final price including discount, taxes & delivery charges
base_price	Base price of the meal
emailer_for_promotion	Emailer sent for promotion of meal
homepage_featured	Meal featured at homepage
num_orders	(Target) Orders Count

fulfilment_center_info.csv:

Contains information for each fulfilment center. The dataset consists of 5 variables and records of 77 unique fulfillment centers.

Variable	Definition
center_id	Unique ID for fulfillment center
city_code	Unique code for city
region_code	Unique code for region
center_type	Anonymized center type
op_area	Area of operation (in km ²)

meal_info.csv:

Contains information for each meal being served

Variable	Definition
meal_id	Unique ID for the meal
category	Type of meal (beverages/snacks/soups....)
cuisine	Meal cuisine (Indian/Italian/...)

Data Pre-Processing

- There are no Missing/Null Values in any of the three datasets.
- Before proceeding with the prediction process, all the three datasheets need to be merged into a single dataset. Before performing the merging operation, primary feature for combining the datasets needs to be validated.
- The number of Center IDs in train dataset is matching with the number of Center IDs in the Centers Dataset i.e 77 unique records. Hence, there won't be any missing values while merging the datasets together.
- The number of Meal IDs in train dataset is matching with the number of Meal IDs in the Meals Dataset i.e 51 unique records. Hence, there won't be any missing values while merging the datasets together.
- As checked earlier, there were no Null/Missing values even after merging the datasets.

3.3 Feature Engineering

Feature engineering is the process of using domain knowledge of the data to create features that improves the performance of the machine learning models.

With the given data, We have derived the below features to improve our model performance.

- Discount Amount: This defines the difference between the “base_Price” and “checkout_price”.
- Discount Percent: This defines the % discount offer to customer.
- Discount Y/N: This defines whether Discount is provided or not - 1 if there is Discount and 0 if there is no Discount.
- Compare Week Price: This defines the increase / decrease in price of a Meal for a particular center compared to the previous week.
- Compare Week Price Y/N: Price increased or decreased - 1 if the Price increased and 0 if the price decreased compared to the previous week.
- Quarter: Based on the given number of weeks, derived a new feature named as Quarter which defines the Quarter of the year.
- Year: Based on the given number of weeks, derived a new feature named as Year which defines the Year.

3.4 Data Transformation

- Logarithm transformation (or log transform) is one of the most commonly used mathematical transformations in feature engineering. It helps to handle skewed data and after transformation, the distribution becomes more approximate to normal.
- In our data, the target variable ‘num_orders’ is not normally distributed. Using this without applying any transformation techniques will downgrade the performance of our model.
- Therefore, we have applied Logarithm transformation on our Target feature ‘num_orders’ post which the data seems to be more approximate to normal distribution.
- After Log transformation, we have observed 0% of Outlier data being present within the Target Variable – num_orders using 3 IQR Method.

3.5 Evaluation Metric

- The evaluation metric for this competition is $100 \times \text{RMSLE}$ where RMSLE is Root of Mean Squared Logarithmic Error across all entries in the test set.

Chapter 4

SYSTEM USAGE

4.1 Applications:

Most demand forecasting solutions focus on small to medium-sized applications that offer low scalability. However, modern food industry businesses are highly diversified in the products that they provide through large chains of network stores. This scale of business presents a significant challenge for traditional demand forecasting software, which is why we created our project.

The use of AI through machine learning techniques associated with a coherent technological stack of analytics. Provides greater information speed, data organization with different granularities (region, state and city), adjustments seasonality, exploration of opportunities and decision making in real time.

In the case of the food sector, the greatest accuracy in forecasting demand means:

- Inventory optimization among Distribution Centers (CDs);
- Reduction of idle stocks;
- Decrease in disruptions that cause loss of market share due to substitute products;
- Direct reduction in losses with perishability (FIFO).

The replenishment of raw materials is done only on weekly basis and since the raw material is perishable, the procurement planning is of utmost importance.

Therefore, predicting the demand helps in reducing the wastage of raw materials which would result in the reduced cost of operation. Increased customer satisfaction by timely fulfilling their expectations and requirements.

4.2 Need:

Food delivery and restaurants benefit from forecasting food demand since it reduces uncertainty and waste increasing margins for the industry. Restaurants in particular need around eighty percent filled-capacity to be profitable and many have not started or partnered with delivery services. By helping restaurants forecast weekly demand we aim to increase the net profit for the industry.

The largest benefit of food demand forecasting is the reduction of inventory, or food waste in the restaurant industry. Food is the highest cost for a restaurant, especially perishable food with a low shelf life. Therefore, reducing food waste has a large environmental and monetary effect for a given restaurant. It also has a marketing benefit, depending on the city the company is located in, since it can be marketed as a green business. Forecasting also helps with understocking since either too much inventory or not enough inventory can lead to customers choosing another restaurant.

Forecasting sales in a given week can help with labor scheduling and cost. The restaurant industry employees around fifteen million people in the US. Since many workers in the industry are part time or depend on hours set around a week to a month ahead some labor cost can be reduced if demand is predicted to be low in a future week or increased if the demand is expected to spike over the average orders.

Reducing uncertainty is a benefit for forecasting in any industry. However, uncertainty in the restaurant and delivery industry has an effect on real lives, since many service jobs in the US are restaurant jobs. Excluding food and labor costs, which are the two largest costs in running a restaurant, reducing uncertainty can help restaurant owners arrange payroll, utilities, marketing and expansion plans. The savings from forecasting demand can be used for expansion or to add new menu items to draw more customers.

Forecasting food demand has a direct effect on restaurant profits by reducing food and labor costs and reducing uncertainty for other costs. Implementing the forecasting methods in this paper will help the restaurant and food delivery industries manage profits.

4.3 Risks identified & Risk Management Approach:

1. Lack of Adequate, Accurate And Timely Demand Data:

Data is to a demand planner like gold is to a jeweller. Demand planning without data can be futile. Traditional demand forecasting falls short of this vital aspect as it stretches over a longer time period which can dilute the essence of real-time data tracking and near-term visibility. Further, traditional methods of stocktaking can be inaccurate and the data is often outdated. This makes demand planning even more difficult a task when there is a lack of visibility across inventory levels, supply chain levers and can pile up unnecessary excess stock levels or they can have stock outages if demand spikes for specific products.

2. Signal Vs. Noise:

Food retailers very often get misled by the slightest abnormal shift in demand, which if not explained can be treated as a signal for change in planning and forecasting models. Establishing the right cause and effect relationships between abnormal shifts in demand that may not repeat itself until the same conditions are met that caused the shift on a continuous basis, is critical to interpreting the trends appropriately and driving correct strategies to accommodate the change.

3. A Time Stretched Forecasting Horizon:

How far into the future do food retailers want to extend their forecasts, depends on the type of commodities and customer behaviour. For fresh produce, forecast accuracy is highest when done for the shortest time intervals as this diminishes in accuracy with long term future predictions. Food retailers should therefore choose shorter and granular data which is refreshed each time there is a change in customer behaviour or market trends, all of which lacks in traditional demand forecasting methods.

4. Confusing Correlation with Causation:

Often traditional demand forecasting can create an overlap between correlation of demand patterns and the causes of fluctuations in demand. At times, food retailers may use techniques to extract customer behavior patterns from correlations in demand shifts and link to external events. This may cause them to think that this is linked to demand shifts and believe it is the true cause of it.

5. Dealing with Product Markdowns:

Most food retailers use product markdowns for fresh produce to avoid waste, creating a risk of training shoppers to wait for the discount and training forecasting systems to buy. Legacy forecasting systems don't account for price elasticity and miss out the actual price paid for the produce, especially when it has one day of shelf life left. Food retailers wouldn't want to replenish these fresh goods that are being marked down at large discounts, just to avoid wastage. This can impact accuracy of forecasts while resulting in out-of-stocks and large scale wastage.

Chapter 5

HARDWARE AND SOFTWARE REQUIREMENTS

The following are basic hardware and software required to train and test the program.

5.1 Hardware Requirements

1. Processor : Intel Dual-Core processor.
2. RAM : 2-4 GB.
3. HDD : 10 GB.

5.2 Software Requirements

1. Operating System - Windows 10,8,7,Windows 2007/XP.
2. Documentation -MS Word, MS PowerPoint, MS Excel.
3. Language - Python, HTML, CSS, Machine Learning

Chapter 6

CONCLUSION

There are various demand of different food items in various areas or operational codes. This may cause the problems of food wastage or somewhere food scarcity. Therefore, there is the need of the system which can predicts the number of orders in respective areas to maintain demand and supply. We have made a predictive model which is trained with various different dataset containing various food items with respect to various areas. The predictive model can predict the number of orders of various food items in respective areas. It will help the organisations to maintain demand and supply of the food items and eventually aids to prevent wastage of food.

Chapter 7

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