REPORT ON

CUSTOMER DEMAND FORECASTING

IN

RESTAURANT INDUSTRY

The dawn of a great age of digitalized restaurants.

VERSION 1.0

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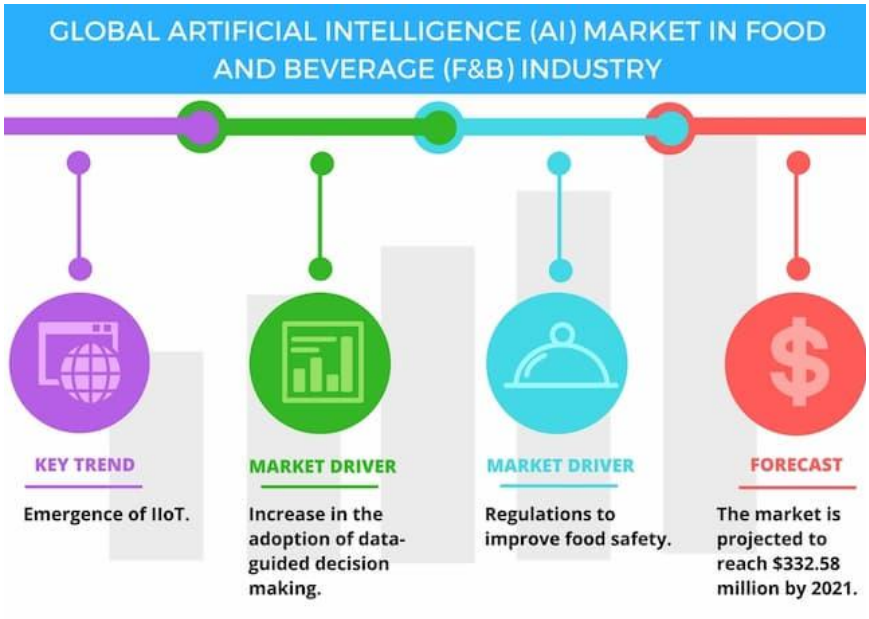
(TASK-0)

Introduction:

A restaurant's success is determined not only by its food and atmosphere, but also by its service. The most significant aspect of the services is the provision of fresh meals. To supply this, restaurants must make meals on a daily basis, which necessitates the purchase of some fresh self-life food products on a regular basis. The most difficult aspect in this will be estimating the number of items to be purchased and prepared. It is quite impossible to forecast how many orders will be placed in a specific restaurant on any given day. A false forecast may result in purchasing and preparing less food, resulting in a food shortage, or purchasing and cooking more food, resulting in food waste. As a result of the unpredictability and variations in customer demand, anticipating exact demand is difficult. Price adjustments, promotions, changes in client preferences, holidays, day, time and weather changes can all generate variations and swings in demand. All of these considerations suggest that some foods are only available for a short time. Although we know that a regular seasonal pattern is to be expected, the characteristics that forecast these seasons are not immediately observable. As a result, seasonal fluctuations in order volume are difficult to forecast. We are exploring methods to forecast demand in order to tackle such challenges.We are investigating food demand forecasting methods utilizing internal data such as order volume.

Many people may not understand the rationale, yet it is reasonable that weather has an impact on restaurant sales. To emphasize this point, a research was done in which 7 out of 15 restaurants stated that the present economic condition had an impact on their sales. A sangria can only be had and enjoyed on a brighter day, while the pleasure of hot chocolate in a nice restaurant can only be had on a cold or lonesome day.

No matter what cuisine a particular restaurant sells or serves, the weather will always have an impact on the amount of guests a cafe serves on any given day. Restaurant proprietors can be aware of menu item increases by depending on machine learning-based technologies.



Problem Statement:

Demand forecasting is an important part of any online business that is developing. It can be practically difficult to have the correct quantity of stock on hand at any one time without effective demand forecasting mechanisms in place. Because a food delivery service deals with a lot of perishable raw ingredients, it's even more critical for them to precisely predict daily and weekly demand. A warehouse with too much inventory risks wastage, while a warehouse with too little inventory risks out-of-stocks, forcing consumers to seek solutions from your rivals.

The customer is a food delivery service with locations throughout the United States. In these cities, they operate a number of fulfillment facilities where they send out meal orders to their consumers. The customer wishes to estimate demand in these centers for the next several weeks so that raw material supply may be planned accordingly. The bulk of raw materials are replenished on a weekly basis, and because the raw materials are perishable, procurement planning is critical. Second, precise demand estimates are quite beneficial when it comes to centre staffing.

We have three data sets ,which is the background of a particular dish being in demand for a specific time or in a specific location for a specific dish. For the future, this can be predicted using a model that can predict on which day, at what time, and under what conditions, such as weather, jam, or a person's personal choice due to any reason, the dishes can be made, so that they don't overfit or underfit any given predicament. We examined a variety cuisines and the dishes that went alongside them. To be able to train, validate, and test a large dataset. To forecast a cuisine's demand in the market in near future.

Customer-Business-Market Need Assessment:

There are numerous questions, such as why did we conceive of consumer demand forecasting as a solution, and what is the need for it in restaurants. Forecasting the amount of a specific food item benefits the market, the firm, and the client in a variety of ways. It's a win-win situation for all of them. In several industries, artificial intelligence is used to assure waste management, but how? Everything depends on time, energy, and resources!!

If a customer purchases more chai (tea) in the winter and cold coffee in the summer, they may request hot coffee the following winter day. We must assume the way the human brain works with the history of several customers ordering the

same cuisine on the same day, effected by the day, time, and weather of that particular area. Any business becomes successful as a result of customers visiting them for the services they give, which benefits not only the consumer but also the business and generates a competitive advantage in the market, how??, Business offers individuals with employment that allow them to earn money, as well as goods and services that they can purchase with that money. Customer responsiveness, information demand, and cost pressure are three major ones that concern firms today, and we're attempting to touch on all three through demand forecasting in a highly promising industry.

Target Specifications and Characterization:

The goal of completing the assignment and forecasting demand can be met if the specification and chain of commands for the desired specifications are given correctly. This will aid the devisers in developing software that will help them achieve the most desirable results, which is the goal of the development team.

- To begin the prediction process, the historical record of demand forecasts for that area should be employed initially.
- A regular basis Forecasting readings should not be modified at all times; instead, a model should be created that takes into account the forecasting of every feature that may be utilised and for which data is available to anticipate demand. It should be done just one time for a day.
- The model's front end should be made user-friendly, and it should be generalised to several sorts of people that will be using it.
- The model should not underfit or overfit; this is one of the main hovering points because if the model underfits, there is a chance that the number of orders will be greater than the quantity of raw material available, and vice versa, which may result in material waste and financial loss in the case of overfit.
- Demand forecasting will have a significant influence on stock control management.
- For better results, neural networks should be used because they can accommodate as many features as possible in order to develop a generalised system. If we move in a more advanced direction, we may be able to mimic and understand exactly what the individual wants today, even if it is not in the dataset's pattern.

External Search:

There are several datasets we have considered in order to do forecast the demand. We have taken the data from Kaggle, under the data of food demand forecasting. We used three csv files, fulfillment, train and meal info. We referred several other sites Benefit of AI in restaurant industry, Applying ML to demand forecasting, AI revolutionizing food processing business and even reviewed some papers as cited:

Tanizaki, Takashi, et al. "Demand forecasting in restaurants using machine learning and statistical analysis." *Procedia CIRP* 79 (2019): 679-683.

Lasek, Agnieszka, Nick Cercone, and Jim Saunders. "Restaurant sales and customer demand forecasting: Literature survey and categorization of methods." *Smart City 360°* (2016): 479-491.

Code help from: A.Anand, A.Lokeshwaran, H.Hanithavarsini.

Bench marking alternate products:

There are several benchmarking models, and many large corporations have used food demand forecasting systems, well, why not? There are several advantages to using it. Here are a few examples:

Delicious Data offers Artificial Intelligence-based Demand Forecasting: Delicious Data is a German firm that creates forecasting solutions for procurement and manufacturing using machine learning. Their service aids bakeries in forecasting sales in order to take demand-driven action and optimising product display positioning in order to attract customers. The programme estimates sales down to the minute, allowing staff to precisely optimise product manufacturing. As a result, there will be less food waste and overproduction, resulting in higher profitability.

Intuendi develops a demand forecasting platform that is cloud-based: Intuendi is an Italian business that specialises in offering a cloud-based demand forecasting tool that uses artificial intelligence to improve inventory planning. Their system automates the data collecting and forecasting process from many sources, allowing them to derive insights from sales data. Promotions, stock shortages, stockouts, calendar events,

seasonality, and other factors are all taken into consideration by the programme. The firm assists food companies in optimising daily purchase orders, perishable item management, cost of dead inventory, and other aspects of their operations.

But there are several disadvantages, risk involved into it, Our projections will never be perfect, even if we have a strong procedure in place and forecasting professionals on staff. Some items and marketplaces are simply more erratic than others. And, in general, demand is influenced by an infinite number of circumstances. It may be time-consuming and resource-intensive, as well as costly, it cannot foresee every event. A severe weather event, for example, might affect product or material supply availability as well as transportation logistics. A sudden economic crisis or a fresh scientific research claiming that particular sorts of items are damaging to one's health may influence consumer purchasing decisions. While the entire impact of these events may take time to manifest, the decisions taken by your organisation have most likely already been implemented, so you may experience some financial consequences.

The inverse of that: We'll gain insights, learn from past mistakes, and may decrease the extra cost.

Applicable Patents:

- Real time demand prediction in a fast service restaurant environment by Kerien W. Fitzpatrick, R. Craig Coulter, Henning M. Pangels (US6842719B1) in 2003

- Real-time demand prediction in a fast service restaurant environment by Abhishek Sharma, Robert Craig Coulter, Kerien W. Fitzpatrick(US8712822B2) in 2007

Applicable Regulations:

The applicable laws, applicable codes and guidelines can be:

- Customers' data protection and privacy legislation.
- Employment Laws.
- Government regulations for small businesses.
- Food service license.
- Regulations against false advertising.

- Antitrust Regulations.
- Open source, academic and research community License for educational purposes.

Applicable Constraints:

- Data Collection from customers and workers
- Lack of technical knowledge for the user(workers)
- Continuous data collection and maintenance.
- Convincing the restaurant holders to implement the system in their restaurant.
- To deliver more precise and dependable findings, a large amount of study is required to compile a worldwide historical record of shipment prices.
- Necessitates current demand pattern and effecting features in order to train the model with current patterns.
- Application development and integration on a continuous basis.

Any project has restrictions and hazards that must be handled in order for the project to be successful in the end. Time, scope, and money are the three key restrictions that project managers should be aware of. These are sometimes known as the project management triangle or the three restrictions.

Business Opportunity:

Because the aforementioned approach has only been employed by major corporations, it may now be used to small enterprises, including not only restaurants and takeaways, but also other potential industries. As a result, there's a good probability that this service will be a profitable venture. Every small business that relies on sales may and should use this service to ensure that they are always aware of what their consumers want. As a result, the birth of every small firm represents a rather significant commercial potential for the services we supply.

Concept Generation:

First and foremost, we began by gaining an understanding of the problem. The restaurant business has long been one of the most popular and active. The increased need in this field, as more people choose to eat outside, has pushed us to make a few advancements as the globe rapidly digitalizes for the betterment.

Why not this sector? There have been numerous ideas previously, and they are still being executed at a basic level. For garbage management, anything from chatbots to smart bins is available. These advantages benefit consumers and businesses straight away, as people visit and receive the desired service, and the firm is able to give it by gaining greater popularity and funds, therefore balancing the market scenerio.

The forecasting system is one of the most desirable concepts of all, as the human tendency is to always foresee the future. We implemented this in restaurants as well. It will benefit the business because they will be able to manage the amount of raw materials they need to buy for a specific time and pre-prepare a meal for that time.

As the model's scope expands, it will be able to include more and more elements to make it more appealing to each and every visitor.

Concept Development:

With the use of summary statistics and graphical representations, we will first evaluate the previous manner of order in terms of the characteristics to be used to do exploratory data analysis on the past data in order to uncover trends, spot anomalies, test hypotheses, and check assumptions. Then we'll examine and investigate current trends in the field. This will be trained and included to the model. When additional data is added to the model, it will be able to anticipate the meal that will be ordered based on a certain day, time, weather, traffic jams, festivals, and the mood of the individual, among other things.

To meet our goals, this product requires the use of machine learning and deep learning models. We can improve the accuracy of these models by customizing them. This notion may be implemented by utilising the relevant API as a deployment mechanism. We may wish to save major data for each and every consumer coming for a tailored experience, thus cloud services must be picked properly safeguarding each customer's data privacy in accordance with GDPR guidelines.

Final Product Prototype:

ABSTRACT:
The process of forecasting entails generating a collection of numbers that correlate to a future event. The many forecasting approaches are investigated in this study, as well as how to determine the most successful forecasting method. Following the formulation of the hypothesis: the efficiency of all forecasting

systems varies. A computer simulation model was utilised to examine the influence of forecasting model selection utilising quantitative approach. The information came from a restaurant. In addition, papers relevant to the research issue were examined. Under different forecasting methods, the results reveal how demand forecasting influences store inventory replenishment decisions and supplier production decisions. The Naïve Approach, moving averages, weighted moving averages, and exponential smoothing are some of the models available. The simulation result indicates that the forecasting model used has an impact on the performance and demand patterns experienced by merchants. The findings also assist managers in selecting appropriate forecasting models in order to increase performance.

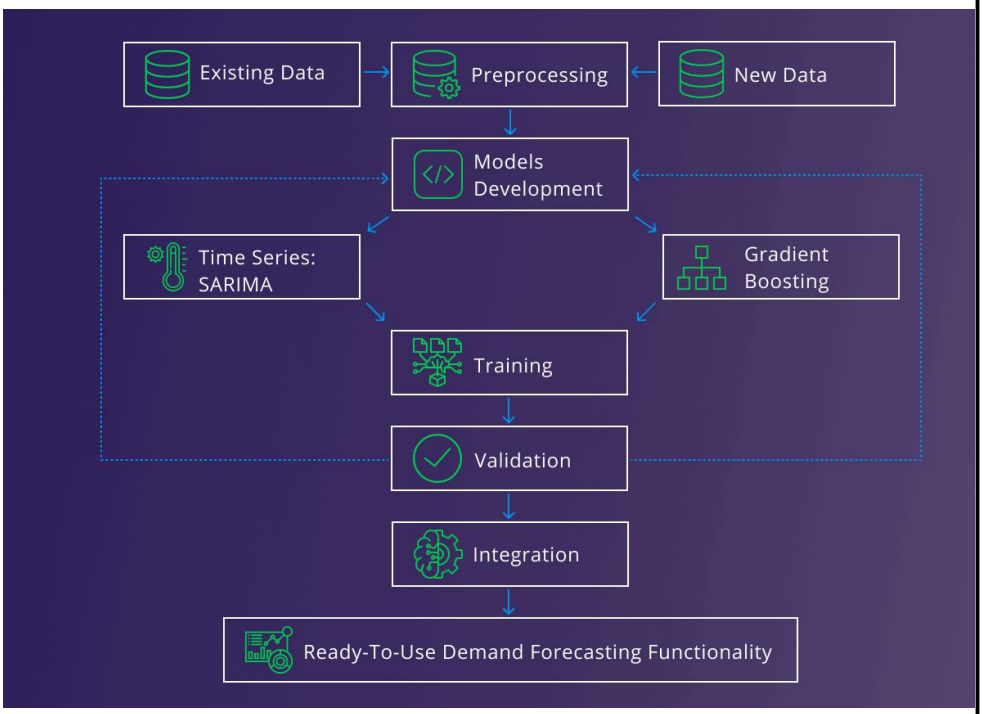
FRONT-END:

1. The user must be provided a variety of parameter alternatives to pick from. Only after extensive testing and investigation of all edge scenarios can this be optimised.
2. The data retrieved from the trained models will return raw and incomprehensible data when viewed interactively. This must be done in a pleasing manner.
3. System of feedback: To comprehend the demands that have not been satisfied, a valuable feedback mechanism must be built. This will allow us to continually train the models.
4. The user's front-end design is created using HTML/CSS/JS.

BACK-END:

To execute predictive forecasting, a variety of supervised machine learning models may be utilised.

a. Data collection and pre-processing are necessary.
b. Techniques for feature selection and feature engineering should be used.
c. Use exploratory data analysis to identify dependent and independent characteristics.



d. To avoid model overfitting and hyperparameter adjustment, algorithm training and optimization are required.
e. This product's integration is based on Python and machine learning models.

Product details:

What is the mechanism behind it? Well, it's an interactive user system; if you click on forecast now, it'll predict the order specifics in terms of day, time, weather, and so on, and display the outcome on screen in layman's terms so that employees can grasp it on a daily basis.

What is the source of the data? For real-time data, they'll need to contact other restaurants that have used this system, or they'll have to build their own in the coming years by capturing all of the data on a data sheet.

Algorithms, frameworks, and software, to name a few. Needed? Machine learning methods are used in this product. The implementation of this needs the Python programming language. NumPy, pandas, matplotlib, seaborn, plotly, and other libraries can be used to create visualisations. For the integrating API, the Flask framework will be utilised. The editors are Visual Studio Code and Google Colab. And for the primary interactive web page, django.

Is a development team required? This would necessitate the hiring of a project manager, a resource manager, a team leader, and team members such as programmers, data analysts, testers, stakeholders, project sponsors, and business assistants, among others.

How much does it cost? By arranging each phase, you can determine the overall cost of labour, materials, equipment, services, software, hardware, facilities, contingency charges, and so on.

Code Implementation on Small Scale:

CODE: Customer Demand Forecasting Restaurant Industry

Data: To begin the offered code, we will begin with three given datasets, which do not exactly portray the conclusion we want to obtain.
As we have taken into account everything in these datasets, as well as the human unpredictability element, weather, and so on. However, because this is the only dataset we discovered, we will work on it.

1. **Weekly Demand data (train.csv):** Contains the historical demand data for all centers, test.csv contains all the following features except the target v

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

2. **fulfilment_center_info.csv:** Contains information for each fulfilment center

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)

3. **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/...)

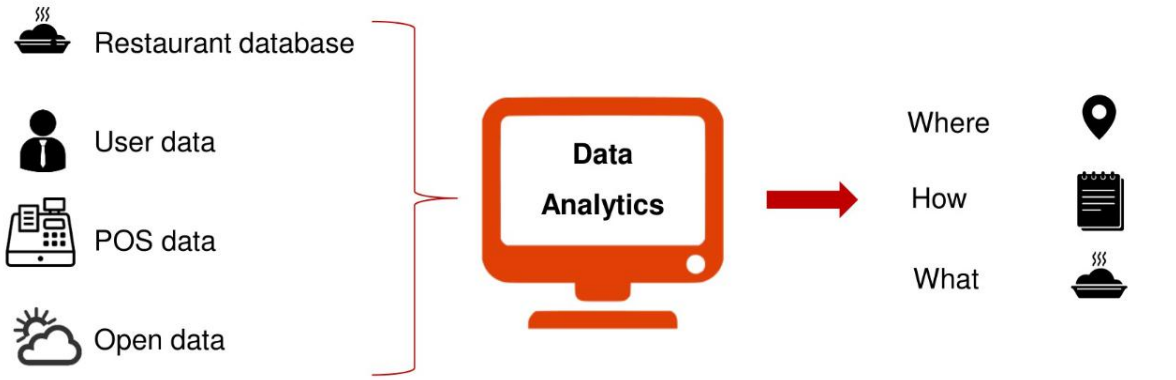
Data Flow/Management

Input

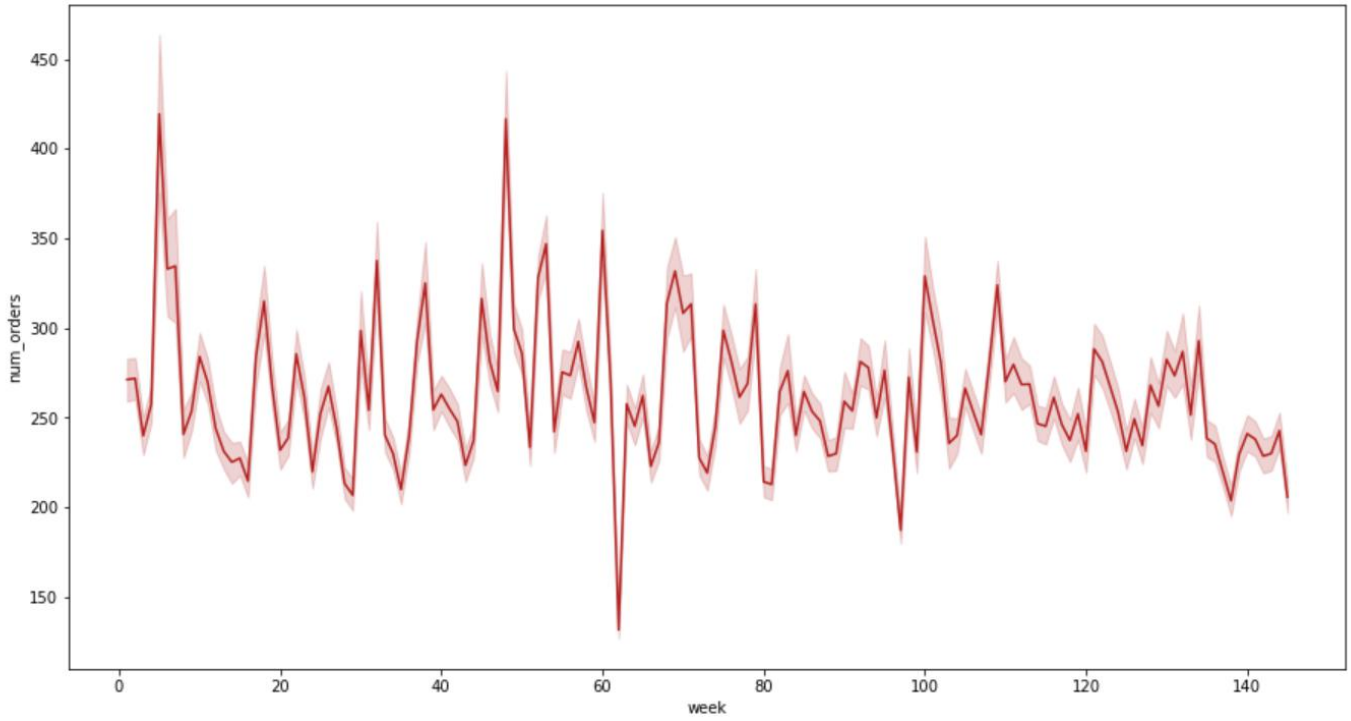
Knowledge from large database

Output

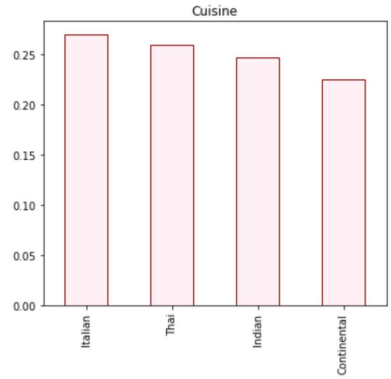
Provide **advice** to restaurants



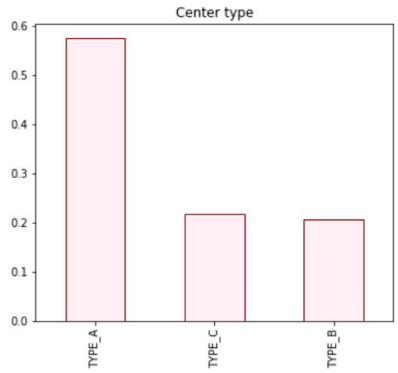
DATA UNDERSTANDING:



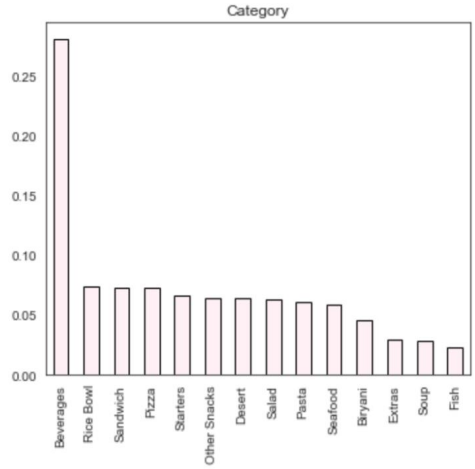
Peak sales occurred in the fifth and fifty-first weeks. The 62nd week saw a significant drop in sales.



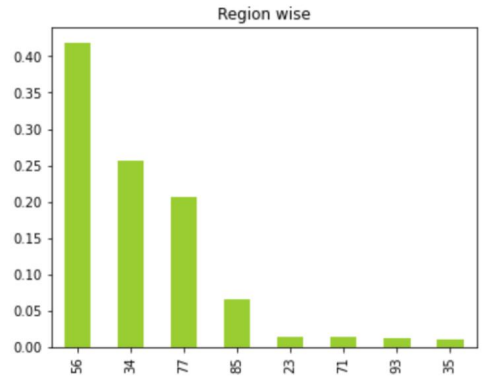
Italian cuisine outsells Indian cuisine in terms of sales.



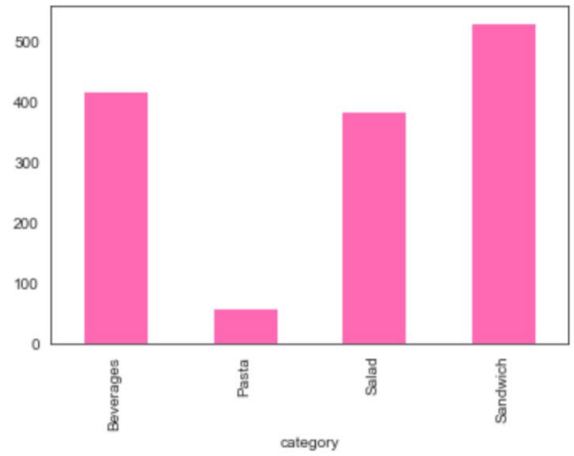
Center type A is in high demand and sells well. Surprisingly, Center Type C outperforms Center Type B.



Bevareges is a popular item

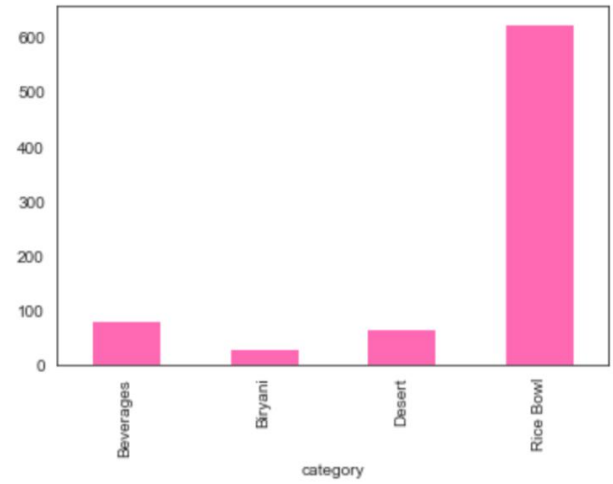


To get Italian cuisine and understand the distribution Data distribution of Italian cuisine



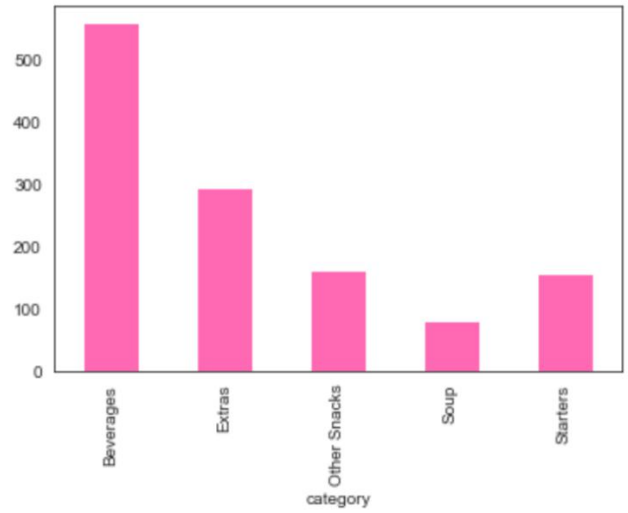
Surprisingly, Italian cusine has more sales of Sandwitch than Pasta Pasta is not demanding item. Salad has good demand.

To get Indian cuisine and understand the distribution Data distribution of Indian cuisine



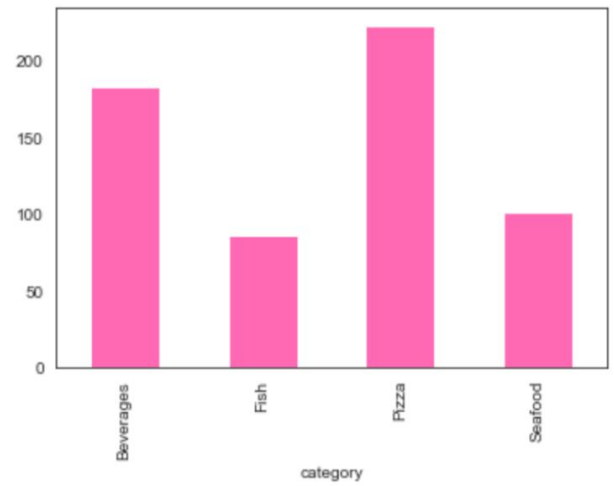
Rice Bowl is obvious option. Biryani is not preferred option from client business.

To get Thai cuisine and understand the distribution Data distribution of Thai cuisine

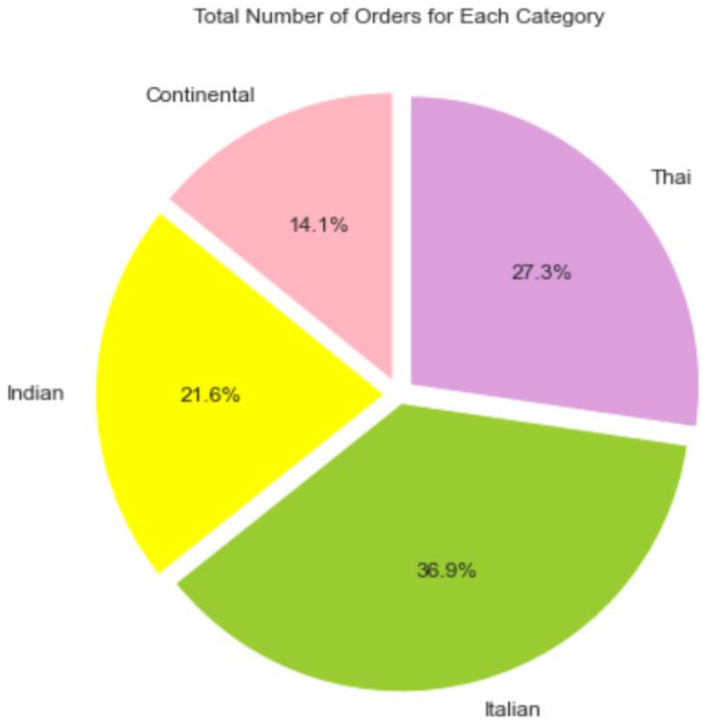


Beverages is preferred food in Thai cuisine. Other snacks is major contributor in overall sales.

To get Continental cuisine and understand the distribution Data distribution of Continental cuisine



Pizza is highly demanding food in Continental cuisine. Beverages and seafood also has good demand.

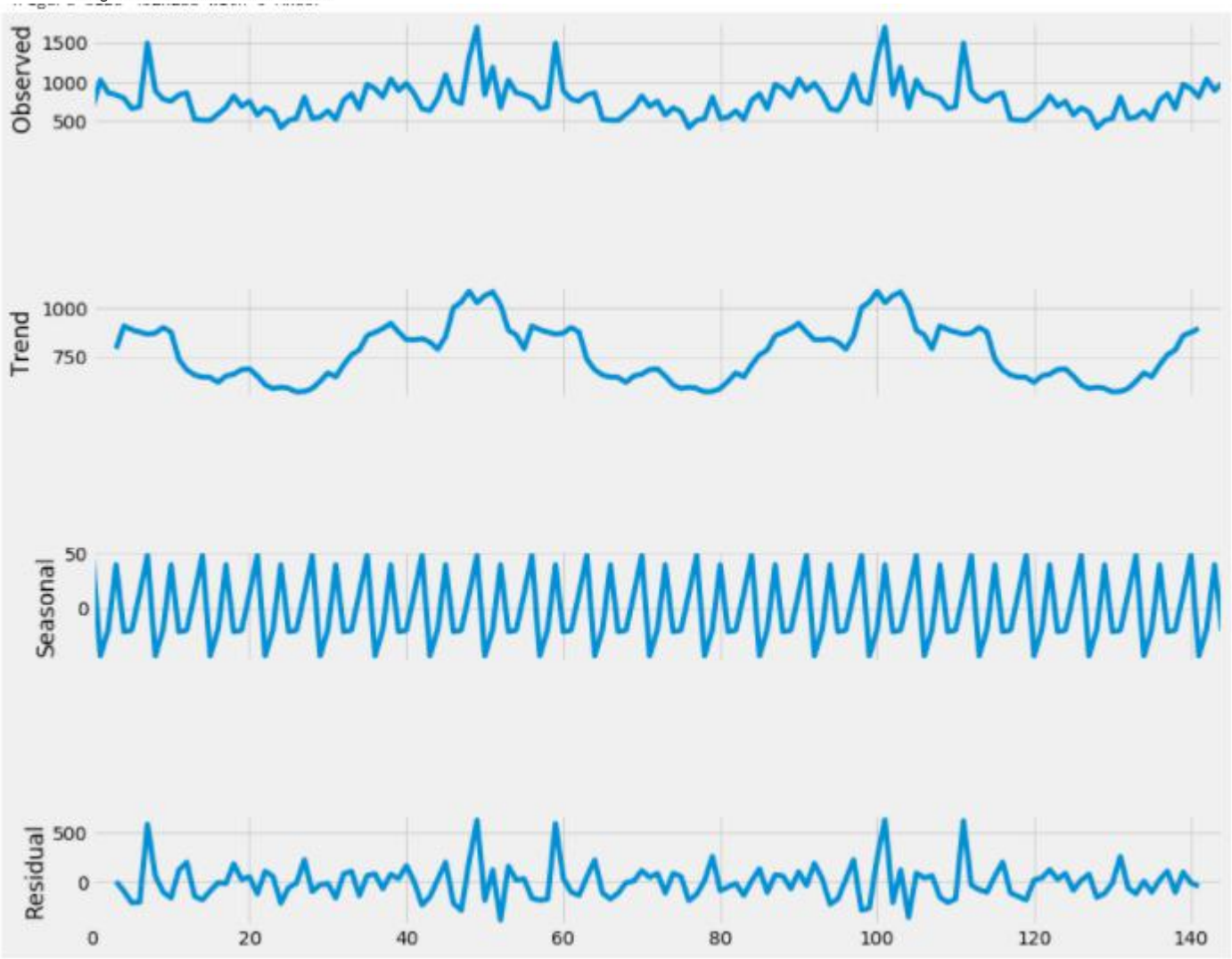


-Data Preprocessing
-Creation of unique_id for Center(55) and Meal_id(1033)
-Use Timeseries models (ARIMA, SARIMA, SARIMAX) to forecast
-Decompose the dataset
-Ploting ACF, PACF plots
-Use Neural Networks – LSTM
-Build LSTM model for full dataset
-Build LSTM model for single Center+meal_id combination.

DECOMPOSING DATA:

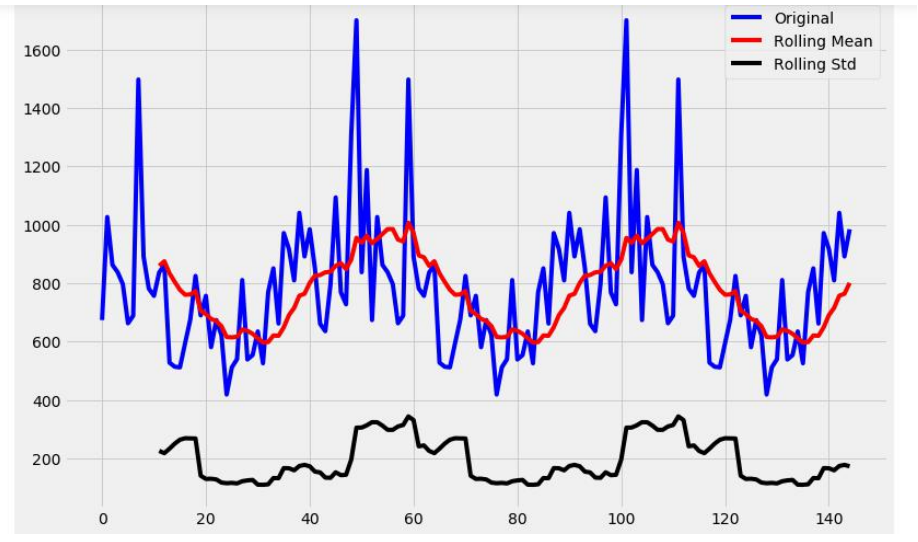
In [57]:
```
#Decompose the time series data
from statsmodels.tsa.seasonal import seasonal_decompose
result = seasonal_decompose(timeseries_data['num_orders'], model = 'additive', freq=7)
fig = plt.figure()
fig = result.plot()
fig.set_size_inches(15, 12)
```

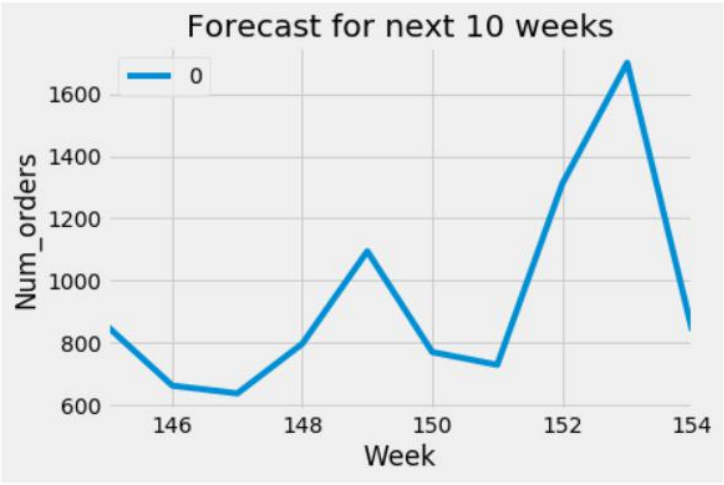
```
<Figure size 432x288 with 0 Axes>
```



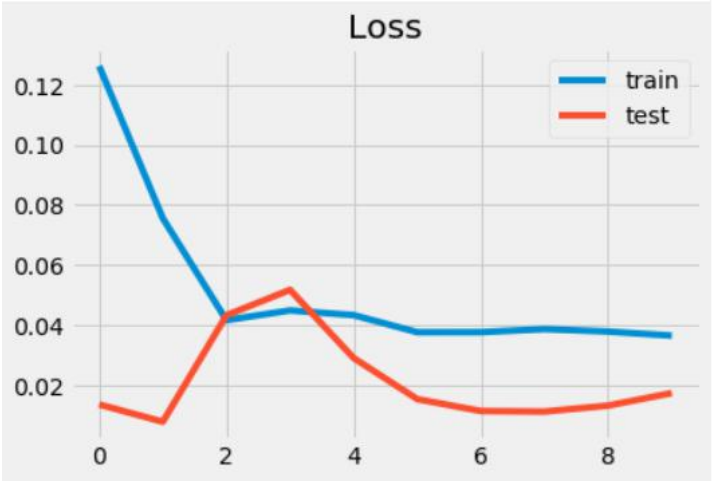
STATIONARIZE THE DATA AND PLOT THE SAME.

MODEL PREDICTION:





MODEL PERFORMANCE:



EPOCH DETAILS:

```
Train on 90 samples, validate on 10 samples
click to scroll output; double click to hide
 - 6s - loss: 0.1263 - val_loss: 0.0136
Epoch 2/10
 - 0s - loss: 0.0756 - val_loss: 0.0078
Epoch 3/10
 - 0s - loss: 0.0417 - val_loss: 0.0433
Epoch 4/10
 - 0s - loss: 0.0449 - val_loss: 0.0518
Epoch 5/10
 - 0s - loss: 0.0433 - val_loss: 0.0290
Epoch 6/10
 - 0s - loss: 0.0376 - val_loss: 0.0153
Epoch 7/10
 - 0s - loss: 0.0377 - val_loss: 0.0114
Epoch 8/10
 - 0s - loss: 0.0387 - val_loss: 0.0112
Epoch 9/10
 - 1s - loss: 0.0379 - val_loss: 0.0132
Epoch 10/10
 - 0s - loss: 0.0365 - val_loss: 0.0174
```

Conclusion:

Demand forecasting is critical in restaurant management's operations planning. Other analyses are based on having a realistic estimate of a menu item's future demand. Various forecasting strategies have been created, each with its own set of benefits and drawbacks when compared to other approaches. AI is altering our behaviour. As a result, we must go to more complex solutions in order to keep up with the rest of the globe. Many firms are shifting their applications to the AI module. With the correct tools, software, and programmes, we can create an automated process that increases customer demand forecasting and improve the customer experience. As a result, I've described the prototype and concept for food demand fforecasting in restaurant industry. It has a lot of application in today's environment. This will undoubtedly generate a fantastic opportunity for businesses in logistics, customer demand forecasting, and other related fields.

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