Food Recommendation System using Neural Collaborative Filtering and Sentiment Analysis

Tinku Singh[1], Ashwin Raut[2], Dhruv Agarwal [3], Rahul Jha[4], Anant Rai[5] and Manish Kumar[6]

***Abstract*— The food is an essential thing for all human beings. Nowadays the companies are taking orders online for the food delivery, this has opened the door of a new market for various companies. The technological advancement can help in increasing the business of the food industry. The online food order transactional data of popular food giants like Zomato and Swiggy can help to gain insight into local food habits of an area in a city. Getting an overview of the food habits of local people in a city can be quite beneficial for opening a new restaurant, opening the branch of existing food store, or deciding whether a dish will be famous amongst customers in a particular area. The transnational data of Zommato available online is used to derive insights for the recommendation to the customers. In this study, we have proposed a method that uses neural collaborative filtering and sentiment analysis using deep learning methods together for the data analysis that provides the insights in a more convenient, well organized, reliable and accurate means. For the better experience of the customer, a web application using node Js is designed that provides the insights into data from various viewpoints. The proposed method provides the food recommendation not only on the basis of the ratings of a restaurant but it also includes the user's reviews as sentiments that helps a user to select the food according to the taste of the user rather than the general trend of his area.**

I. Introduction

India is one of the most diverse countries in the world, and the food habits of the people vary according to their cultures and geographical location. With the increasing usage of the internet nowadays, various companies are providing home delivery of the food. it is easy for peoples to order food online according to their taste and budget. Billionaires are investing money in the Indian food industry. It is giving a big contribution to the Indian economy with a high growth rate and high profit. It has acquired 32% share of the Indian market. In year 2020, the online food industry collected 10196 million US$ dollar revenue and 203.6 million users in India[3].

Online food ordering is part of the food industry. It has given exponential growth to the Indian food industry capital in recent years. Zomato, Swiigy, FoodPanda, TinyOwl are the biggest game-changer of this industry. The online food industry has made a profit of US$300 million in year 2016[10].

Due to technological inflation in the mobile industry, because of smartphones, it has become easy to access the Internet for the peoples. As per estimation, Mobile users will reach up to 442 million in India by 2022. Thus, the online food industry has made smartphones as its strong platform. With food from about ten kilometres away delivered at your doorstep with just a few taps of your phone, restaurants are experiencing sales like never before. As expected this led to a lot of data being collected and consumers will get recommendations based on aggregate data. As per the survey taken in[12], 96% of people aware of food ordering apps, 54% of customers ordered food online, 90% of restaurants using online delivery apps.

But even with such a large data source ready at our disposal, fewer efforts have been made to utilize the data to extract insights from this informative dataset. Various useful information for instance aggregate consumer behaviour, what type of menu in restaurants lead to the highest sales, how much does the average consumers want to spend, what cuisines are famous among peoples and the list continues. These insights could help restaurant owners adjust their menu accordingly and moreover help new restaurant owner plan their menu, location as well as pricing such as to get the highest profits.

With the purpose of utilizing the untapped knowledge source and helping the restaurant owners gain insights from it, A web application is created that is hosted at git hub[9]. It provides a total of 16 different kinds of plots, for instance, the number of restaurants area-wise, approx cost of cuisines, ratings of the restaurants, popular dishes, North Indian restaurant, south Indian restaurant etc. that can help restaurant owners to make a better and more informed decision. It will include the behaviour of locals in a particular city that will help in attracting more customers.

For the experiment, the data is collected using the Zomato API, the useful information is extracted and stored in a tabular format. Neural collaborative filtering along with sentiment analysis is used for processing the data and finding useful insights. The text comments are processed using the sentiment analysis through deep learning technique like sentiment extraction. It converts a text review by a user into a numeric rating between a numeric number 1 to 5. Rating is used for deriving the insights.

Further, this paper is organized as in section II litera-

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[1]Tinku Singh is Research Scholar, Indian Institute of Information Technology Allahabad rsi2018006 at iiita.ac.in

[2]Ashwin Raut is Research Scholar, Indian Institute of Information Technology Allahab rsi2018004 at iiita.ac.in

[2]Dhruv Agarwal is bachelor's student, Indian Institute of Information Technology Allahab iit2017131 at iiita.ac.in

[2]Rahul Jha is bachelor's student, Indian Institute of Information Technology Allahab iit2017100 at iiita.ac.in

[2]Anant Rai is bachelor's student, Indian Institute of Information Technology Allahab iit2017103 at iiita.ac.in

[2] Manish Kumar is Faculty with IT department, Indian Institute of Information Technology Allahab manish at iiita.ac.in

ture review of the recommendation systems using various techniques is discussed, section III discusses the problem statement. In section IV, preliminary information about the proposed methodology which includes the comparison between Traditional collaborative filtering and Neural network-based collaborative filtering, Sentiment analysis through deep learning are discussed. Section V gives a detailed explanation of the experimental setup while in section VI, the experimental results are discussed. Finally, concluding remarks of this paper are discussed in section VII.

II. Literature Review

Data exploration is considered to be one of the most important tasks to get in-depth knowledge about the data. It plays an important role in the development of model architecture. A Survey of Scholarly Data Visualization by Jiaying Liu et al. [8], introduces various visualization approaches that can help to understand and present the data in effective ways to visualize different datasets. Boltzmann machines are known for their ability to attain the state of a data-set and this is what Hanene Ben Yedder et al. [15] had exploited to develop an approach to build recommender systems, Modeling Prediction in Recommender Systems Using Restricted Boltzmann Machine. They build a recommender system based on joint distributions of similarity and popularity scores, called Neighborhood-conditional RBM(N-CRBM). The developed approach had been tested on a data-set from Kaggle and achieved very promising accuracies. With the rise of interest in deep learning and computation power, an approach to harness the power of deep learning for building recommender systems were developed by Xiangnan He et al. [6], in their work Neural Collaborative Filtering. Various deep learning-based architectures and a comparative study conclude that with traditional deep learning-based approaches much better results can be achieved. Traditional recommender systems did not work well in a mobile environment, to overcome this situation Jun Zeng et al. [16], proposed a restaurant recommender system Based on User Preference and Location in Mobile Environment. The recommender system adopts a user preference model by using the features of the user's visited restaurants and also utilizes the location information of users and restaurants to dynamically generate the recommendation results.

Walter Kasper et al. [7], utilised user reviews and comments on the web for establishing good quality control and hotel management systems. The information collected using sentiment analysis for hotel reviews helps in travel planning. They proposed BESAHOT an interactive web application that handles data acquisition(using web crawler), analysis(using NLP, text processing and sentiment analysis) and storage that systematically collects and summarizes the relevant information from the web for managing the hotels.Emma Haddi et Al[5], explore the role of text pre-processing in sentiment analysis. Support Vector Machines along with feature selection is used to achieve higher accuracy in sentiment analysis. The complete process is a three-step process including feature extraction, SVM classification and result analysis. Dietmar Gräbner et al.[4], proposed a system to perform classification of customer reviews using sentiment analysis. The system provides an elaborate method to extract a domain-specific lexicon of semantically relevant words based on a given corpus. The process of sentiment analysis is then backed by the resulting lexicon, as the overall sentiment value of any text is derived from the entries in the lexicon. if the classifying reviews are only good or bad, then the model achieves an accuracy of 90%.

In Deep Learning based Recommender System: A Survey and New Perspectives Shuai Zhang et al.[17], provides and devises a taxonomy of deep learning-based recommendation models, along with providing a comprehensive summary of the state-of-the-art methods used for the recommender system.Many Deep Learning-based recommender systems provide recommendation by trying to understand the similarity in training data. While J. Ben Schafer et al.[11], proposed a Collaborative Filtering based recommender system to evaluate items through the opinions of other peoples. It is based on the principle: if two users like certain items then we can recommend the items not in the intersection to the other person since their liking's are similar. This concept works well if the data is not very large. The training of RNN can not be performed in parallel in text analysis thus leads to a slow training process. To resolve this issue ashish vaswani et al. [14], proposed Attention Is All You Need, a method that can solve the slower training of RNN by proposing a mapping known as Attention which can capture the features of text like the rules of tenses, the occurrence of words etc. these features can be parallelized that leads to improvement in training speed of RNN. To solve the issue of vanishing and exploding gradients in longer RNNs Jianpeng Cheng et al.[1], proposed Long Short-Term Memory-Networks for Machine Reading, a method of adding gates to existing recurrent networks, to make sure that the only the essential bits are passed forward to a certain depth and rest are suppressed. This limiting of depth solves the issue of gradient explosion and thus deeper models could be trained easily.

III. Problem Statement

The recommendation systems in the online food industry uses the neural collaborative filtering for recommendation of food items. It uses the rating of a restaurant for recommendation. the user's personal choice for a different type of food and his positive or negative comments as sentiments are not included in recommendation. To improve upon the recommendations, neural collaborative filtering can be integrated with sentiment analysis that will produce the most accurate results.

IV. Methodology

A. Collaborative Filtering

Collaborative filtering is a technique that filter out the items in a search, based on the choice of a similar group of peoples. It is a popular choice for building the recommender system[13].

Traditional Collaborative filtering method: Traditional collaborative filtering methods are based on the matrix product of the user's table and item table. The resulting matrix values can be interpreted as a recommendation of items to users, for instance, row-1 indicates the recommendation scores of the items for user -1. The maximum row value represents the highly recommended item for a user. For a better understanding of the concept, consider a small dataset of 4 users and 4 items as shown in Fig. 1, it contains two tables user and item respectively, these tables represents the characteristics of users preference for items and food item random scores respectively. .

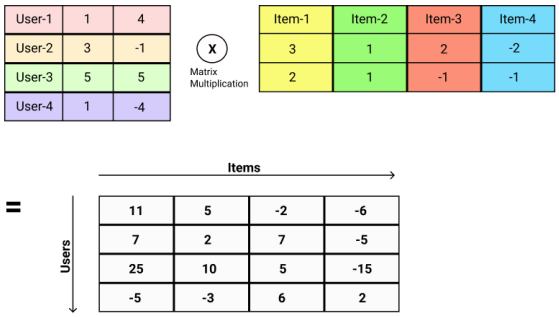

Fig. 1. Traditional Collaborative filtering algorithm

The initial values of these features are chosen from a random distribution that gets updated during the training process. With sufficient data and training, the resultant metric of user-item combination shows the filtered results. For instance, in Fig. 1 the User-1 and Item-1 have a score of 11 while the same user (User-1) and Item-3 have a score of -2, these scores imply that User-1 has a high liking towards Item-1 while very less liking for Item-3.

Neural Collaborative Filtering(NCF): The Collaborative filtering method discussed in section IV-A have the shortcomings of vague representation of user and items. With the popularity of deep learning, more robust algorithms were proposed, in this study we are focusing on neural collaborative filtering method. NCF exploits the power of neural networks to get a much better representation for a user and an item. Different factors of the study can be used as the embedding vectors. In this study two embedding vectors have been used to represent users liking's and item description. These embedding are concatenated to obtain a large vector that is used as an input to the neural network. The output of the neural network is ratings for a user for all restaurants. Regression is performed on the output of neural network with the actual ratings in the training loop.

The Fig. 2 gives a visual understanding to the architecture of the neural collaborative filtering method. The yellow vector represent the embedding of users, while the green vector represent the embedding of items.

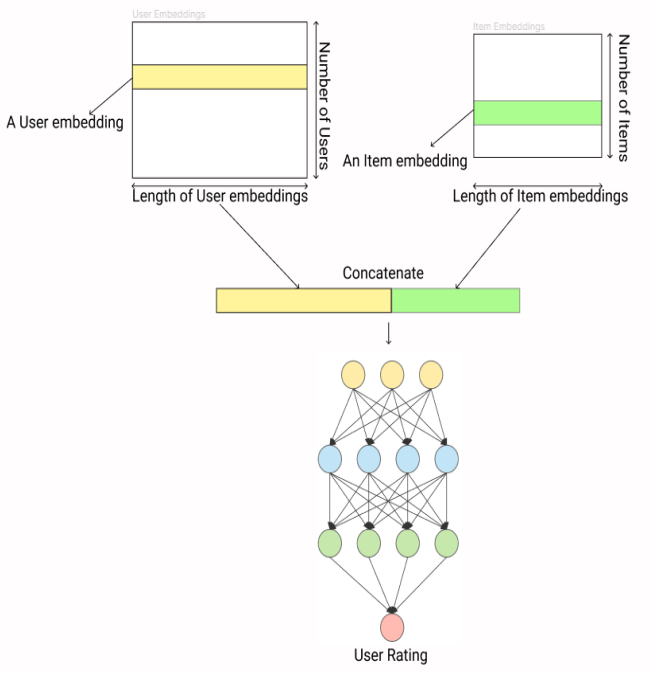

Fig. 2. Neural Collaborative filtering architecture

B. Sentiment Analysis

Sentiment analysis is the process of extracting the basic understanding of text and statements. This can be very difficult, as human speech is not easily definable with basic rules and structure.Consider the following sentence -

```
You're so brilliant and smart!
```

This statement in itself can be easily identified as a compliment (positive tone). However the same sentence put into a context like below -

```
Really Sherlock?
You're so brilliant and smart!
```

Now the sentence has a sarcastic and overall negative tone. This example illustrates the complexity of assessing the sentiment of a text based content. For such a problem, we use deep learning approaches to understand the semantics and extract various sentiments.

Sentiment extraction is useful in automatically deriving compact, useful and meaningful data from sentences. Otherwise large text corpus, requiring manually to be read to be understood and used. It also helps in giving structure to the unstructured textual data. The basic and common attributes

of expression that are estimated in sentiment analysis are as follows:-

- **Polarity** - Speaker's expression as positive or negative opinion.
- **Subject** - The main focus of the text.
- **Opinion holder** - the person who is expressing in the text

The extracted data can be used in recommender systems, rating /review systems and other forms of business analysis.

In this study, we are using the data extracted from Zomato [2] to train the sentiment analysis for finding the robust model. The embedding of sentiment analysis with deep learning model can be seen in the Fig. 3. The reviews and ratings given by the same person are incorporated, and used as input. Rating is used as label to guide the model, how to interpret the reviews.

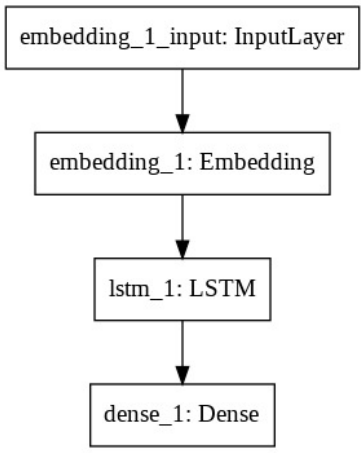

Fig. 3. Architecture of sentimental analysis model

V. Experimental Setup

A. Dataset Used

In this study, two datasets are used for the experiment. For the first dataset web scraping is performed to collect the data from Zomato [2], the extracted data is stored in a tabular form. The sample format of the dataset can be seen in table I. The second Dataset contains the user's review database which keeps an organized collection of ratings of a particular user about the individual dining place. The organised data is kept in the tabular format, which includes the following features:

- **User Id** - To identify the unique users.
- **Place Id** - To identify unique food joints.
- **Ratings** - It shows the rating given by a user to a particular food joint.

TABLE I
Extracted data from Zomato

Field	Data Type	Field	Data Type
URL	string	Address	string
Name	string	Online Order	binary(yes/no)
Book Table	binary(yes/no)	Rate	float
Votes	Int (count)	Phone	string
Location	string	Rest Type	string
Cuisines	string	Approx Cost	int
Latitude	float	Longitude	float
Reviews	list of strings		

B. Data Exploration

C. Front-End

The frond-end plays an important role in representing the knowledge mined from the data easily and interactively. The end-user only cares about the results displayed on the screen, better representation makes the task much interesting and interactive to the user. For this purpose, a web application is developed in *Vue.js* that follows the latest material design guidelines to drive the user experience towards a pleasant and easy to use interface. The user is greeted with a screen as can be seen in Fig. 4 that requires to provide the name of the city as input whose analysis needs to be performed.

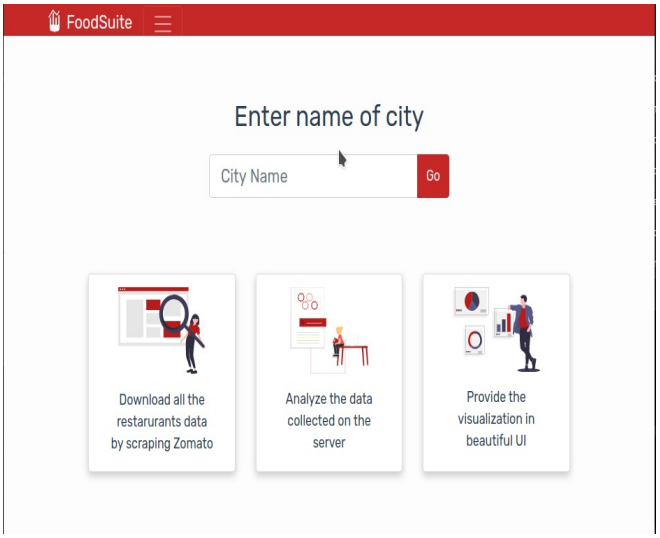

Fig. 4. Front-End Home Screen

D. Back-End

The back-end layers that deals with dataset consist of three phases:

- **The Dataset Downloader:** This phase of the back-end server interacts with the Zomato API and web scrapping code to download all the related data to restaurants in the city. It stores the results in a csv file in a folder that is named according to the city name.
- **The Data Analyzer:** In this phase, the csv file written to the directory in phase 1 is loaded into memory and it is executed by using the algorithms mentioned in section

IV. The results are stored into the city name directory for further use.

- **The Data Uploader:** In the previous phases, raw python processes were uploading data to the server. In this phase server switches to Node.js that reads the files and uploads them to the cloud database. The plot titles data are stored on the Firebase.

To connect the back-end with the front-end an application programming interface(API) is required. For this purpose Flask, which is based on Python is a suitable candidate.

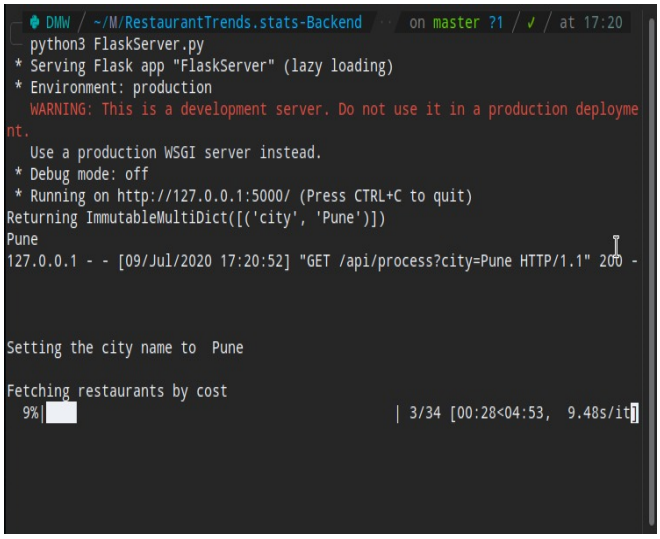

Fig. 5. Back-end processing upon request to process a new city

Whenever a request for the search of a new city that has not been analyzed by the application before is made, front-end calls the Flask back-end requesting it to upload the data for the given city to Firebase. Once the back-end gets the instruction, it starts to process the data that spawn a new child process and ask it to execute the back-end layers mentioned in the section V-D for the given city as can be seen in Fig. V-D. As a result, it returns the status that the data is processing to notify the front-end.

E. Technology used

- **Vue.js** : It is the most lightweight and rapidly developing web based framework for front-end development. it is used in the development of the web application.
- **Python** : The web scraping and mining process in back-end are performed using the Python language.It provides a set of libraries for instance numpy, pandas, matplotlib, sklearn etc, that are suitable for the study.
- **Flask** : It is a lightweight Web Server Gateway Interface(WSGI). This gateway helps in listening to incoming request and provide suitable response in client server scenario. The API server is written using this framework since the other parts like analysis module is written in Python.
- **Firebase** : It is free service provided by Google that can be used to host the raw data like HTML pages on the web accessible to anyone via a provided URL. Firebase is used as the data repository from where the web-app fetches and displays the information to the user.
- **Node.js**: It is the popular java script framework with largest community acceptance. it is used for writting the scripts that uploads the data to Firebase.

VI. Results and Discussion

The dataset is restructured to form a matrix of users and places, output of the same can be seen in the Fig. 6 that is generated by the program. Each cell represents the ratings of a user(row) for a restaurant(column). The NaN value represents that no rating is given to the restaurant by any user till now.

placeID	132825	132834	132862	132921	135032	135038	135041	135042
userID								
U1003	2.0	NaN	1.0	NaN	NaN	NaN	0.0	NaN
U1016	NaN	2.0	2.0	NaN	2.0	NaN	NaN	1.0
U1022	NaN	NaN	NaN	NaN	1.0	2.0	NaN	NaN
U1024	1.0	1.0	NaN	NaN	2.0	1.0	1.0	1.0
U1053	1.0	NaN	NaN	NaN	2.0	2.0	NaN	2.0
U1061	1.0	1.0	NaN	1.0	NaN	NaN	2.0	NaN
U1071	2.0	1.0	2.0	NaN	2.0	NaN	NaN	2.0
U1075	NaN	1.0	NaN	NaN	1.0	NaN	1.0	NaN
U1089	NaN	1.0	NaN	1.0	NaN	0.0	NaN	NaN

Fig. 6. Restructure Dataset

Neural network is trained to find the best learning rate, to achieve this loss is calculated over different learning rates and steepness is observed for the decrements of the loss. The considerable slope is chosen to be the best learning rate as can be seen from the Fig. 7. The model is trained using this learning rate over 10 epochs and with train-val split of 80%:20%. The values of different parameters during the model run can be seen in the table II.

epoch	train loss	valid loss	time
0	0.609277	0.5077	00:00
1	0.5223	0.488	00:00
2	0.49	0.55	00:00
3	0.48	0.483	00:00
4	0.467	0.468	00:00
5	0.454	0.534	00:00
6	0.44	0.555	00:00

TABLE II
Loss VS Learning rate

The model is trained for the sentiment analysis using the reviews dataset extracted from Zomato. This model includes the review of those users as well who does not provide ratings in terms of number for instance 1 to 5 for a particular cuisine instead, they write the comments, based on comments or

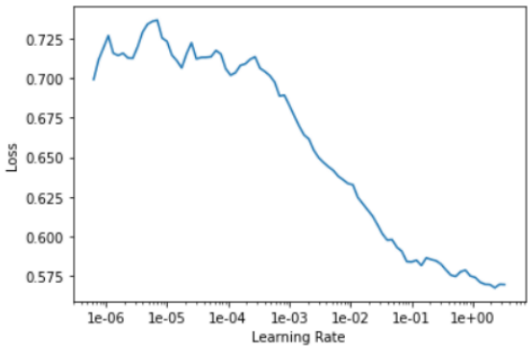

Fig. 7. Loss VS Learning rate

feedback they have provided using the sentiment analysis a score can be included. This model achieves the 78% accuracy on the validation dataset. It provides an approach to refine the reviews of any restaurant based on ratings and comments.

In the frond-end application while searching for a new city that has not been analyzed before by the server, a message is displayed that the back-end is processing their city before the application displays the results of the search, result of the same can be seen in the Fig. 8.

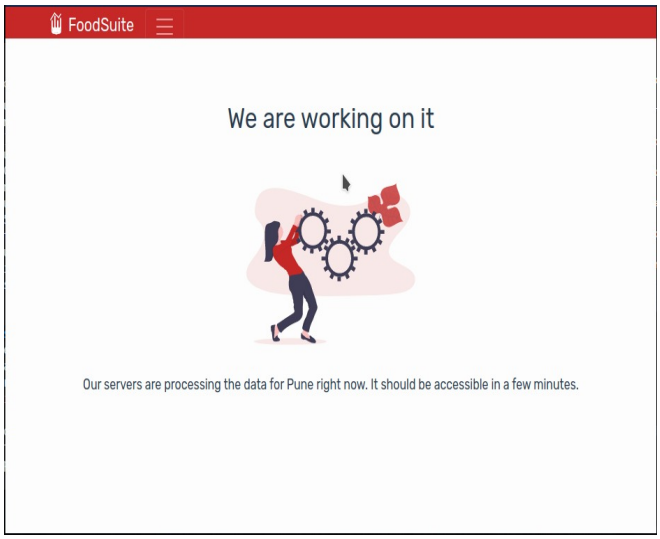

Fig. 8. Front-End if City is not processed before

VII. Conclusion and Future Work

If the city name has been searched earlier in the application then the user will instantly see the various options, for instance, the approx cost of cuisine, the approx cost for two persons, the histogram of ratings, most popular cuisine, popular dishes, rating restaurant types, North Indian restaurant, south Indian restaurant etc.. The different hotspots for the food in a city in our case Allahabad city is selected can be seen in the Fig. VI. it will gain all the necessary insights regarding the popular cost trends, cuisines and so on.

In this study an experiment is performed for the food based recommendation system that uses the neural collaborative filtering and sentiment analysis. Neural collaborative filtering is a better choice for the recommendation system in compared to traditional collaborative filtering. When neural collaborative filtering is clubbed with sentiment analysis it provides better results in terms of recommendation. To provide the user a better experience a web based portal is created using vue JS, Flask and python. The users can get a detailed information of the restaurants based on city. The various analysis are provided to get a more personalized feedback of restaurants that they could try for good food and at the same time access reviews refined by our intelligent systems. However, more than the end-users this platform is beneficial to restaurant managers, both the ones that are already established well enough and want to improve in comparison to their competitors and the ones who are new to the business and want to get an idea of the preferences of the locality to select their cuisines or hot spots where they could open the restaurants. In future, an android application with more features can be added to this recommendation system so that it becomes more useful to the users.

References

[1] Jianpeng Cheng, Li Dong, and Mirella Lapata. “Long short-term memory-networks for machine reading”. In: *arXiv preprint arXiv:1601.06733* (2016).

[2] Zomato Developers. *Zomato API: Power your content with the most exhaustive curated restaurant information*. 2020. URL: `https://developers.zomato.com/documentation`.

[3] India Brand Equity Foundation. *indian-food-industry*. 2019. URL: `https://www.ibef.org/industry/indian-food-industry.aspx`.

[4] Dietmar Gräbner et al. “Classification of customer reviews based on sentiment analysis”. In: *ENTER*. Citeseer. 2012, pp. 460–470.

[5] Emma Haddi, Xiaohui Liu, and Yong Shi. “The role of text pre-processing in sentiment analysis”. In: *Procedia Computer Science* 17 (2013), pp. 26–32.

[6] Xiangnan He et al. “Neural collaborative filtering”. In: *Proceedings of the 26th international conference on world wide web*. 2017, pp. 173–182.

[7] Walter Kasper and Mihaela Vela. “Sentiment analysis for hotel reviews”. In: *Computational linguistics-applications conference*. Vol. 231527. 2011, pp. 45–52.

[8] Jiaying Liu et al. “A survey of scholarly data visualization”. In: *IEEE Access* 6 (2018), pp. 19205–19221.

[9] Anant Rai Rahul Jha Dhruv Agarwal and Tinku Singh. *Food Suite*. 2020. URL: `https://rahul-jha98.github.io/RestaurantTrends.stats/#/`.

[10] Anupriya Saxena. “An Analysis of Online Food Ordering Applications in India: Zomato and Swiggy”. In: *International Journal of Research in Engineering, IT and Social Sciences* (2019), p. 09.

[11] J Ben Schafer et al. “Collaborative filtering recommender systems”. In: *The adaptive web*. Springer, 2007, pp. 291–324.

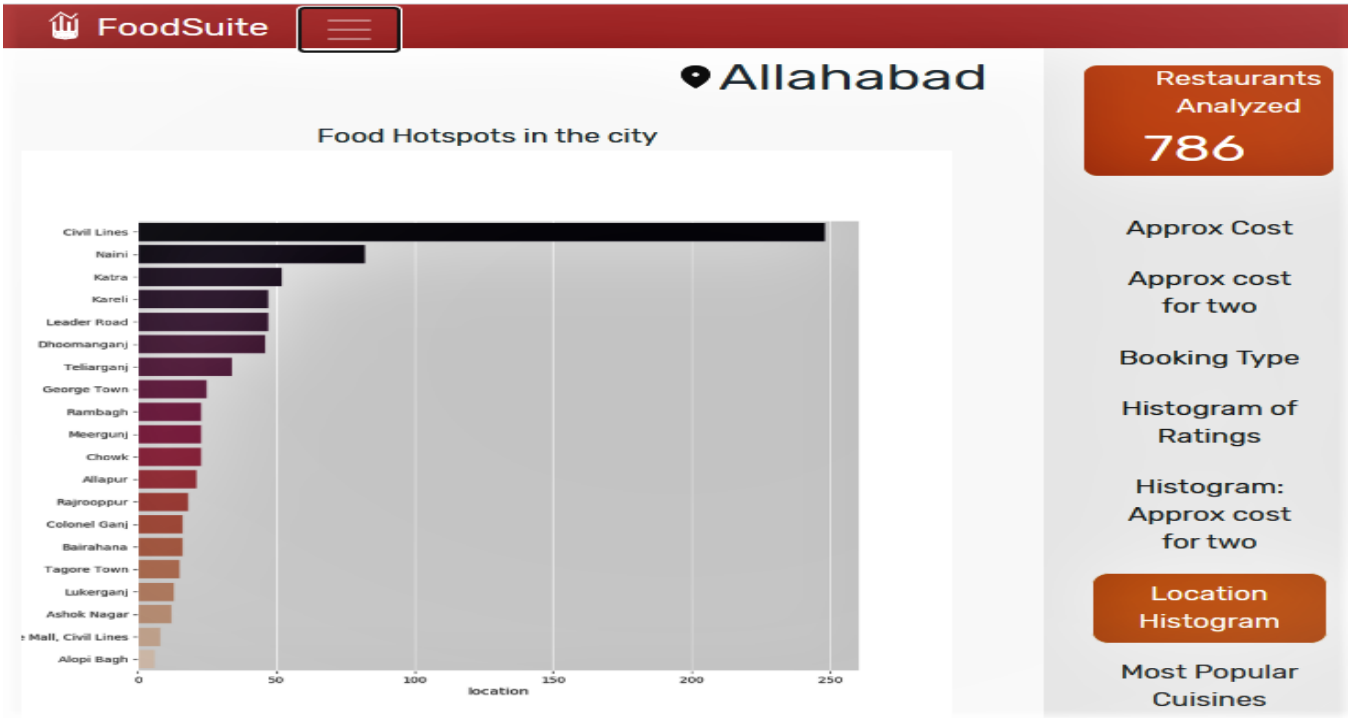

Fig. 9. Front-End if City is already processed before

[12] statista. *Online Food Delivery*. 2020. URL: https://www.statista.com/outlook/374/119/online-food-delivery/india.

[13] Xiaoyuan Su and Taghi M Khoshgoftaar. "A survey of collaborative filtering techniques". In: *Advances in artificial intelligence* 2009 (2009).

[14] Ashish Vaswani et al. "Attention is all you need". In: *Advances in neural information processing systems*. 2017, pp. 5998–6008.

[15] Hanene Ben Yedder et al. "Modeling prediction in recommender systems using restricted boltzmann machine". In: *2017 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*. IEEE. 2017, pp. 2063–2068.

[16] Jun Zeng et al. "A restaurant recommender system based on user preference and location in mobile environment". In: *2016 5th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)*. IEEE. 2016, pp. 55–60.

[17] Shuai Zhang et al. "Deep learning based recommender system: A survey and new perspectives". In: *ACM Computing Surveys (CSUR)* 52.1 (2019), pp. 1–38.