Restaurant Recommender System

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Zilin Wang

500702682

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# Abstract

Yelp, an application which publish information of local restaurants, provides users with useful insights about whether the restaurant would satisfy their needs by reviews from users. Users of Yelp could engage and interact with the application through searching restaurants, writing reviews, rating, connecting with other users, and “checking in” at restaurants. Currently, customers have to type in keywords and search in order to find a restaurant accord with their personal tastes, which is passive and not intelligent. By building a successful personalized recommendation system, it would significantly improve Yelp’s user experience and thus increase revenue.

In this project a restaurant recommender system will be implemented to provide a personalized restaurant recommendation. The datasets were downloaded from [Yelp](http://www.yelp.com/dataset), which includes the datasets of the restaurant and user reviews. After data preprocessing, all necessary data were merged into one CSV file and then split into 70% training and 30 testing datasets. Based on above datasets, memory-based collaborative filtering (CF), model-based CF, and text-based CF techniques will be applied to predict the rating or preference that a user would give to the restaurant. This project will be implemented on Jupyter Notebook, a popular, interactive Python IDE , and the project source code will be shared on my [GitHub](https://github.com/zilin0618/YELP_recommender_system/blob/main/Yelp_RS-checkpoint.ipynb).

The original dataset contains 8,021,122 reviews from 1,968,703 users for 168,903 restaurants. After data preprocessing, the finalized dataset for models have total of 219,410 reviews from 13,927 users for 4,562 restaurants in city of Toronto. Each user has more than 4 reviews.

This report shows detailed root mean squared errors (RMSE) and mean absolute error (MAE) for each method, model with a lower RMSE values provides more accurate predictions of predicted ratings on test data. The RMSE and MAE bar chart for each model was provided in the figure below.

![Chart, bar chart

Description automatically 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bar chart

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Figure .MAE (left) and RMSE(right) of each Recommender System

# Literature Review

Recommendation system is a topic both of academic as well as commercial interest, and it is well studied in the area of data mining and machine learning. Currently, recommendation systems could be broadly classified into various categories: Memory-based CF, Model-based CF, and the hybrid CF which is a combination of the previous two [1]. Due to the limitation of hardware and knowledge, the model of hybrid CF was not successful, but a text-based NLP model was implemented instead.

Memory-based CF makes recommendations based on the previous ratings from users to items. The general idea is that the ratings for similar items from a given user should be similar, and the ratings to one item by similar users should also be similar [2]. One of the most famous examples of collaborative filtering is the recommendation system of Amazon.com, which utilizes the item-item similarities [3]. Though collaborative filtering is one of the most widely used recommender systems [4]. The major challenges of this method including the cold start problem, scalability, and sparsity, mainly because the number of items in modern application is extremely large, and each user could have only rated a tiny fraction of it. Also, when a user is newly entered the system, there is no previous ratings to be readily used [5].

Model-based Collaborative Filtering is based on matrix factorization to find the hidden features from the given data, which mainly as an unsupervised learning method for latent variable decomposition and dimensionality reduction [1]. Matrix factorization is found to be the most accurate approach to reduce the problem of high levels of sparsity in database and solve the problem of dimensional reduction for extremely large dataset [1].

Lastly, besides only using the numerical information from ratings, the text reviews written by users were analyzed and used to make recommendation predictions. Important information could be extracted from the review text, it exposes user preference and sentiment instead of rating value. We could also get how often these features were mentioned from the reviews for a specific restaurant. By comparing the frequency of these words, we could match up customers and restaurants by similarities.

# Dataset

The datasets were downloaded from Yelp official website. There were five datasets downloaded and two datasets (‘Business’ and ‘Reviews’) were used. The original datasets contain 8,021,122 reviews from 1,968,703 users for 168,903 restaurants. After data preprocessing, the finalized dataset for models have total of 219,410 reviews from 13,927 users for 4,562 restaurants in city of Toronto. Each user has more than 4 reviews.

The finalized datasets which dropped unnecessary attributes are listed as below:

* Business: (‘business\_id’, ‘name’, ‘address’, ‘latitude’, ‘longitude’, ‘stars’, ‘categories’)
* Reviews: (‘user\_id’, ‘business\_id’, ‘stars’, ‘text’)

Before building the system and training the model, the sum of original ‘business’ and ‘review’ datasets was more than 5GB, which is a heavy workload for local Jupyter Notebook. In order to speed up the development cycle, it is necessary to extract a smaller dataset but still able to represent the entire dataset.

# Approach

Graphical user interface, diagram

Description automatically generated

Figure . Project Approach Overview Diagram

## Data Preparation

In order to obtain the data matrix for modeling, the raw datasets were processed as the following steps:

First, filtering the ‘business’ dataset, to filter out the closed restaurants. It is impossible to recommended restaurants to users that not exist anymore.

Secondly, among all restaurants that still open, top 3 cities with the highest amount of review records were selected as ‘Las Vegas’, ‘Phoenix’, and ‘Toronto’, which has 1253572, 431877, and 338328 review records. Due to the hardware constraint of local computer, less data would be easier faster to operate. The restaurants in the city of Toronto were extracted as the sample data since Toronto has 5462 restaurants which is the highest among the top 3 cities.

Thirdly, recommender systems have a problem known as user cold-start, in which is hard do provide personalized recommendations for users with none or a very few number of consumed items, due to the lack of information to model their preferences [1]. For this reason, we are keeping in the dataset only users with more than 4 reviews.

Lastly, missing values and duplicate rows were checked and removed. For better visualization, unnecessary attributes were dropped. Business and review records from Toronto were all extracted and merged to one csv file.

## Exploratory Data Analysis

To explore the dataset in detail, it is important to perform exploratory data analysis. The figures below show the star distribution of 5462 restaurants in Toronto and the 10 most popular restaurant attributes in Toronto.

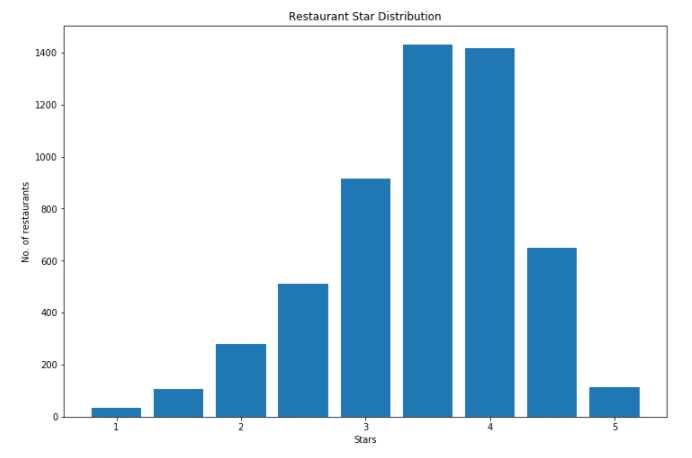


Figure . Restaurant Star Distribution in Toronto

This bar chart was generated by counts the number of restaurants at each star level. There are 1432 restaurants got 3.5 stars, 35 restaurants got 1 star, and 115 restaurants got 5 stars. There are 934 restaurants got stars under 3, which could be considered as unsatisfactory; 3765 restaurants got 3 stars or more but under 4.5 which could be considered as satisfactory; 764 restaurants got 4.5 and 5 stars which is excellent level of dining experience.

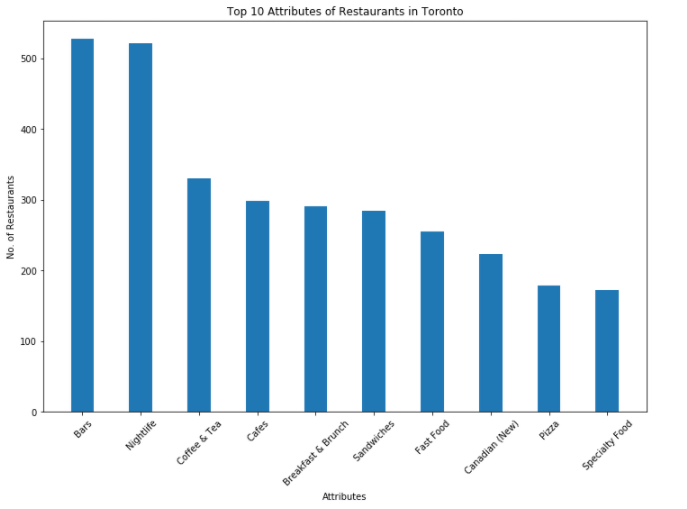


Figure 4. Top 10 Toronto restaurant attributes

The figure above illustrates the top 10 popular restaurant type among 8329 restaurant categories. It is obvious that ‘Nightlife’ and ‘Bar’ restaurant are the most popular type, there are 521 of ‘Nightlife’ type restaurants and 527 ‘Bar’ type restaurants in Toronto.

![Chart, bar chart

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEA8ADwAAD/4RDsRXhpZgAATU0AKgAAAAgABAE7AAIAAAALAAAISodpAAQAAAABAAAIVpydAAEAAAAWAAAQzuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHppbGluIHdhbmcAAAAFkAMAAgAAABQAABCkkAQAAgAAABQAABC4kpEAAgAAAAM1MwAAkpIAAgAAAAM1MwAA6hwABwAACAwAAAiYAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Figure 5. Top 10 restaurants with the most reviews in Toronto

As we can see from the chart above, Pai Northern Thai Kitchen was the most popular restaurant with overall stars of 4.5 and 2834 reviews from users. The second place was Banh Mi Boys with 1747 reviews from users and overall stars of 4. It is obvious that Pai is more popular than Banh Mi Boys from the significant difference of numbers of reviews.

![Chart, line chart

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEA8ADwAAD/4RDsRXhpZgAATU0AKgAAAAgABAE7AAIAAAALAAAISodpAAQAAAABAAAIVpydAAEAAAAWAAAQzuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHppbGluIHdhbmcAAAAFkAMAAgAAABQAABCkkAQAAgAAABQAABC4kpEAAgAAAAMxOAAAkpIAAgAAAAMxOAAA6hwABwAACAwAAAiYAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Eqi2hlNp5SvDDJ5eMIORgZIGO1aFnplrotgtroOnWlrCJAfIiUQoAWG9sKp+bGT05IAJGcgA848DadDa6/BYPqNlD9mu2vorWWCS3vbh/sgtyWjkAzkBpGZd25jnOOq+KdOE/jLVv7PmuZUu7eSy1IQaPLcPEJorcMqyqQufLiQgEHaZCTnIFdBoHh/VbbXLe81nR9Pmlj3Z1CbXJ7yeIlSP3aPboqZzghCgwT16HE1947Px9fxX32oy37xGyjtfEa2DSKI1XHkiRC53BvmIJPA6KKAPT6KKKACiiigAooooAKKKKACiiigAooooAKKKKAK2o2MOqaXdWFzu8m6heGTY21trKVOD2OD1rldJ+HEel6umqPrt9dXq3DzNNJa2e+RWkLFGfyN+MHacMOOm0YA7OigDh/iL4fXX5tLTULG+vtKhEzTxWKRSOJTsEZKyA5XHmcryCR2JrO0/Ttf0LwRqTX17qVlZafZm7tI1ktlmUIZ/3LEIyqPLWAnjAYtg4GK9JoIBBBGQeoNAHl3gvxNFD4rjtdT8daZrn2+13ReRewbUk3oFjIChmdtx28j7rfL0r1GoxBCCCIkBHQhRUlAHA/EMXreIdAGmavFo85iuv9JmuFhRl/dZTJRtxPB28cKT/DVHSfE2t3ngm9hle6uLy0MLi+00i4luYXunjcxjygCdsMm0hcFCjZBJI9HuLaC7hMV3BHPGTkpKgYfkaxvGEYbws8CssYkuLaFUJKrLunjURMVBIV87CcHAYnB6UAV/CFto8ct9PpdhqkN1N5f2q51SGdZbjG7b80vLAZbgcLnoM1z2nXfia98T6kkKahNbyahEsd2zxi3gSG8mEyhSdwzCI0xtyzZbphql+FtxczJPDfKsUtlp9lZJHG7OkyReaguFZlXO9g46dIwckEV048GeGRqp1MaBpovmn+0G5FqnmGXOd+7Gd2ec0Abdc54+iEvgm9BktI9rQyA3sipCxWVGCuWIBU4wVJG4HGRnNdHVHWdNGsaRPYM0aLMACZIEmGAwJ+RwVPTuDjrQByPw3uX1G71fUZ7BrCaUQRtHFY+RbuF34dHDusrHcQWB4AQY457ysPwz4UtfC8dwtnd3lx9oKlhcSDYmM/cjQLHH152qM8Z6CtygDjZfANzcvqq3XinUmttUkLTQpb2q/IYljKBvKJHypjK4/PLHrLi0trxVW7t4p1UkqJUDAEqVPX1VmH0JHepqKAKFhpuleHbHyNPt7bT7ZpR8qAIrOxCj6knao/Aelcb4b8VTarqOiaOdX0yWazz9quINWhnbUdsLr8kandyxEhyBt2Y5613GoXi2FjJcyQT3Cx4/d28Rkc5IHCjk9c1wfg3Vbm9vNJuNT1HXRcXiEm3l023isnfy2YhJBCHK4BK/PkgDOeRQBBq/hrxXq13qd3NoelfbLnb9iuzrcwk0/CKv7vEH94F+MZLEHIq58WZtPvPD/9j3V9Bb3MoLRxXUUphlLxyRoGZEblWYOBgndGvHQ16BXLePLiOzsdMu5ZL63EF+GF3Y27TvbZhlG8xhH3Kc7TkcB85BAoAp+H5Ite8J+IrkzWly2pTTedBFNLFDC3kJGY/NZAwGFBZ9nBZuOMVV8HPc2XiwaZdlWD6fJLG0fiSfUgArxqQUkjXafmGGznqB3xf0ySFvBGuX2kPc63dXKzTOdSs2h+1SiFVVfLZEGwqqLwMHnknJrN8D22q6b4ru7K6i2QCO483y9IS0iBWZRAyyKoEm6Ik4BO0gg8kUAehVxfje006913SYdTu4rFjbzvbXVxtMSTJNbSqCGxuJ8vpkZUSfUdpUdxbQXcJiuoY54yclJEDA/gaAON0ec2nwiv7izuinlQ6hJDdW8IK8SSlZIk6bOjIuSNu0ZPWo/APhuHQ72ae38N3ujG5h3TPLqouY5HyD90ORu6/Njpkd67We1gurOS0uIY5beWMxyROoKshGCpHcEcYrO0nwp4f0G4M+i6LYafMyeWXtrdYyVyDtyB0yBx7UAV4fB2m22pvfW9xqkbvcm6aJdUuBCXLbj+737ME9Vxg+lXL7w9o+qX0d5qemWt5PEoWN7iISbACT8obIB5PI5rSooARVVECooVVGAAMACloooAK4nX59FtvEUltr2t3mkRpaLcQzNrElsk5aSUuqjIBKfL0yQHUYAArtq8+8QSaq+tx2rfbrdneX7LGmsWsRnCsz71R0LcKfwUDPQmgC74huHn+Ettcy/abCZ4bKQNLOPMtZPMiKtJJIjY2Ngs7KeFY4zUPhdr3Wf7X0fXtWttfSMW7PIVguLdkZmLRkJEgDEJyG3YDIw64rrtMzLoln5xMhe3TcXkWQtlRnLLw31HBqDUbuy8NaR9oCW1parPFG2f3caeZKqFjgHH3s+nqQOQAcH4F0y0tdasbjSNPhWzeIiO8g8NparLHsO0+dv3YPByRzx65rf1zwV9s1ybUtOs9DlN1biCaLUrDzQp3MxkUgjJbfhgfvbV5GKwvAggOoaY9hdWJs3iLwww+LLu6YKYyQBbSIoPXocbeuMjFem0AU9I0/8AsnQ7HThK0ws7aODzWGC+xQu4+5xmrlFFABXl3iuWJJvGUJ1SytYptn2mwnhVrq8/0aML9nfeNu77i5ST51Yjngeo1FJa28s8c8sETyxf6uRkBZPoe1AEtFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABUF9Y2upWUlpqFvHcW8gAeORcg4OR+RAP1FT0UAVbPS7HTyDY2sVviGO3AjXAEcediAdgNzYHuatUUUAFFFFABRRRQAUUUUAFc3pfhBtOuNOEmr3V1Y6Tn7BaPHGoh/dtGNzBQz7UZlGfXJyea6SigArE8UaHJrtnaLAbUyWl0tysN5CZYZiFZdrqCP7+4HsyqcHFbdFAHC6n4YbT/hv4khvJzD9qjnu5YNHjEKqPJCmKMMG4YJknHLMxwM1F4Su4LvxkZUubzU4GtblNP1Ge+WZZESSFZtqKigAuUAbLZ8tvu9+t8SXM9l4V1a6s5RDcQWU0kUhXcEdUJBxg5wR0wfpXOeCzr0l1CNRttQgtLaO7RpL+WN2uN9yGtyCjNnbECCeB8wAzjgA7WiiigAooooAKKKKACiiigAryzxUvie8+IAuPDelKl7psKSs0rRSrJFi5iiZQZEKlvNmODkZVc4xz6nWXq3hrRtcljl1bTYLqSNSivIvO09VJ7qfQ8UAM8JfZx4K0T7Du+zf2fb+TvbLbPLXbkgDJxjtWjdyW0VrI188SW+MOZiAmDxznjvUkcaQxJHEixxooVUUYCgdAB2FNuLaC7gaC7hjnibG6OVAynBzyD70AeV+Adb87WbPSlhhS7hvD5qpp6Qxw2wshlIpAoDBZyVXaWJUEkkc16xXD+H/AU2j6jpTyf2SsOk7/LuLWx8u5ut0bJ+9bOOd25sfeYA8dK7igAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigDETxNFLqt1aw6fdyW1nKYbrUMxLBC4QOQdzh8AMMkKRz14OLC+JtBbTxfrrenGzMhiFyLuPyy4GSu7OM4BOPQVy3ifwfrGr6tPeaHFpujXzZ2azBcSfaHAjKqskQjCuM4HzM2AMgZAqLS/Auqw6wl5fNbCP+1IL4wtfz3jKI7eSI/vJVyzbmUjoAB7cgHVSa54d1Kzu4JNU0y6txamS6Q3MbqIGX7zjP3Cp6ngg1k6UngrRLizuPC9hpYa+uDpyz6VHEQrbGkKsyngYj6euOK57xB4G1C38EXcVrHBLJDpmsQ+TbqztI1zIJEVVC/N93keuMZrXbwhqt7rC6leNZWbm8ikeG0ldlWOO3miDBig+cmUcYAAUDJxQB0q+I9EeG7mTWdPaKyOLpxdIVgOcYc5+XkY5xVy0vLbULSO6sLiG6t5BlJoXDo49iODXAab8P7qy0U2k+n21zcW9tBbwXB128zJ5UiurAMreRgoGATdzx0rs/D9rqVnocEGt3K3V6pcvIpzwXJVc7V3EKVUttG4jOBnFAGlRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAf/2Q==)

Figure 6. Top 30 most frequent words from user reviews

The diagram above shows the most frequently used words from user reviews. As we can see, the positive words like ‘good’, ‘like’, ‘great’, ‘nice’, ‘well’, and ‘delicious’ are on the list and much more than negative words ‘dont’. Which means that overall people more intend to give positive feedbacks, the numbers of positive feedbacks are much more than negative feedbacks. Note that, ‘Chicken’ is on the list which means people in Toronto had chicken in restaurant more than any other meat dishes.

In addition, a word cloud picture was made and illustrated below, it shows the overall weight and frequency from review text without English stop words.

![Text

Description automatically generated with low confidence](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEA8ADwAAD/4RDsRXhpZgAATU0AKgAAAAgABAE7AAIAAAALAAAISodpAAQAAAABAAAIVpydAAEAAAAWAAAQzuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHppbGluIHdhbmcAAAAFkAMAAgAAABQAABCkkAQAAgAAABQAABC4kpEAAgAAAAM2OQAAkpIAAgAAAAM2OQAA6hwABwAACAwAAAiYAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Figure 7. Word Cloud from all review text

## Model Implementation

To predict the rating a user will give to a restaurant, models were build based on the methods below, which are Memory-based Collaborative Filtering (User-based and Item-based), Model-based CF (SVD), and Text-based NLP model. All of these methods are usually employed in building recommendation systems.

### Memory-based Collaborative Filtering

To implement a Memory-based CF, first, a user-item matrix was created, so the similarity between two users or two items can be calculated. For items, the similarity of ratings will be calculated. For users, all the items that are rated by users and how much their rating are similar will be calculated. After that, similarity matrices for item-item and user-user are obtained, leading to item-item CF and user-item CF respectively. To calculate the similarities for all the user-user and item-item pairs, the similarity matrix for users and restaurants used cosine similarity. We consider the ratings as vectors in n-dimensional space, and calculate the angle between these vectors to determine the similarity.

To make predictions by computing the similarities for all of the user-user and restaurant-restaurant pairs, the similarity matrix for users and restaurants can be constructed by using 'pairwise distance' function from 'sklearn'.

For the memory-based collaborative filtering, we have two ways to make predictions. The first is based on the similarities between users. To predict user similarity, the weighted average of the ratings from all the users to the restaurant was computed, with the similarities between users as the weights. Since some users tend to always give higher or lower ratings, the subtraction of average rating from each user were made to eliminate the bias, then the equation become as below [6]:

Text, letter

Description automatically generated

The second way to make prediction is based on the item-item (restaurant-restaurant) similarities, but it is not necessary to do the subtraction to eliminate bias as the user-user similarity matrix above.



### Model-based Collaborative Filtering

Model-based Collaborative Filtering is based on matrix factorization, which mainly as an unsupervised learning method for latent variable decomposition and dimensionality reduction. Matrix factorization is widely used for recommender systems where it can deal better with scalability and sparsity than Memory-based CF.

The goal of MF method for the Yelp dataset is to learn the latent preferences of users and the latent attributes of items from known ratings. A prediction of unknown ratings will be made by conducting dot product of the latent features of users and items. If the matrix has a large sparsity and scale, by doing matrix factorization which restructure the user-item matrix into two low rank matrices and allows filling in the original matrix; it predicts unknown ratings by taking the dot product of the two low rank matrices of users or items. For implementing matrix factorization, we used singular value decomposition (SVD). SVD is solved as follows [1]:

𝑆𝑉𝐷(𝐴)=𝑈∗∑∗

Where [1]:

* U and V are m x m and n x n matrices orthogonal matrices respectively
* ∑ is the m x n singular orthogonal matrix with non-negative elements

### Text-based NLP Model

For the NLP model, first, transfer the review texts to vectors that can be used in machine learning model. The first machine learning model was built without using TF-IDF (term frequency-inverse document frequency) but using ‘CountVectorizer’ to get the frequency of each single word in all the review texts. Then split the dataset into 70% training and 30% testing datasets. Model of multinomial Naïve Bayes classifier were applied to the training dataset to make a prediction.

Secondly, another machine learning model was built by using TF-IDF. The TF-IDF weight is composed by two terms: the first computes the normalized Term Frequency (TF), which is the number of times a word appears in a document, divided by the total number of words in that document, measuring how frequently a term occurs in document; the second term is the Inverse Document Frequency (IDF), computed as the logarithm of the number of the documents in the corpus divided by the number of documents where the specific term appears, measuring how important a term is. TF-IDF weight is a weight often used in information retrieval and text mining. This weight is a statistical measure used to evaluate how important a word is to a document in a collection or corpus.

## Performance and Evaluation

To evaluate the accuracy of the predicted ratings, we choose to use one of the most popular metrics for the recommendation system, the Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) [1]:

Where,

* is the prediction for user i
* is the prediction for how user I will rate item
* k is the number of items users I has rated

The MAE measures the difference as absolute value between the rating by algorithm prediction and the actual rating given by users. RMSE is similar as MAE but the reason of using RMSE is that it can have the greatest impact on the user decision [1].

Precision and Recall are the two metrics that evaluating classification model, which was the text-based NLP Model. It is better to have high precision and recall values. However, these two metrics are inversely related. When precision is increased recall usually decreases.

The definition of precision and recall in recommendation system are listed as below:

* Precision: the ratio of relevant items to recommended items
* Recall: the proportion of relevant items that have been recommended to the total number of relevant items.

### Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model | Train RMSE | Test RMSE | Train MAE | Test MAE |
| Memory-based (User) | 0.170770 | 0.113542 | 0.016558 | 0.012532 |
| Memory-based (Item) | 0.171236 | 0.113428 | 0.014490 | 0.010416 |
| Model-based (SVD) | 0.165669 | 0.118501 | 0.015494 | 0.012140 |
| Text-based (without TF-IDF) | 0.772209 | 0.843369 | 0.433416 | 0.526199 |
| Text-based (with TFIDF) | 1.146198 | 1.158503 | 0.790275 | 1.158503 |

Table 1. Training and Testing RMSE and MAE of models

![Table

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEA8ADwAAD/4RDsRXhpZgAATU0AKgAAAAgABAE7AAIAAAALAAAISodpAAQAAAABAAAIVpydAAEAAAAWAAAQzuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHppbGluIHdhbmcAAAAFkAMAAgAAABQAABCkkAQAAgAAABQAABC4kpEAAgAAAAM4OAAAkpIAAgAAAAM4OAAA6hwABwAACAwAAAiYAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Figure 8. Classification Report for Model without TF-IDF

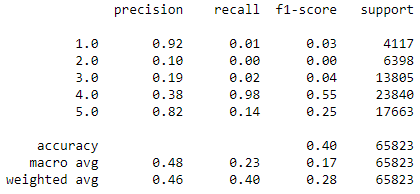


Figure . Classification Report for Model using TF-IDF

### Result Discussion

There were 30% of data randomly stratified selected by ‘stars’ from the dataset to become the test dataset. Using all the models built from the training dataset, the test errors were computed and shown in the tables above.

By comparing all the results, it was obvious that the model with the best performance is item-based Memory-based CF, which has the lowest test error of 0.113428, while the RMSE for item-based Memory-based CF was extremely close to user-based model which was 0.113542. However, for model-based CF using matrix factorization, the RMSE result of this model was not better than Memory-based CF which was 0.118501.

Since the dataset was very large and had a high level of sparsity, theoretically, matrix factorization model should have a better performance because model-based CF can deal with the sparsity and scalability problem better, and Memory-based CF had the limitations on both sparsity and scalability.

The result from text-based model is not as good as other models because of the sparsity of the review data. As we can see from Figure 8 and 9, the precision and recall values from model that not using TF-IDF were overall better than the TF-IDF Model.

For text-based model not using TF-IDF, the precision and recall value were similar, but not high enough. For text-based model which using TF-IDF, the precision and recall value were inversely related to each other. But the common thing is that, both method had relatively high precision on ‘1 star’ and ‘5 stars’ compare to 2-4 stars, indicating that text based model deal with the text words better on classifying words to either good or bad, but can not do classification to the median level.

# Conclusion and Future Works

According to the analysis of the models, the best model we recommend for predicting the rating and making recommendation is the Memory-based collaborative filtering by constructing user-user matrix. This model provides significantly lower training and testing RMSE, and it appears to be the most promising algorithm for all datasets when optimizing for performance and accuracy.

However, there maybe some error in model-based CF should be looked at, and also more model should be tried to see how other models performed. So far, some widely used CF methods for recommendation were implemented, in the future, hybrid CF will be tried which could take advantage of all the models we built. As for the data, if we could get the real time location information of the user then employing location information in making prediction would make the recommendation system much more intelligent.

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