# Restaurant Recommendation System

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## 1. Introduction

Have you ever wanted to go out to eat but didn't know exactly where? Or perhaps you are in a new city and want to find the best restaurants based on your preferences? In this report a content-based recommendation system will be built to give the costumer personalized recommendations. This will be made using data from my hometown (Braga, Portugal) assuming the user already rated several restaurants. Then, based on the user's preferences we will use the recommendation system to give personalized recommendations on different restaurants located in Braga. This recommendation system could be used in other cities if we gathered the information and ratings of the restaurants located in the respective cities. Such could be useful if you are travelling to a new city and want personalized suggestions on where to eat.

## 2. Data Section

### 2.1 Acquiring the Data

We will be using Forsquare API to obtain the required data:

- Name and type of different restaurants located in Braga, Portugal.

Firstly, we find the geospatial coordinates of the city of Braga using Nomatim form geopy.geocoders library. Then, after providing our Forsquare API credentials, we can explore the venues in a radius of 1000 relative to the geospatial coordinates. We request them in json file format and then convert it to a pandas data frame, Figure 1.

| | Name | Category | Address | Latitude | Longitude |
|---|---|---|---|---|---|
| 0 | Jardim de Sta. Bárbara | Garden | R. Dr. Justino da Cruz, 127 (R. Eça de Queiroz) | 41.551308 | -8.425489 |
| 1 | Sé de Braga | Church | R. D. Paio Mendes | 41.549835 | -8.427574 |
| 2 | DeGema Hamburgueria Artesanal | Burger Joint | Pç. Dr. José Augusto Ferreira Salgado (R. Dr. ... | 41.551292 | -8.425344 |
| 3 | Dona Petisca | Restaurant | Braga | 41.549792 | -8.427953 |
| 4 | Setra | Bar | Rua de São João, 15 | 41.550058 | -8.425931 |
| ... | ... | ... | ... | ... | ... |
| 95 | A Astoria | Portuguese Restaurant | Portugal | 41.551572 | -8.423084 |
| 96 | Lado B | Brewery | 4700-422 Braga | 41.550167 | -8.429622 |
| 97 | Confeitaria Sto. António | Coffee Shop | Portugal | 41.552217 | -8.427534 |
| 98 | Lusitana | Bakery | Rua Dr. Justino Cruz, 127 (Jardim Sta. Bárbara) | 41.551325 | -8.425460 |
| 99 | Restaurante Botafogo | Portuguese Restaurant | Rua De Sto. André 11 | 41.553603 | -8.422928 |

100 rows × 5 columns

*Figure 1. Pandas Data frame containing information of venues in Braga, Portugal.*

## 2.2 Data Preprocessing

We are only interested in the venues which have the word 'Restaurant' in the Category column. Therefore, we filtered from the data frame shown in Figure 1 the desired venues, resulting in the data frame displayed in Figure 2.

| | Name | Category | Address | Latitude | Longitude |
|---|---|---|---|---|---|
| 3 | Dona Petisca | Restaurant | Braga | 41.549792 | -8.427953 |
| 6 | Michizaki | Japanese Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 |
| 11 | Cozinha da Sé | Portuguese Restaurant | R. D. Frei Caetano Brandão, 95 | 41.550021 | -8.428584 |
| 13 | Anjo Verde | Vegetarian / Vegan Restaurant | Lg. da Praça Velha, 21 (ao Arco da Porta Nova) | 41.550206 | -8.429015 |
| 21 | Adega Malhoa | Portuguese Restaurant | R. D. Paio Mendes, 17 | 41.549642 | -8.428807 |
| 23 | Lakkana | Thai Restaurant | R. Don Gualdim Pais, 34 | 41.549186 | -8.427645 |
| 25 | La Piola | Italian Restaurant | R. D. Afonso Henriques | 41.548922 | -8.427519 |
| 26 | Lapa Sushi | Asian Restaurant | Praça da República, 4 | 41.551688 | -8.423488 |
| 27 | Nikko | Sushi Restaurant | Largo de S. Paulo | 41.548215 | -8.427458 |
| 28 | Casa de Pasto das Carvalheiras | Tapas Restaurant | R. D. Afonso Henriques, 8 | 41.548484 | -8.428799 |
| 29 | Brac | Restaurant | Campo das Carvalheiras | 41.548646 | -8.428869 |
| 31 | Time To | Restaurant | 4700-030 Braga | 41.548811 | -8.427999 |
| 35 | Retrokitchen | Restaurant | R. do Anjo, 96 | 41.548417 | -8.425305 |
| 36 | Alfacinha | Vegetarian / Vegan Restaurant | R. D. Gonçalo Pereira | 41.548897 | -8.427012 |
| 40 | Hibiscus | Vegetarian / Vegan Restaurant | Largo de São Francisco 32 | 41.552486 | -8.424120 |
| 41 | Sale & Dolce | Italian Restaurant | Lg. S. Paulo 1 | 41.548210 | -8.427451 |
| 43 | Aopé Dasé | Restaurant | Portugal | 41.550098 | -8.426009 |
| 47 | Tasca D. Ferreira | Restaurant | R. S. Vicente | 41.554479 | -8.423207 |
| 51 | O Alexandre | Portuguese Restaurant | Braga | 41.549850 | -8.430119 |
| 53 | Gosto Superior | Vegetarian / Vegan Restaurant | Praça Mouzinho de Albuquerque | 41.553455 | -8.420367 |
| 56 | Restaurante Silvas | Restaurant | C. C. Granjinhos (R. 25 de Abril) | 41.547361 | -8.421606 |
| 58 | Dom Augusto | Portuguese Restaurant | Rua de São Vicente 222 | 41.555397 | -8.422152 |
| 59 | Cruz Sobral | Portuguese Restaurant | Campo das Hortas, 7/8 | 41.550025 | -8.429933 |
| 63 | Ignácio | Portuguese Restaurant | Campo das Hortas, 4 | 41.550041 | -8.429837 |
| 65 | Mercado das Tapas | Tapas Restaurant | Pç. Conde de Agrolongo, 116 | 41.553068 | -8.428400 |
| 71 | Trotas | Portuguese Restaurant | Rua do Raio | 41.551326 | -8.417657 |
| 77 | Boutique do Leitão | Restaurant | R. Eça de Queirós | 41.551668 | -8.426193 |
| 82 | Migaitas da Estação | Portuguese Restaurant | Largo da Estação | 41.547984 | -8.435113 |
| 84 | Alma d'Eça | Sushi Restaurant | R. Eça de Queirós | 41.551688 | -8.425949 |
| 85 | Norte da China | Chinese Restaurant | Portugal | 41.555773 | -8.422427 |
| 87 | BLB - Braga Loves Bifana | Modern European Restaurant | Largo Da Senhora A Branca | 41.551941 | -8.416705 |
| 89 | Um Cibo no Prato | Portuguese Restaurant | Braga | 41.551852 | -8.416348 |
| 92 | O Bacalhau | Restaurant | Braga | 41.549601 | -8.430321 |
| 95 | A Astoria | Portuguese Restaurant | Portugal | 41.551572 | -8.423084 |
| 99 | Restaurante Botafogo | Portuguese Restaurant | Rua De Sto. André 11 | 41.553603 | -8.422928 |

*Figure 2. Pandas data frame with the Restaurant venues in Braga, Portugal.*

We then checked if any rating was available using Forsquare API. Since there were none, we decided to web scrap the information stored in the link https://d7leadfinder.com/app/view-leads/1680829/, as it contains a list of restaurants in Braga with the respective rating. After doing some data cleaning, such as removing entries with NaN values, we ended up with the list displayed in Figure 3.

| | Name | Rating |
|---|---|---|
| 0 | Bira dos Namorados | 4.8 |
| 1 | Michizaki | 4.8 |
| 2 | Restaurant | 4.4 |
| 3 | Restaurante O Jacó | 4.5 |
| 4 | Lakkana | 4.6 |
| ... | ... | ... |
| 196 | Take Away Wok-Grill | 4.3 |
| 197 | Mammamia - Gelato I... | 4.4 |
| 198 | Carreira do Tiro | 4.3 |
| 199 | Boutique do Leitão | 4.0 |
| 200 | THE TRUTH BRAGA | 3.5 |

201 rows × 2 columns

*Figure 3. Pandas Data frame containing the name and rating of some restaurants located in Braga, Portugal.*

Now, the goal is to append the ratings displayed in Figure 3 to the restaurants data frame displayed in Figure 2. We accomplished such task by matching the names of the restaurants of both data frames and then construct a new data frame which contains all the restaurants which have a rating. Such data frame is presented in Figure 4.

| | Name | Category | Address | Latitude | Longitude | Rating |
|---|---|---|---|---|---|---|
| 0 | A Astoria | Portuguese Restaurant | Portugal | 41.551572 | -8.423084 | 3.8 |
| 1 | Adega Malhoa | Portuguese Restaurant | R. D. Paio Mendes, 17 | 41.549642 | -8.428807 | 4.2 |
| 2 | Alfacinha | Vegetarian / Vegan Restaurant | R. D. Gonçalo Pereira | 41.548897 | -8.427012 | 4.7 |
| 3 | Alma d'Eça | Sushi Restaurant | R. Eça de Queirós | 41.551688 | -8.425949 | 4.5 |
| 4 | BLB - Braga Loves Bifana | Modern European Restaurant | Largo Da Senhora A Branca | 41.551941 | -8.416705 | 4.3 |
| 5 | Boutique do Leitão | Restaurant | R. Eça de Queirós | 41.551668 | -8.426193 | 4.0 |
| 6 | Brac | Restaurant | Campo das Carvalheiras | 41.548646 | -8.428869 | 4.6 |
| 7 | Dom Augusto | Portuguese Restaurant | Rua de São Vicente 222 | 41.555397 | -8.422152 | 4.6 |
| 8 | Dona Petisca | Restaurant | Braga | 41.549792 | -8.427953 | 4.6 |
| 9 | Gosto Superior | Vegetarian / Vegan Restaurant | Praça Mouzinho de Albuquerque | 41.553455 | -8.420367 | 4.7 |
| 10 | Hibiscus | Vegetarian / Vegan Restaurant | Largo de São Francisco 32 | 41.552486 | -8.424120 | 4.6 |
| 11 | Ignácio | Portuguese Restaurant | Campo das Hortas, 4 | 41.550041 | -8.429837 | 4.2 |
| 12 | La Piola | Italian Restaurant | R. D. Afonso Henriques | 41.548922 | -8.427519 | 4.4 |
| 13 | Lakkana | Thai Restaurant | R. Don Gualdim Pais, 34 | 41.549186 | -8.427645 | 4.6 |
| 14 | Michizaki | Japanese Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 | 4.8 |
| 15 | Nikko | Sushi Restaurant | Largo de S. Paulo | 41.548215 | -8.427458 | 4.1 |
| 16 | Norte da China | Chinese Restaurant | Portugal | 41.555773 | -8.422427 | 4.3 |
| 17 | O Bacalhau | Restaurant | Braga | 41.549601 | -8.430321 | 3.9 |
| 18 | Restaurante Botafogo | Portuguese Restaurant | Rua De Sto. André 11 | 41.553603 | -8.422928 | 4.0 |
| 19 | Restaurante Silvas | Restaurant | C. C. Granjinhos (R. 25 de Abril) | 41.547361 | -8.421606 | 4.4 |
| 20 | Retrokitchen | Restaurant | R. do Anjo, 96 | 41.548417 | -8.425305 | 4.7 |
| 21 | Tasca D. Ferreira | Restaurant | R. S. Vicente | 41.554479 | -8.423207 | 4.6 |
| 22 | Time To | Restaurant | 4700-030 Braga | 41.548811 | -8.427999 | 4.5 |
| 23 | Trotas | Portuguese Restaurant | Rua do Raio | 41.551326 | -8.417657 | 4.5 |
| 24 | Um Cibo no Prato | Portuguese Restaurant | Braga | 41.551852 | -8.416348 | 4.5 |

*Figure 4. Pandas Data frame with the restaurants and its ratings.*

# 3. Methodology

## 3.1 Data Analysis

Now, let's look at the different categories and edit them so we can build a better recommendation system. Some editing will be made based on the following category descriptions:

- **Portuguese Restaurant**: Traditional portuguese cuisine.
- **Vegetarian / Vegan Restaurant**: Vegetarian / Vegan options only.
- **Modern European Restaurant**: Modern approach of Mediterranean cuisine.
- **Healthy Food Restaurant**: Includes vegetarian / vegan options as well as non-vegetarian healthy food.
- **Sushi Restaurant vs Japanese Restaurant**: Sushi restaurants focus mainly on Sushi while Japanese restaurants serve traditional japanese dishes.

*Important Note*: If a restaurant fits in more than one category, it is reasonable to insert it more than one time under different categories (eg. *Michizaki* serves traditional Japanese cuisine as well as sushi, so we will insert two different entries for this restaurant). The data frame containing the correct Categories is displayed in Figure 5.

| | Name | Category | Address | Latitude | Longitude | Rating |
|---|---|---|---|---|---|---|
| 0 | A Astoria | Portuguese Restaurant | Portugal | 41.551572 | -8.423084 | 3.8 |
| 1 | Adega Malhoa | Portuguese Restaurant | R. D. Paio Mendes, 17 | 41.549642 | -8.428807 | 4.2 |
| 2 | Alfacinha | Vegetarian / Vegan Restaurant | R. D. Gonçalo Pereira | 41.548897 | -8.427012 | 4.7 |
| 3 | Alma d'Eça | Sushi Restaurant | R. Eça de Queirós | 41.551688 | -8.425949 | 4.5 |
| 4 | BLB - Braga Loves Bifana | Modern European Restaurant | Largo Da Senhora A Branca | 41.551941 | -8.416705 | 4.3 |
| 5 | Boutique do Leitão | Portuguese Restaurant | R. Eça de Queirós | 41.551668 | -8.426193 | 4.0 |
| 6 | Brac | Modern European Restaurant | Campo das Carvalheiras | 41.548646 | -8.428869 | 4.6 |
| 7 | Dom Augusto | Portuguese Restaurant | Rua de São Vicente 222 | 41.555397 | -8.422152 | 4.6 |
| 8 | Dona Petisca | Tapas Restaurant | Braga | 41.549792 | -8.427953 | 4.6 |
| 9 | Gosto Superior | Vegetarian / Vegan Restaurant | Praça Mouzinho de Albuquerque | 41.553455 | -8.420367 | 4.7 |
| 10 | Hibiscus | Vegetarian / Vegan Restaurant | Largo de São Francisco 32 | 41.552486 | -8.424120 | 4.6 |
| 11 | Ignácio | Portuguese Restaurant | Campo das Hortas, 4 | 41.550041 | -8.429837 | 4.2 |
| 12 | La Piola | Italian Restaurant | R. D. Afonso Henriques | 41.548922 | -8.427519 | 4.4 |
| 13 | Lakkana | Thai Restaurant | R. Don Gualdim Pais, 34 | 41.549186 | -8.427645 | 4.6 |
| 14 | Michizaki | Japanese Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 | 4.8 |
| 15 | Nikko | Sushi Restaurant | Largo de S. Paulo | 41.548215 | -8.427458 | 4.1 |
| 16 | Norte da China | Chinese Restaurant | Portugal | 41.555773 | -8.422427 | 4.3 |
| 17 | O Bacalhau | Portuguese Restaurant | Braga | 41.549601 | -8.430321 | 3.9 |
| 18 | Restaurante Botafogo | Portuguese Restaurant | Rua De Sto. André 11 | 41.553603 | -8.422928 | 4.0 |
| 19 | Restaurante Silvas | Portuguese Restaurant | C. C. Granjinhos (R. 25 de Abril) | 41.547361 | -8.421606 | 4.4 |
| 20 | Retrokitchen | Healthy Food Restaurant | R. do Anjo, 96 | 41.548417 | -8.425305 | 4.7 |
| 21 | Tasca D. Ferreira | Portuguese Restaurant | R. S. Vicente | 41.554479 | -8.423207 | 4.6 |
| 22 | Time To | Modern European Restaurant | 4700-030 Braga | 41.548811 | -8.427999 | 4.5 |
| 23 | Trotas | Portuguese Restaurant | Rua do Raio | 41.551326 | -8.417657 | 4.5 |
| 24 | Um Cibo no Prato | Portuguese Restaurant | Braga | 41.551852 | -8.416348 | 4.5 |
| 25 | Michizaki | Sushi Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 | 4.8 |

*Figure 5. Pandas data frame of restaurants in Braga with corrected categories.*

Since we are building a content-based recommendation system, it is ideal to feed categorical data using the One Hot Encoding technique. Basically we convert the respective features (in this case restaurant categories) in vectors, so that if a restaurant matches that feature it gives a value of 1, and if it doesn't then it retrieves a value of 0. Such data frame is displayed in Figure 6.

| | Name | Portuguese Restaurant | Vegetarian / Vegan Restaurant | Sushi Restaurant | Modern European Restaurant | Tapas Restaurant | Italian Restaurant | Thai Restaurant | Japanese Restaurant | Chinese Restaurant | Healthy Food Restaurant |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | A Astoria | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1 | Adega Malhoa | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | Alfacinha | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | Alma d'Eça | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4 | BLB - Braga Loves Bifana | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | Boutique do Leitão | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | Brac | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7 | Dom Augusto | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 | Dona Petisca | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 | Gosto Superior | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 10 | Hibiscus | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11 | Ignácio | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 12 | La Piola | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 13 | Lakkana | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| 14 | Michizaki | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 |
| 15 | Nikko | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 16 | Norte da China | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| 17 | O Bacalhau | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 18 | Restaurante Botafogo | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 19 | Restaurante Silvas | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20 | Retrokitchen | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| 21 | Tasca D. Ferreira | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22 | Time To | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23 | Trotas | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24 | Um Cibo no Prato | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 25 | Michizaki | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

*Figure 6. Pandas data frame when one hot encoding of the restaurant categories is performed.*

At this point you may be wondering why are we doing this if each restaurant fits in just one category. One must consider the possibility of a restaurant having different menu options such as Michizaki (serves both sushi and Japanese traditional food). Attributing different categories to the same restaurant has a drawback: since each restaurant has only one general rating it makes it a bit ambiguous (the rating *4.5* for the restaurant *Michizaki* applies for both sushi and Japanese tradition food, despite of representing different categories). However, it is also reasonable to assume that if the restaurant has a very good/low rating you will probably enjoy/not enjoy the food for all the categories. On a separate note this feature could be useful in the user rating input since we can attribute different ratings for the same restaurant under different categories.

## 3.2 Building a content-based recommendation system

A content-based recommendation system recommends the user new items based on the user's preferences. In this case, we are going to figure out which restaurant categories the user prefers and use it to suggest new restaurants.

In order to build a content-based recommendation system, user rating data of different restaurants needs to be inserted. I will construct a user input dataset based on my previous experiences. Such data frame can be found in Figure 7.

| | Name | Category | Rating |
|---|---|---|---|
| 0 | Il Fiume | Italian Restaurant | 4.0 |
| 1 | Sale & Dolce | Italian Restaurant | 4.9 |
| 2 | Otsu Biru | Sushi Restaurant | 4.5 |
| 3 | Pórtico | Portuguese Restaurant | 4.7 |
| 4 | Temple San | Sushi Restaurant | 4.0 |
| 5 | Café Aires | Portuguese Restaurant | 3.0 |
| 6 | Pausa Útil | Vegetarian / Vegan Restaurant | 4.5 |

*Figure 7. Pandas data frame of the user's input restaurant dataset.*

After performing the One Hot Encoding technique on the user's input restaurant dataset, we are able to calculate the weights relative to each category by summing the ratings, Figure 8.

```
Chinese Restaurant              0.0
Healthy Food Restaurant         0.0
Italian Restaurant              8.9
Japanese Restaurant             0.0
Modern European Restaurant      0.0
Portuguese Restaurant           7.7
Sushi Restaurant                8.5
Tapas Restaurant                0.0
Thai Restaurant                 0.0
Vegetarian / Vegan Restaurant   4.5
Name: Weights, dtype: float64
```

*Figure 8. Output of the calculated weights using the user's input dataset.*

We now have all the necessary information to calculate the weighted average of each restaurant:

$$w_{avg} = \frac{v_{rest} \times w_i}{\sum_i w_i},$$

where $w_{avg}$ is the weighted average of a restaurant, $w_i$ is the weight of $i^{th}$ category displayed in Figure 8 and $v_{rest}$ is the one hot encoding vector of the respective restaurant in the datafame of Figure 6. For a correct calculation one has to firstly to drop the *Name* column of the data frame of Figure 6 and then sort the columns alphabetically (to match the order presented in Figure 8).

# 4. Results

The weighted average for each movie is listed in Figure 9.

```
12    0.300676
15    0.287162
3     0.287162
25    0.287162
21    0.260135
24    0.260135
1     0.260135
23    0.260135
5     0.260135
7     0.260135
11    0.260135
0     0.260135
17    0.260135
18    0.260135
19    0.260135
9     0.152027
2     0.152027
10    0.152027
13    0.000000
14    0.000000
22    0.000000
20    0.000000
8     0.000000
16    0.000000
6     0.000000
4     0.000000
dtype: float64
```

*Figure 9. Weighted average of each restaurant. The numbers on the left column are the indexes of the each restaurant.*

We can now build a recommendation table, where the restaurants are sorted according to its weighted average value, Figure 10.

One can further improve the recommendation system if we sort the restaurants with equal weighted average by rating. In this way, the higher rated restaurants that have the same weighted average will appear first on the recommendation table, Figure 11.

| | Name | Category | Address | Latitude | Longitude | Rating |
|---|---|---|---|---|---|---|
| 12 | La Piola | Italian Restaurant | R. D. Afonso Henriques | 41.548922 | -8.427519 | 4.4 |
| 15 | Nikko | Sushi Restaurant | Largo de S. Paulo | 41.548215 | -8.427458 | 4.1 |
| 3 | Alma d'Eça | Sushi Restaurant | R. Eça de Queirós | 41.551688 | -8.425949 | 4.5 |
| 25 | Michizaki | Sushi Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 | 4.8 |
| 21 | Tasca D. Ferreira | Portuguese Restaurant | R. S. Vicente | 41.554479 | -8.423207 | 4.6 |
| 24 | Um Cibo no Prato | Portuguese Restaurant | Braga | 41.551852 | -8.416348 | 4.5 |
| 1 | Adega Malhoa | Portuguese Restaurant | R. D. Paio Mendes, 17 | 41.549642 | -8.428807 | 4.2 |
| 23 | Trotas | Portuguese Restaurant | Rua do Raio | 41.551326 | -8.417657 | 4.5 |
| 5 | Boutique do Leitão | Portuguese Restaurant | R. Eça de Queirós | 41.551668 | -8.426193 | 4.0 |
| 7 | Dom Augusto | Portuguese Restaurant | Rua de São Vicente 222 | 41.555397 | -8.422152 | 4.6 |
| 11 | Ignácio | Portuguese Restaurant | Campo das Hortas, 4 | 41.550041 | -8.429837 | 4.2 |
| 0 | A Astoria | Portuguese Restaurant | Portugal | 41.551572 | -8.423084 | 3.8 |
| 17 | O Bacalhau | Portuguese Restaurant | Braga | 41.549601 | -8.430321 | 3.9 |
| 18 | Restaurante Botafogo | Portuguese Restaurant | Rua De Sto. André 11 | 41.553603 | -8.422928 | 4.0 |
| 19 | Restaurante Silvas | Portuguese Restaurant | C. C. Granjinhos (R. 25 de Abril) | 41.547361 | -8.421606 | 4.4 |
| 9 | Gosto Superior | Vegetarian / Vegan Restaurant | Praça Mouzinho de Albuquerque | 41.553455 | -8.420367 | 4.7 |
| 2 | Alfacinha | Vegetarian / Vegan Restaurant | R. D. Gonçalo Pereira | 41.548897 | -8.427012 | 4.7 |
| 10 | Hibiscus | Vegetarian / Vegan Restaurant | Largo de São Francisco 32 | 41.552486 | -8.424120 | 4.6 |
| 13 | Lakkana | Thai Restaurant | R. Don Gualdim Pais, 34 | 41.549186 | -8.427645 | 4.6 |
| 14 | Michizaki | Japanese Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 | 4.8 |
| 22 | Time To | Modern European Restaurant | 4700-030 Braga | 41.548811 | -8.427999 | 4.5 |
| 20 | Retrokitchen | Healthy Food Restaurant | R. do Anjo, 96 | 41.548417 | -8.425305 | 4.7 |
| 8 | Dona Petisca | Tapas Restaurant | Braga | 41.549792 | -8.427953 | 4.6 |
| 16 | Norte da China | Chinese Restaurant | Portugal | 41.555773 | -8.422427 | 4.3 |
| 6 | Brac | Modern European Restaurant | Campo das Carvalheiras | 41.548646 | -8.428869 | 4.6 |
| 4 | BLB - Braga Loves Bifana | Modern European Restaurant | Largo Da Senhora A Branca | 41.551941 | -8.416705 | 4.3 |

*Figure 10. Recommendation table where the values are sorted according to the weighted average of each restaurant.*

| | Name | Category | Address | Latitude | Longitude | Rating |
|---|---|---|---|---|---|---|
| 12 | La Piola | Italian Restaurant | R. D. Afonso Henriques | 41.548922 | -8.427519 | 4.4 |
| 25 | Michizaki | Sushi Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 | 4.8 |
| 3 | Alma d'Eça | Sushi Restaurant | R. Eça de Queirós | 41.551688 | -8.425949 | 4.5 |
| 15 | Nikko | Sushi Restaurant | Largo de S. Paulo | 41.548215 | -8.427458 | 4.1 |
| 21 | Tasca D. Ferreira | Portuguese Restaurant | R. S. Vicente | 41.554479 | -8.423207 | 4.6 |
| 7 | Dom Augusto | Portuguese Restaurant | Rua de São Vicente 222 | 41.555397 | -8.422152 | 4.6 |
| 24 | Um Cibo no Prato | Portuguese Restaurant | Braga | 41.551852 | -8.416348 | 4.5 |
| 23 | Trotas | Portuguese Restaurant | Rua do Raio | 41.551326 | -8.417657 | 4.5 |
| 19 | Restaurante Silvas | Portuguese Restaurant | C. C. Granjinhos (R. 25 de Abril) | 41.547361 | -8.421606 | 4.4 |
| 1 | Adega Malhoa | Portuguese Restaurant | R. D. Paio Mendes, 17 | 41.549642 | -8.428807 | 4.2 |
| 11 | Ignácio | Portuguese Restaurant | Campo das Hortas, 4 | 41.550041 | -8.429837 | 4.2 |
| 5 | Boutique do Leitão | Portuguese Restaurant | R. Eça de Queirós | 41.551668 | -8.426193 | 4.0 |
| 18 | Restaurante Botafogo | Portuguese Restaurant | Rua De Sto. André 11 | 41.553603 | -8.422928 | 4.0 |
| 17 | O Bacalhau | Portuguese Restaurant | Braga | 41.549601 | -8.430321 | 3.9 |
| 0 | A Astoria | Portuguese Restaurant | Portugal | 41.551572 | -8.423084 | 3.8 |
| 9 | Gosto Superior | Vegetarian / Vegan Restaurant | Praça Mouzinho de Albuquerque | 41.553455 | -8.420367 | 4.7 |
| 2 | Alfacinha | Vegetarian / Vegan Restaurant | R. D. Gonçalo Pereira | 41.548897 | -8.427012 | 4.7 |
| 10 | Hibiscus | Vegetarian / Vegan Restaurant | Largo de São Francisco 32 | 41.552486 | -8.424120 | 4.6 |
| 14 | Michizaki | Japanese Restaurant | R. D. Frei Caetano Brandão, 169 | 41.548418 | -8.428323 | 4.8 |
| 20 | Retrokitchen | Healthy Food Restaurant | R. do Anjo, 96 | 41.548417 | -8.425305 | 4.7 |
| 13 | Lakkana | Thai Restaurant | R. Don Gualdim Pais, 34 | 41.549186 | -8.427645 | 4.6 |
| 8 | Dona Petisca | Tapas Restaurant | Braga | 41.549792 | -8.427953 | 4.6 |
| 6 | Brac | Modern European Restaurant | Campo das Carvalheiras | 41.548646 | -8.428869 | 4.6 |
| 22 | Time To | Modern European Restaurant | 4700-030 Braga | 41.548811 | -8.427999 | 4.5 |
| 16 | Norte da China | Chinese Restaurant | Portugal | 41.555773 | -8.422427 | 4.3 |
| 4 | BLB - Braga Loves Bifana | Modern European Restaurant | Largo Da Senhora A Branca | 41.551941 | -8.416705 | 4.3 |

*Figure 11. Final recommendation table where the values are sorted firstly according to the weighted average of each restaurant and also by its rating (if the weighted average is the same).*

## 5. Discussion

The results presented in the final recommendation table makes sense based on the user input dataset: it rates the Italian restaurants higher, then the sushi restaurants and so on. No user's input rating is available for certain categories such as Japanese, Healthy Food, Thai, Tapas, Modern European and Chinese restaurants so this are placed in the bottom of the table. This indicates that such method gives highly personalized recommendations, but might miss on something the user hasn't experienced yet and might like. Here the user input dataset had only 6 entries: once the user starts going to different restaurants and provide a rating for each, the user input dataset will grow and more accurate suggestions will be made.

Note that the same restaurant can be recommended to you more than once (eg. *Michizaki*), and each category of the respective restaurant will have its own place on the recommendation table. Contrary to content-based movies recommendation systems, where all categories/genres are incorporated in one movie entry, here the categories are evaluated separately. This makes sense, because when you watch a movie you have no choice upon the different genres which are incorporated in the movie whereas when you go to a restaurant you can choose what type of food to order. One of the main disadvantages of a content-based recommendation system is that it doesn't take into consideration other user's preferences, and this targets that drawback.

## 6. Conclusion

In this report a content-based recommendation system of different restaurants located in Braga was built using Forsquare API and web scraping. Restaurant categories and respective ratings were taken into consideration, and reasonable recommendations were made taking into account the user's input dataset. The recommendation system is highly personalized for the user and learns from the user's preferences.

Building a recommendation system based only on restaurant categories can be limiting, as it doesn't address the location of the place, nor the price. These parameters could be useful to make a better recommendation system in the future. Also, getting the user to try and rate different restaurants would be of extreme importance since the recommendations heavily depend on the user input ratings.

This system could be applied to any city/area given that the restaurant information from that area can be retrieved.