
***Master of Technology Intelligent Systems 2021***

***Intelligent Reasoning Systems***

***Final Project Report***

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## *EXECUTIVE SUMMARY*

*A panoply of considerations go into choosing the meals we partake in each day. These could include the nutritional value of dishes, as well as the taste, dietary and budgetary preferences of an individual for that particular meal. More often than not, we find ourselves overwhelmed with the plethora of available food choices, making it extremely difficult to decide upon a dish with absolute conviction, a circumstance commonly known as 'choice paralysis'.*

*What2Eat aims to streamline this decision process by leveraging Intelligent Systems to recommend dishes tailored to users' palates. This is done through understanding and recognizing their taste and dietary preferences, as well as their current mood which is known to be closely associated with food cravings. Understanding that taste preferences often alters over time, the solution accepts ratings from the users, ensuring that the recommendation remains optimized and relevant.*

*The following techniques have been applied to create What2Eat:*

- *Reasoning Systems:*
  - *Rule-based Decision Making*
  - *Content-based Filtering*
- *Knowledge Discovery: Natural Language Processing (Name Entity Recognition)*

## *PROBLEM STATEMENT*

*Along with the gargantuan and diverse selection of food dishes made easily accessible today is the growing dilemma faced by individuals in choosing the dishes to have in a meal. With the large amount of cuisines available and the myriad of ingredients going into each dish, it is more often than not challenging to choose one that satisfies an individual's palate.*

*Research conducted by Barclays Plan & Invest revealed that Britons spend 54 minutes deliberating what to eat for breakfast, lunch and dinner each day, with two in five of those polled reporting that they felt stressed or anxious when making decisions (Barclays, 2020). A separate survey noted that the average American couple spends approximately 132 hours a year deciding on what to eat (New York Post, 2017). While spending time deciding what to eat is seemingly harmless, being constantly weighed down by such trivial decisions on a daily basis causes cognitive fatigue and may impair our judgement when making bigger and important life decisions - like deciding on the purchase of a house or changing jobs.*

*The problem with the growing indecisiveness surrounding food choices is accompanied with the improvement in living standards and people's demand for higher quality food. In comparison to the past, people are less likely to settle for food that does not satisfy their taste buds and cravings. In essence, food has evolved far from being mere bodily sustenance to a form of enjoyment that individuals look forward to each day. This then begs the question as to how we can ensure that the palates of individuals are being pleased, while reducing the time they waste in deliberating on the food dishes to have every meal.*

## *SOLUTION*

*What2Eat is a browser-based recommender with a user login function to ensure that users can request for dish recommendations on different devices anywhere. The application strives to alleviate users' dilemma and reduce the unnecessary time spent in deciding on a meal. By harnessing the strength of intelligent reasoning systems, What2Eat will be able to curate food dishes based on the user's taste preference.*

*The incorporation of meal preference selection in the application allows the satisfaction of users' cravings with simple options such as, "Healthy", "Carnivorous", "Rainy" or "Scorching". Furthermore, to cater to the even less decisive and ensure that users will not be constantly recommended the same set of recipes, users will also be able to opt for the "Surprise Me" option for a completely random recommendation. Reducing the available options to a mere few categories prevents users from being flooded with excessive choices, which could otherwise result in choice paralysis (Barry Schwartz, 2004).*

*Acknowledging the constant changes in our taste palates, What2Eat is kept updated through users' ratings of the recommended dishes. This would enable the improvement of What2Eat's recommendations with every meal, ensuring that the dishes recommended remain relevant and always tailored to users' taste preferences.*

*What2Eat would be rolled out on a free-to-use basis with supporting ads. Users could also opt to pay a small annual subscription fee for the ad-free premium version of What2Eat. A free-to-use version in the budding stage of What2Eat is imperative to obtain a substantial user base. Having done so, various other revenue streams will then be introduced in the future improvement of What2Eat.*

## 1. DATA PRE-PROCESSING

### 1.1. Food data Sourced from Kaggle

*Kaggle dataset for recipes URL: https://www.kaggle.com/elisaxxygao/foodrecsysv1*

*Dataset was constructed from Allrecipe.com with a total of 52,821 recipes sourced from year 2000 to 2018. The dataset size was a total of 6.74GB but for the purpose of the application we would use a random size for 500 different recipes for our use case.*

| | index | recipe_id | recipe_name | aver_rate | image_url | review_nums | ingredients | cooking_directions | nutritions | reviews |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 8351 | 219933 | Benny's Famous Jalapeno Poppers | 4.768116 | https://images.media-allrecipes.com/userphotos... | 58 | cream cheese^shredded Cheddar cheese^fresh cor... | {'directions': Prep 20 m Cook 10 m Ready In 3... | {'directions': Prep 20 m Cook 10 m Ready In 3... | {12241793: {'rating': 5, 'followersCount': 0, ... |
| 1 | 6001 | 245278 | Chicken Posole Verde Soup | 4.833333 | https://images.media-allrecipes.com/userphotos... | 6 | Chicken^large skinless boneless chicken breas... | {'directions': Prep 10 m Cook 5 h Ready In 5 ... | {'directions': Prep 10 m Cook 5 h Ready In 5 ... | {5471779: {'rating': 5, 'followersCount': 7, '... |
| 2 | 24115 | 68454 | Cinnamon Gelatin Salad | 4.181818 | http://images.media-allrecipes.com/userphotos/... | 11 | raspberry flavored Jell-O® mix^boiling water^c... | {'directions': Prep 5 m Ready In 3 h 5 m In a... | {'directions': Prep 5 m Ready In 3 h 5 m In a... | {20259813: {'rating': 5, 'followersCount': 0, ... |
| 3 | 17615 | 22733 | Kids' Snack | 4.058824 | http://images.media-allrecipes.com/userphotos/... | 16 | sweetened honey corn and oat cereal^bear-shape... | {'directions': Prep 5 m Ready In 5 m Combine ... | {'directions': Prep 5 m Ready In 5 m Combine ... | {15492896: {'rating': 5, 'followersCount': 1, ... |
| 4 | 1688 | 245406 | Fried Brussels Sprouts | 4.612717 | https://images.media-allrecipes.com/userphotos... | 133 | bacon^onion^fresh Brussels sprouts trimmed and... | {'directions': Prep 15 m Cook 20 m Ready In 3... | {'directions': Prep 15 m Cook 20 m Ready In 3... | {17731072: {'rating': 4, 'followersCount': 0, ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 495 | 37200 | 238919 | Stacked Tomato and Burrata Salad | 4.851852 | https://images.media-allrecipes.com/userphotos... | 21 | vine-ripened tomato^flaked sea salt and freshl... | {'directions': Prep 15 m Ready In 15 m Place ... | {'directions': Prep 15 m Ready In 15 m Place ... | {14874080: {'rating': 5, 'followersCount': 0, ... |
| 496 | 670 | 214706 | Easy Green Chile Stew | 4.590909 | https://images.media-allrecipes.com/userphotos... | 19 | ground beef^onion^hominy (do not drain)^frozen... | {'directions': Prep 10 m Cook 40 m Ready In 5... | {'directions': Prep 10 m Cook 40 m Ready In 5... | {5015584: {'rating': 5, 'followersCount': 0, '... |

*Figure 1 - Recipe dataset*

*The following columns are kept from the original dataset:*

- *Recipe_id*
- *Recipe_name*
- *Image_url*
- *Ingredients*
- *Cooking directions*

*The recipe id would be used as our dish identifying in our application, this will help to retrieve the other necessary information. As the data was from Kaggle, minimal data cleaning was needed. Simple separators such as 'U' ', '^ 'were included in each of the columns which makes splitting the data easier for processing.*

### 1.2. Data Pre-Processing

*Dataset columns such as recipe_id, recipe_name & ingredients will be used to create ingredient tags and allow for ingredient matrix to be formed, these will be used in our application's recommender model. The team has decided that additional tables would need to be generated in order to apply within our application.*

- *Ingredient Table with individual ingredient tags*
- *Recipe vs ingredient tags as columns table*
- *Ingredient Category to be used in our rules system*

### *1.3. Ingredient Tag Generation*

*In the ingredient column, data is stored as lists with a list of descriptive words paired with the base ingredients. In order to generate individual ingredient tags, we would need to apply the use of a* ***Cognitive System*** *such as Natural Language Processing (NLP) to extract keywords from each of the ingredient lists in the dataset. To achieve this, we would rely on a pre-labelled dataset from the New York Times in order to train our model to extract. (https://open.nytimes.com/our-tagged-ingredients-data-is-now-on-github-f96e42abaa1c) The dataset was created using manually annotated ingredient phases with over 180,000 labelled ingredient data.*

| Input | Name | Quantity | Unit | Comment |
|---|---|---|---|---|
| 1 6-inch white-corn tortilla | white-corn tortilla | 1.0 | | 6-inch |
| 3 cups seedless grapes, equal amounts of red and of green grapes | grapes | 3.0 | cup | seedless, equal amounts red and green |
| 1/4 cup good quality olive oil | good quality olive oil | 0.25 | cup | |
| 3 large cloves garlic, smashed | garlic | 3.0 | clove | smashed |
| rind from 1/2 pound salt pork | salt pork | 0.5 | pound | rind from |

*Figure 2 - New York Times Ingredient Dataset*

*The New York Times ingredient dataset allows us to make use of Spacy's nlp capabilities to train a model using a Name-Entity-Relation (NER) Method to identify key ingredient phases to extract the base ingredients from a list. NER is used to locate and classify named entities in unstructured text into predefined categories such as people, organizations etc.*

*Once trained, we apply the trained model onto our ingredients column to generate a new ingredient tag column. However, within the dataset because of the unique recipe list, there are some errors found in the ingredient tags that will have to be removed. Common problems encountered are when there are a lot of compound descriptive words within the ingredient column e.g., "fresh ahi (yellowfin) tuna steak"*

| | recipe_id | recipe_name | ingredients | ingredient_tags |
|---|---|---|---|---|
| **0** | 219933 | Benny's Famous Jalapeno Poppers | cream cheese | cheese |
| **1** | 219933 | Benny's Famous Jalapeno Poppers | shredded Cheddar cheese | cheese |
| **2** | 219933 | Benny's Famous Jalapeno Poppers | fresh corn kernals | kernals |
| **3** | 219933 | Benny's Famous Jalapeno Poppers | salt and ground black pepper to taste | pepper |
| **4** | 219933 | Benny's Famous Jalapeno Poppers | fresh jalapeno peppers | peppers |
| **...** | ... | ... | ... | ... |
| **4495** | 228981 | Sashimi Tuna Salad With Mint Lime Cilantro Dre... | avocado sliced | |
| **4496** | 24934 | Whole Wheat Wraps | wheat flour | flour |
| **4497** | 24934 | Whole Wheat Wraps | salt | salt |
| **4498** | 24934 | Whole Wheat Wraps | baking powder | |
| **4499** | 24934 | Whole Wheat Wraps | warm water | water |

*Figure 3 - Ingredient Tags*

*Other errors found were tags that were extracted were not ingredients but were descriptive words such as 'jarred', 'quarters' that describe the form of the ingredient. These words were removed from the tags in order to improve accuracy.*

### *1.4. Ingredient Columns*

*Once tags were generated, we would generate a dataframe with the recipe_id and the individual tag as columns. We would then populate the table with the availability of each unique ingredient, this table will be used later to apply ratings to ingredients to be used in a recommender model.*

| ingredient_tags | ahi | ale | allspice | almond | almonds | alum | amaranth | ancho | anchovy | annatto | .. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| recipe_id | | | | | | | | | | | |
| **6666** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **6742** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **6773** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **6791** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **6962** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | .. |
| **260312** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **260469** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **260679** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **260682** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |
| **262355** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .. |

500 rows × 297 columns

*Figure 4 - Ingredient Columns Availability*

### *1.5. Ingredient Category for Rules*

*The last table we would need to generate would be the category rules table, this contains the various counts of ingredient categories. Ingredients are grouped into 7 different categories, mainly Grains, Fruits, Vegetables, Meats, Dairy, Fats and Oils and Sweets/Sugars.*
*(https://www.sharecare.com/health/healthy-eating-guidelines/how-many-groups-food-classified)*

*To group the ingredient tags, we would use scrapped ingredient lists of the 7 different categories and then use them as lists to classify the ingredient tags. This will result in each recipe having a different count of categories, this can be used in our recommender system to help users to filter through our application's different selections.*

| ingredient_category | carbs | dairy | meat | oil | sugar | veg |
|---|---|---|---|---|---|---|
| recipe_id | | | | | | |
| **6666** | NaN | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **6742** | NaN | 2.0 | NaN | NaN | NaN | 1.0 |
| **6773** | NaN | 4.0 | NaN | NaN | 2.0 | NaN |
| **6791** | NaN | 2.0 | 1.0 | NaN | 1.0 | 1.0 |
| **6962** | NaN | 2.0 | NaN | NaN | 1.0 | NaN |
| **...** | ... | ... | ... | ... | ... | ... |
| **260312** | NaN | 1.0 | NaN | NaN | NaN | NaN |
| **260469** | NaN | 1.0 | 2.0 | 1.0 | NaN | 4.0 |
| **260679** | NaN | 4.0 | 1.0 | NaN | 2.0 | NaN |
| **260682** | 1.0 | 1.0 | 1.0 | NaN | NaN | 1.0 |
| **262355** | 1.0 | 1.0 | NaN | 1.0 | NaN | 1.0 |

492 rows × 6 columns

*Figure 5 - Ingredient Category*

## *2. KNOWLEDGE REPRESENTATION*

*In this section we will explain the process of constructing rules for What2Eat's application.*

### *2.1. Ingredient Category Representation*

*What2Eat will use a knowledge-based reasoning system to allow users to select different moods or choices of categories through the application. In order to do this, the team has chosen to categorize the ingredients in different groups.*

*The major food groups are as follows:*

- *Grains or Carbohydrates*
- *Fruits/Vegetables*
- *Meats*

- *Dairy Products*
- *Fats/Oils*
- *Sweets/Sugar*
- *Saucy*

*For the last 2 food groups, Sweets and Saucy are not technically distinct food categories but What2Eat's purpose is to capture individuals' taste preferences. Having recipes that contain more sweets/dessert or containing "Sauce" would be able to cater to people's unique preferences in food. In the earlier section on data pre-processing, we have created a table that breaks down each individual recipe into its different food categories. This table can then be used as a reference for our rule-based reasoning system to allocate different recipes depending on the user's preferences.*

### *2.2. Establishing User's Preferences*

*What2Eat will allow users to select from 5 different preferences, these are:*

- *Healthy*
- *Carnivorous*
- *Scorching*
- *Rainy*
- *Surprise Me*

*Healthy: According to most health guides, a healthy balanced diet will have more portions of Fruit/Vegetables, starchy foods such as potatoes or rice and some protein. As What2Eat will take into consideration users who are unable to take dairy products as protein, recipes with dairy products will be excluded in its filtering. Users choosing healthy will allow recipes that have 3 different food groups, all healthy and balanced meals should have a Fruits/Vegetables Component, Meat and Grains as part of the meal. As such the recipes that have all 3 of these ingredient categories can be filtered through this selection.*

*Carnivorous: In a health article (https://www.healthline.com/nutrition/carnivore-diet#what-it-is) it is mentioned that a Carnivore diet is a restrictive diet that only includes meat, fish and other animal meats. The carnivore diet also recommends limiting dairy intake as these products may contain sugar found in milk and dairy products. Users may want to have a meat-based recipe as part of their carnivore diet. As such in this selection recipes that have ingredients tags with meats and grains will be filtered to support a meat-heavy dish.*

*Scorching: This selection is used to represent what users may want to eat during a hot day. Contrary to the popular belief, it is encouraged to have spicy foods in hot weather. This is because having spicy food stimulates heat receptors in the mouth*

*and will trigger sweat which will help the body cool down. However, much of the literature is often varied with regards to what foods to eat during hot weather. In most cases, having a balanced diet rich in fruits and vegetables are often recommended. To make our rule-based system work, we have derived that scorching would be in essence the opposite of Rainy selection. We achieve this by introducing a new ingredient tag called "saucy" which represents the element of a liquid heavy recipe. Users selecting this preference will get filtered recipes which do not contain "saucy" as its ingredient tag.*

*Rainy: This selection represents what users would want to eat during a rainy day. Often in rainy or slightly colder weather, more carbohydrates are consumed in order to warm the body. Foods that take a longer time to digest are generally recommended in order to raise body temperature through food metabolizing. But based on our feedback from users, people tend to associate soupy or "sauce" heavy foods that they go to comfort themselves in a rainy weather. In order to capture this unique user preference, we have to classify soup-based recipes as "saucy" and use this as an indicator. Users that select rainy preference will get more soup-based recipes recommended to them.*

*Surprise Me: This selection will introduce a randomizer that will select a random recipe each time the user selects this. We have decided to include this as a selection in order to capture the user's lack of preference and ensure that other types of recipes will get recommended. As the user uses What2Eat, more data will be gathered and the surprise me selection could help to introduce more user ratings to previously not rated recipes to increase accuracy.*

*Through the use of various If-Else statements, we are able to establish basic rules for each of the user's selections. This will help to filter out relevant recipes that will be parsed through our recommender system and output recipes that are similar to the user's preferences.*

## *3. Knowledge Reasoning System*

*In this section, we will describe the basic information of the recommendation system used in What2Eat.*

### *3.1. Recommender System*

*A recommendation system is an information filtering system that aims to predict a user's preference based on a given dataset. In our use case for What2Eat, we have chosen to use a content-based filtering approach to derive the recommendation for the user. Content-based filtering approach uses a series of pre-tagged characteristics of an item in order to recommend other items with similar properties.*

*Using the ingredient tag table, we have created a table with recipes and the availability of each ingredient as columns. This table will be used as a base to update the user's rating onto it, you may refer to Figure 4 for your reference. As part of the recommendation system's pipeline, our system follows this sequence of steps:*

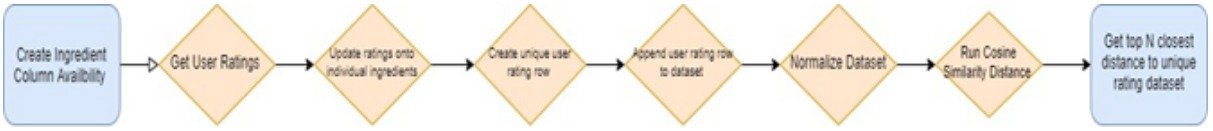



*Figure 6 - Sequence of Recommendation System*

*Step 1 ~ Get User Ratings: We collect the user's ratings based on the ratings given during the start of the initialization of the application*

*Step 2 ~ Update Ratings onto individual ingredients: Once user ratings are collected, these ratings will be used as weights and multiplied onto the ingredients table. This will ensure that users who like a dish, gets the ratings updated across its ingredients*

*Step 3 ~ Create Unique User Row: Using the initial user ratings, these get calculated into a unique rating to ingredient row using the mean weightage along the ingredients.*

*Step 4 ~ Append User Rating Row to Dataset: The unique row will then be appended onto the main dataset using unique identifier "10001", this unique row will be the base to compare with in the recommendation model*

*Step 5 ~ Normalize Dataset: Before parsing the data into the recommender model, the dataset must first be normalized. This will ensure that the result will not be skewed and the recommendation is sound.*

*Step 6 ~ Run a Cosine Similarity Distance calculation: Calculate across the entire dataset to find out the relative distance between the rest of the recipes and the unique user rated row*

*Step 7 ~ Get Top N Closest Distance to Unique Rating Dataset: Once distance is calculated, rank the top N recipes that have the closest distance to the user rated row. The close the distance, the more likely that the user's preference is captured through the previously rated dishes.*

### *3.2. Similarity-Based Reasoning (Cosine Similarity Distance)*

*Our recommendation system uses a similarity-based reasoning calculation known as Cosine Similarity.*

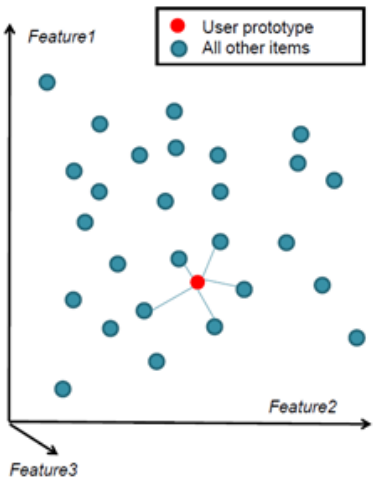



*Figure 7 - Cosine Similarity*

*We usually express our features (ingredients) as points within a dataset, this is shown as a point in the figure above. When a user has a preference, a new point is created and we can start to compute the vectors or distance between this and the other points within the dataset.*

*There are various ways to compute the distance but, in our application, we use Cosine Similarity to compute. Mathematically, this equation measures the cosine of the angle between two vectors to compute the distance.*

$$cosine(x, y) = \frac{x.y^T}{||x||.||y||}$$

*Figure 8 - Cosine Similarity Calculation*

# 4. SYSTEM ARCHITECTURE AND DESIGN

## 4.1. System Components

### 4.1.1. Web User Interface Design

*The web client user interface is written using Angular - an open-source front-end framework developed that helps to build interactive and dynamic single page applications (SPAs) with its compelling features including templating, two-way binding, modularization, RESTful API handling, dependency injection, and AJAX handling. Below are reasons why we choose Angular over other frontend development tools:*

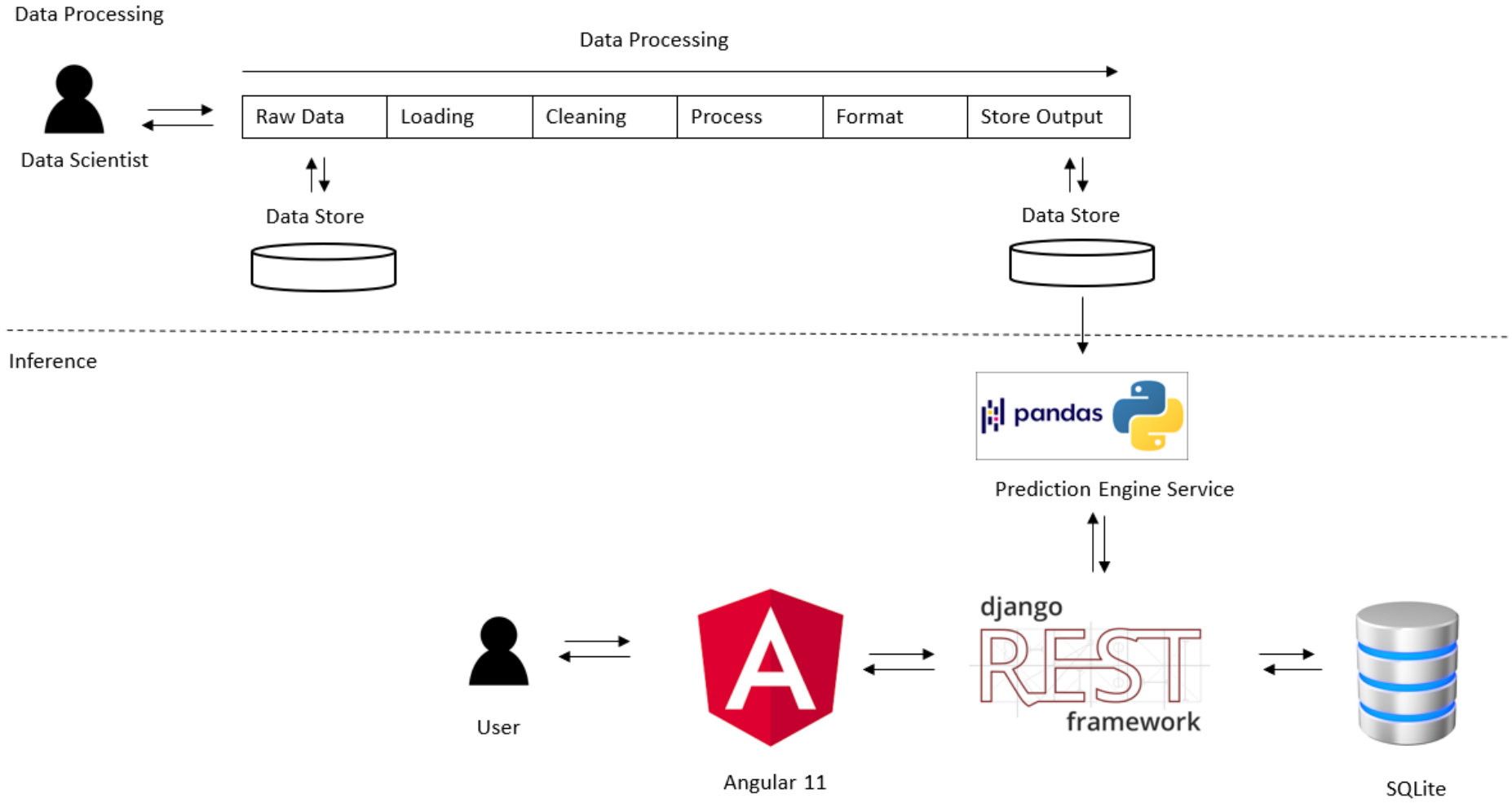
1. *Component-based architecture - Components define sets of screen elements that Angular can choose among and modify according to the functions. Each function will be independent of each other, thus, it will be easy for us to distribute the function among team members.*
2. *Ahead of time compilation(AOT) - It compiles the application during the build process and provides a faster rendering in the browser. It actually saves a lot of time for us during development.*

### 4.1.2. Django Rest Framework

*The Django REST Framework is a powerful toolkit for building RESTful APIs on top of the popular Python framework Django. Below are some of reasons that we consider to use Django are:*

1. *By default, Django uses the SQLite database and SQLite is stored as a single file which makes it easier to share databases.*
2. *Django is a high-level Python Web framework that encourages rapid development and clean, pragmatic design. It takes care of much of the hassle of web development, so that we can focus on writing our application without needing to reinvent the wheel.*

## 4.2. System Architecture and workflow




*What2Eat System Architecture and workflow*

*We build the What2Eat System based on Angular (frontend), Django Rest Framework (backend) and SQLite (database).*

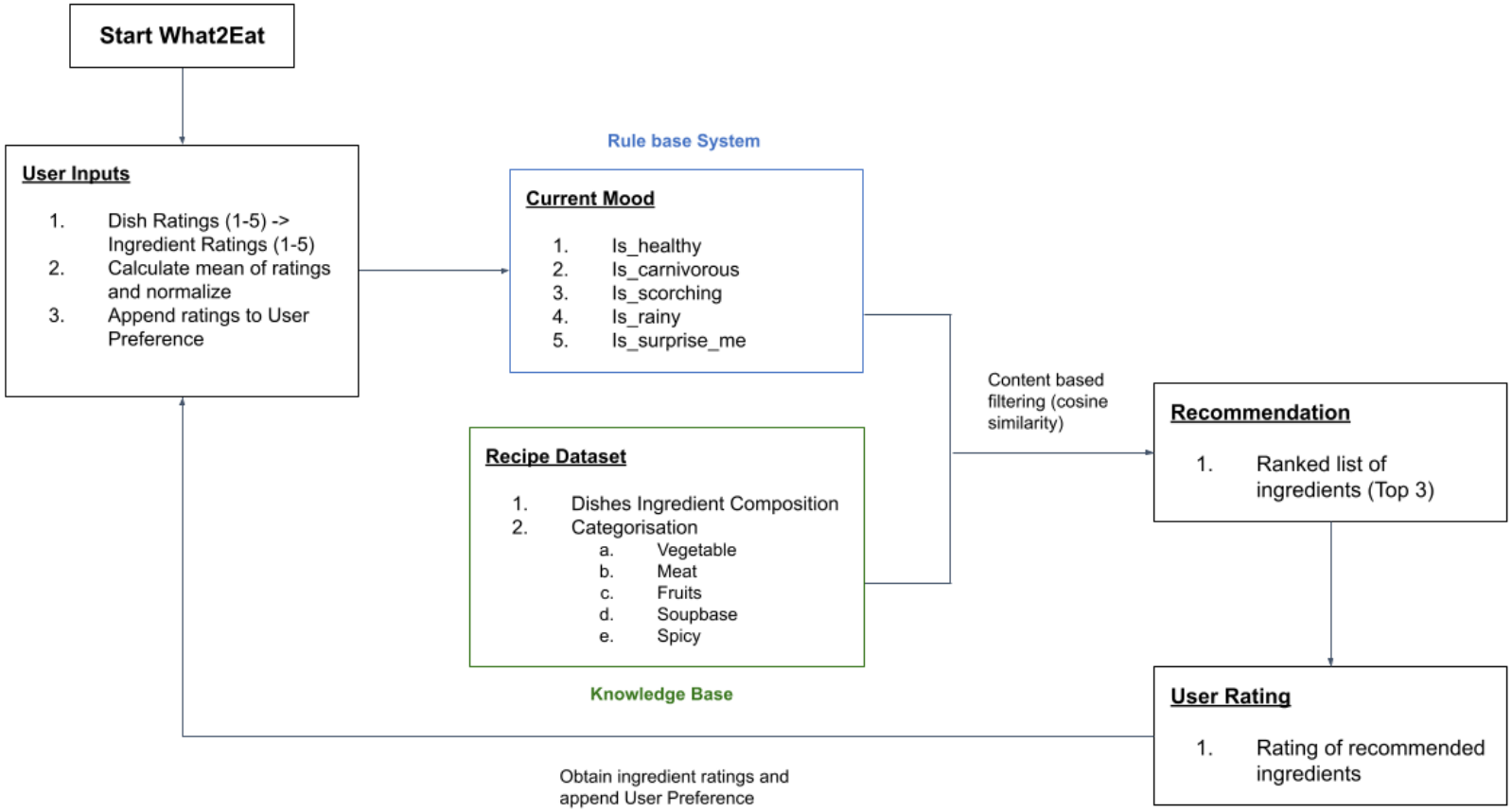
*At inference time:*

1. *On registration, User will give a list of recipe ratings that serve as a baseline user preference for making predictions.*
2. *After successful registration, User logs into What2Eat.*
3. *User chooses Mood options.*
4. *What2Eat takes user's past ratings from registration and Mood options and calls prediction engine service to generate user predictions.(see below prediction engine architecture)*
5. *User receives recipe predictions.*
6. *User gives recipe ratings for generated predictions (feedback ratings) to serve as feedback for the generated predictions.*
7. *Future What2Eat generated user predictions will take into account feedback ratings in addition to past ratings from registration and Mood options.*

*For data processing:*

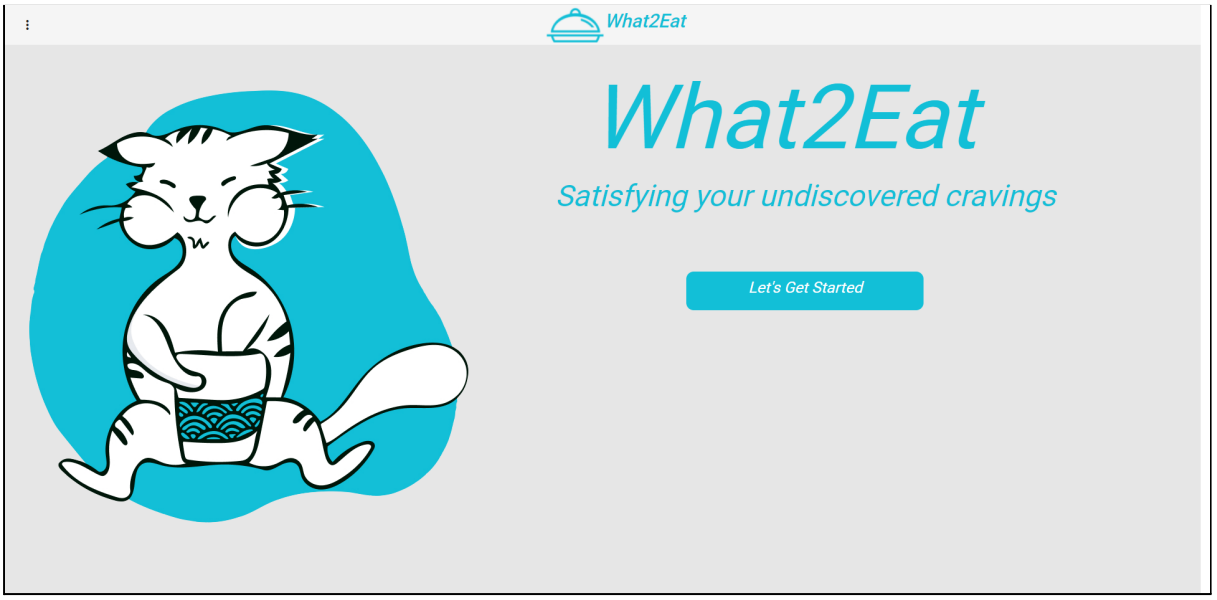
8. *Every week our AI Specialist will curate new raw recipe data, load, clean, process, format and test output to ensure that our prediction engine runs smoothly.*

## ***Prediction Engine Architecture***



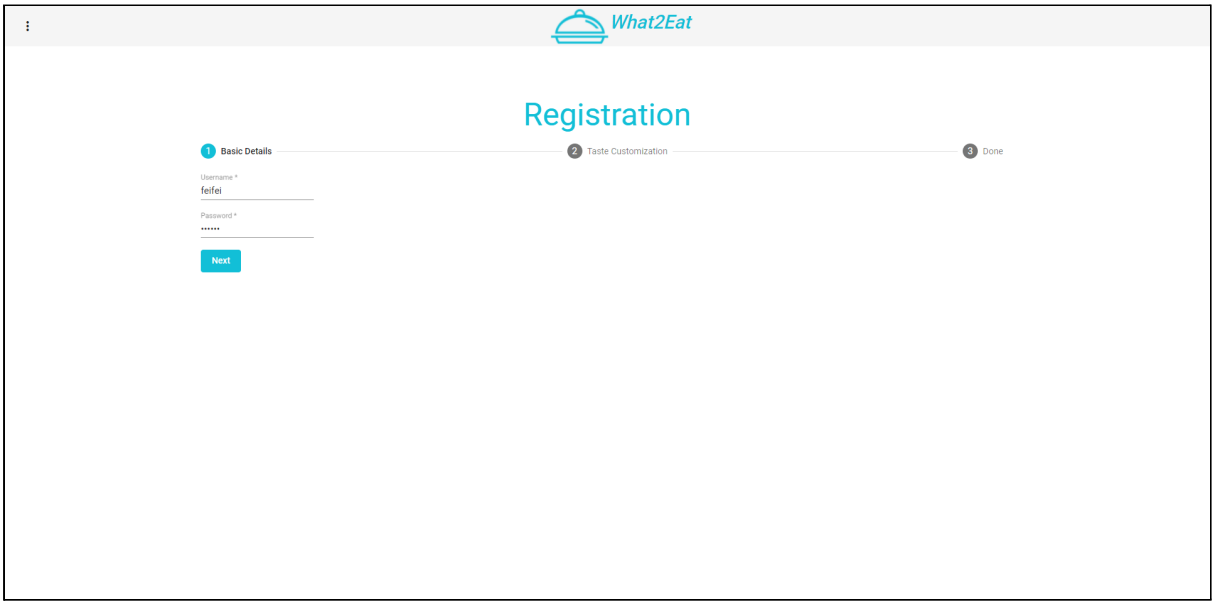
# 5. PROTOTYPE DESIGN

## 5.1. Landing Page

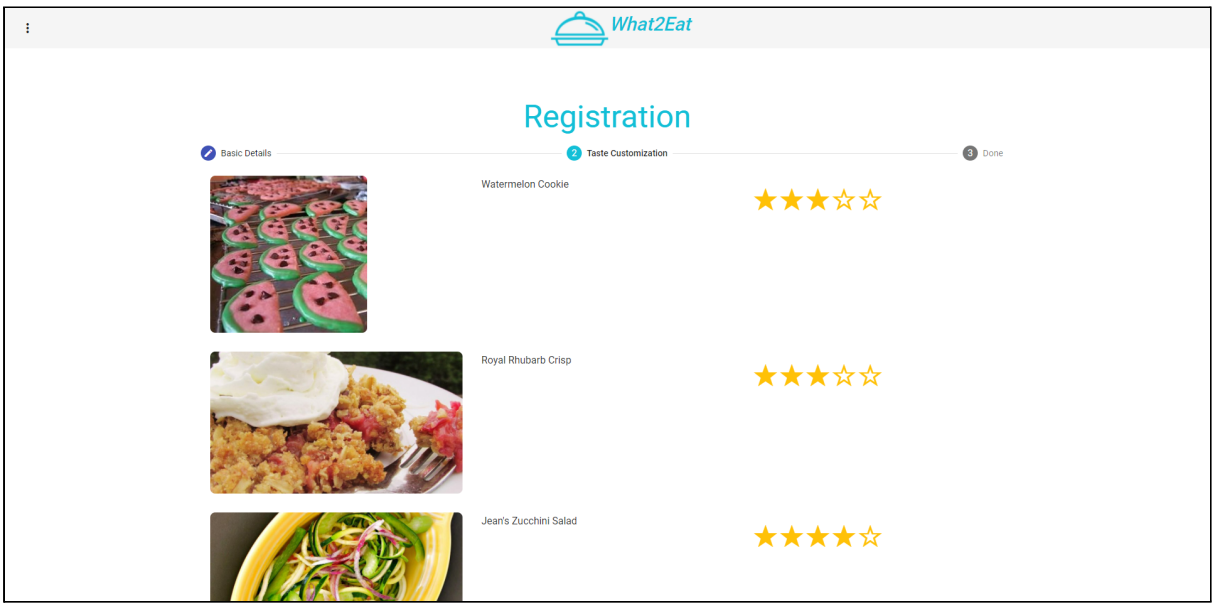


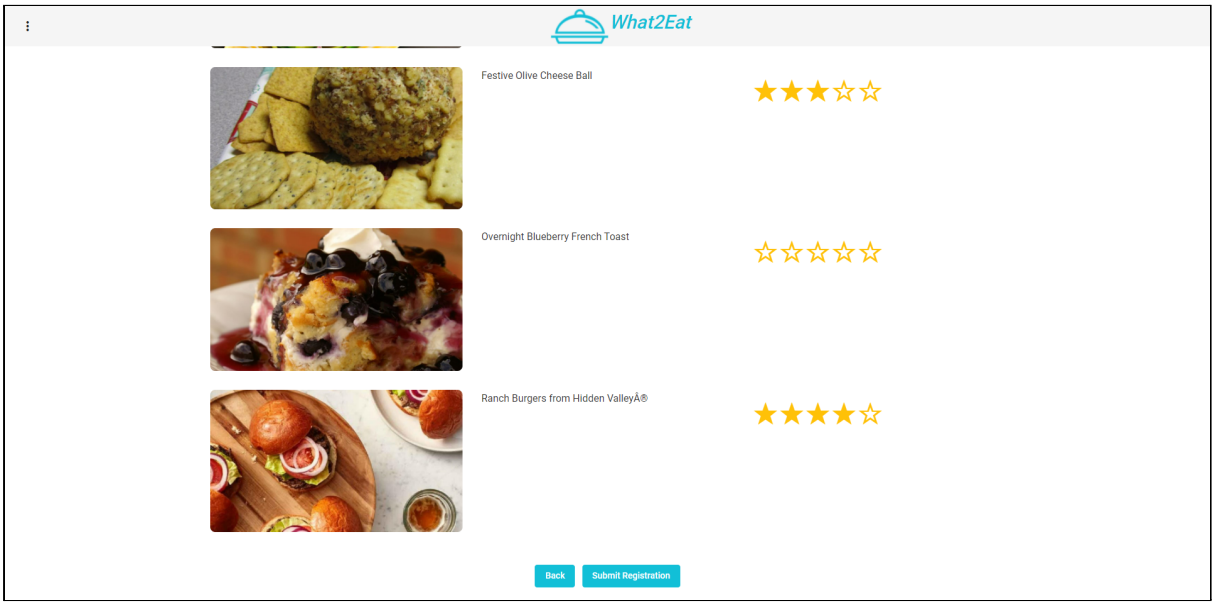

## 5.2. Registration (one-time)

### 5.2.1. Input username and password for registration

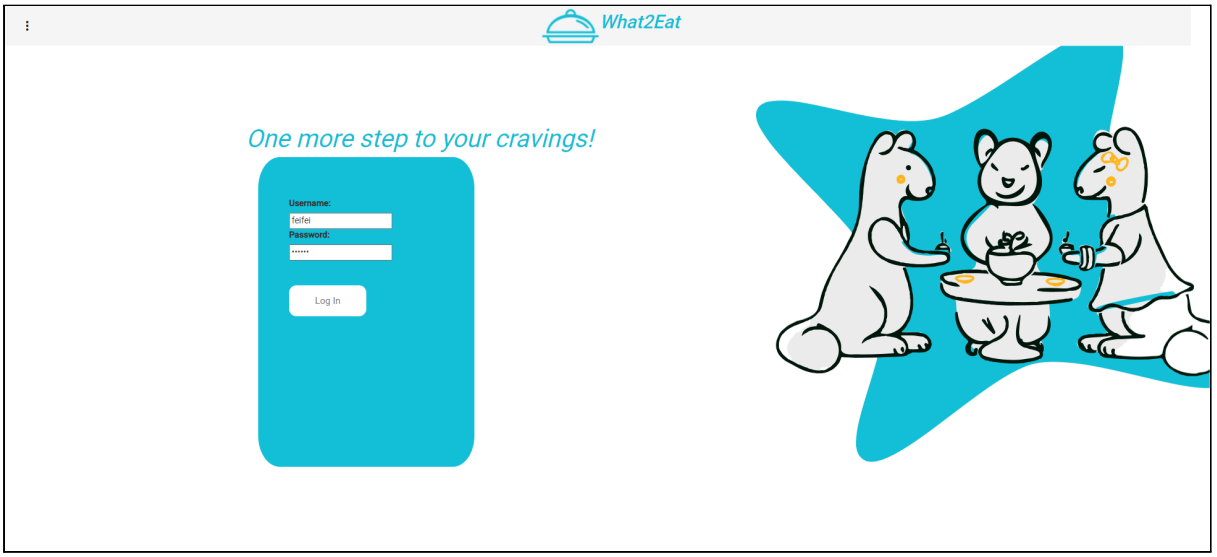


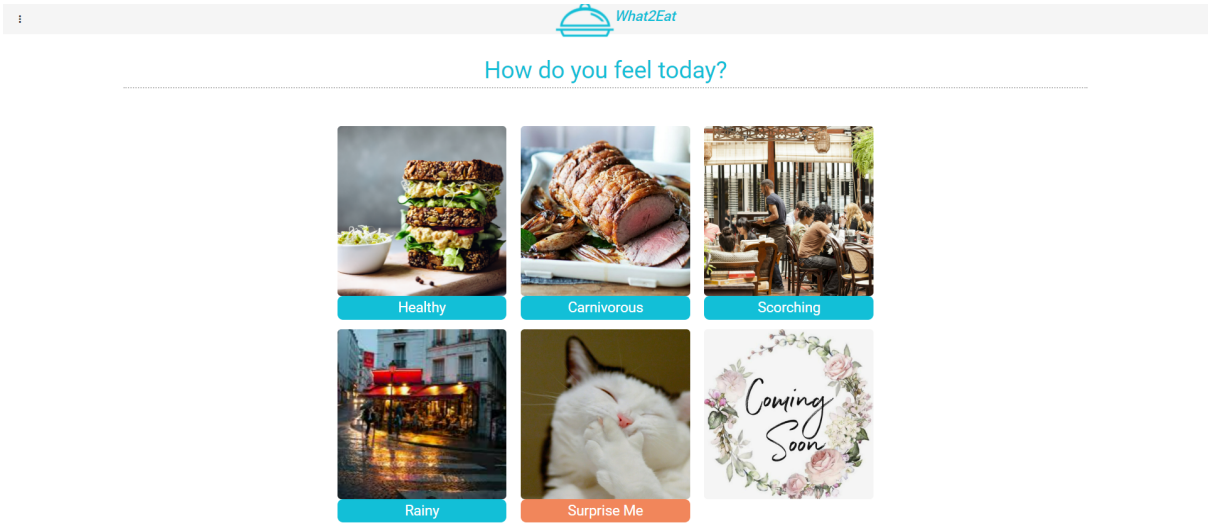
### 5.2.2. ***Input ratings for randomly generated dishes (taste customization)***



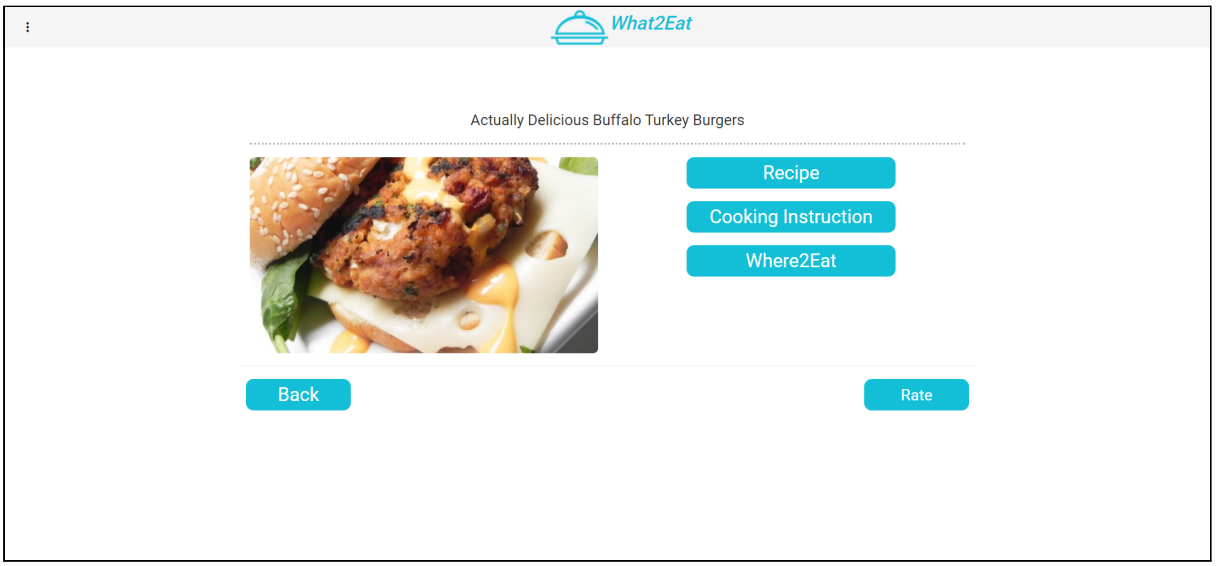
## 5.3. Login Page



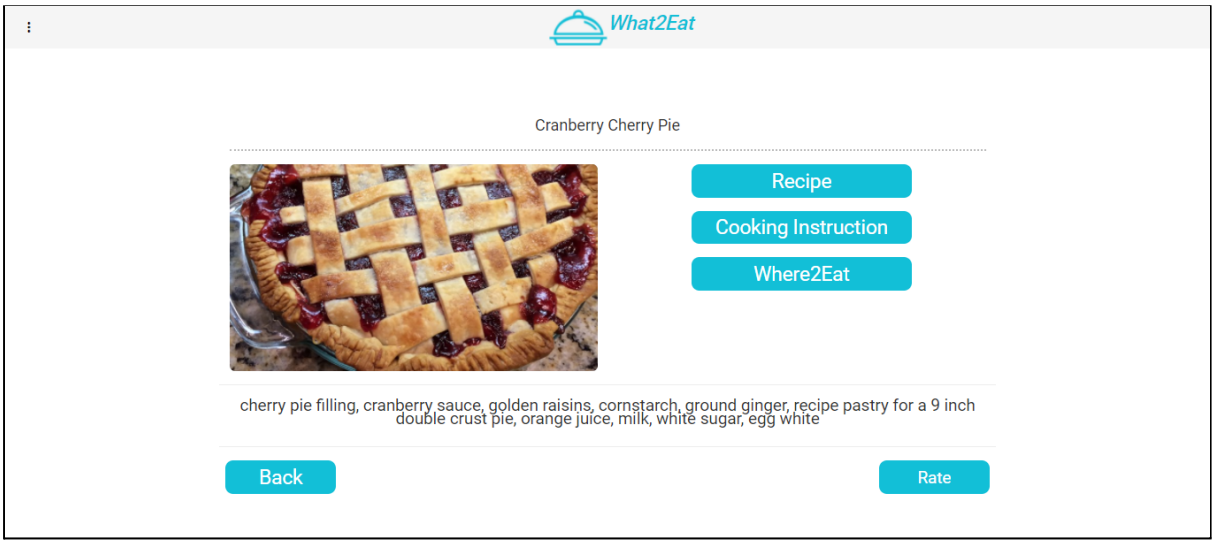



## 5.4. Dish Recommendations

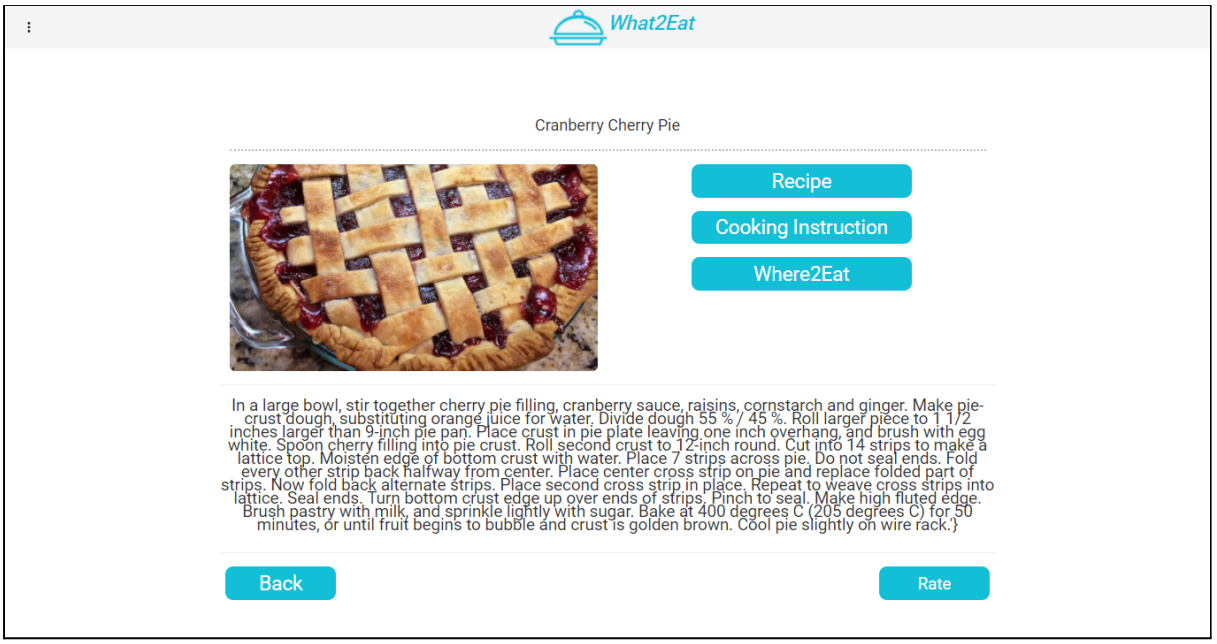

## 5.5. Select a Dish



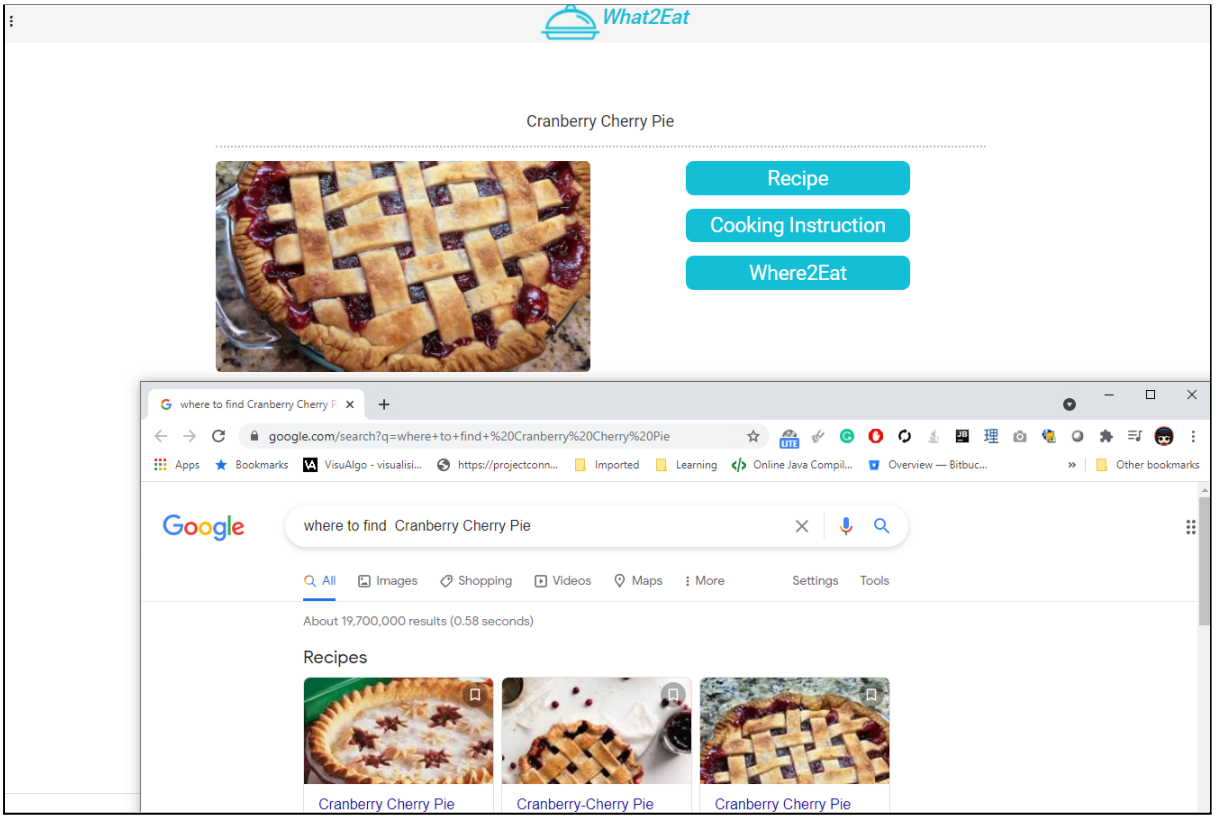
## 5.6. Recipe



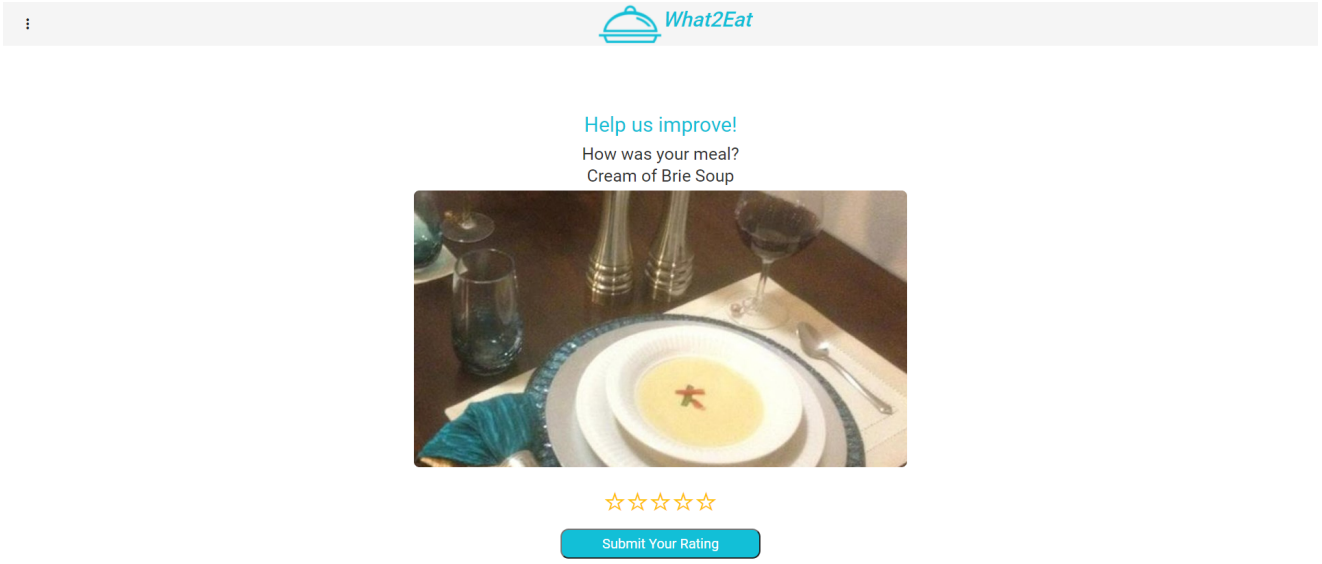

## 5.7. Cooking Instruction



## 5.8. Where2Eat




## 5.9. Dish Rating



## 6. LIMITATIONS

### 6.1. Assumption of the Correlation between Dish and Ingredient Ratings

*The greatest limitation in developing What2Eat is in ensuring that the recommended dishes are accurate to the user's taste preference. This is due to the complexity in quantifying and labelling the multitudinous flavours of food dishes. As such, in developing the initial version of What2Eat, the assumption has been made that users are fond of all the ingredients within their highly rated dishes. Based on this assumption, the user's rating for a dish would be universally applied across the ingredients within the dish. To circumvent this limitation and further enhance the accuracy of the recommendations, the ensuing "What Others are Having" feature will utilize collaborative filtering to recommend dishes based on likeness of taste preferences with other What2Eat users.*

### 6.2. Diversity of Recommendation

*Another limitation in developing What2Eat is ensuring the right amount of diversity in our recommendations. Currently, What2Eat is largely optimised to show content similar to that which is already highly rated by the user. Therefore, the challenge would be incorporating the sufficient diversity and serendipity into What2Eat's recommendations, so that users could discover dishes that are novel or surprising yet suited to their preferences.*

## 7. *FUTURE IMPROVEMENTS*

### *What2Eat enhancements*

*Possible enhancements that could be made to What2Eat includes allowing the user to input specific ingredients that are liked/disliked, as well as the user's budget. In addition to enlarging the recipe dataset to include more cuisines, What2Eat could potentially collaborate with restaurants or food delivery platforms to recommend restaurants based on the recommended dishes and the user's location, allowing the user to go from generating a recommendation to the booking of restaurants. To further bring about convenience in using the app, recommendations could also be triggered through speech with the use of simple speech-to-text models.*

*With the rising health consciousness amongst individuals, What2Eat could also empower users with the ability to request for food recommendations based on inputs of relevant nutritional criteria, including calorie count, amount of fats, carbohydrates, cholesterol, sodium and fiber. As opposed to generic recommendations of nutritional values, this would allow the recommendations to be tailored to the user's specific nutritional requirements, and have proven to be far more effective in increasing the user's motivation towards dietary changes.*

### *Multi Users Functionality*

*What Others are Having (Collaborative Filtering)*

*Having obtained a substantial user base for the application, What2Eat will introduce the "What Others Are Having" feature where recommendations would be made using collaborative filtering. With this, food dishes will be recommended based on the similarity of the user's highly rated dishes with that of other users within the application. This feature would allow the user to explore dishes closely associated with other users of similar taste preferences.*

*Group Order*

*As meals are more often than not partook in groups (among friends, colleagues, classmates etc), the "Group Order" feature will allow food recommendations to be made taking into consideration several users' taste preference. Upon selecting "Group Order" and adding other users, What2Eat will consolidate the taste preferences of the included users to return a recommendation tailored to their preferences, ensuring that the meal recommended would be enjoyed by all. This would address the common question faced by groups of individuals when deciding on What2Eat.*

### *What2Cook*

*In parallel to What2Eat, What2Cook will ride on the available recipe dataset and trained model of What2Eat to generate dish recommendations taking into account the available ingredients owned by the user. The recipes that highly match the user's available ingredients will be recommended so that users can fully optimize the use of their bought ingredients. Recognizing the perennial problem of food wastage globally - one-third of world's food lost or wasted each year (FAO, 2019), What2Cook would not only enable users to explore new and novel recipes, it would also reduce the wastage of ingredients. For the remaining few ingredients that users may be short of, What2Cook could also be in partnerships with various major grocery stores and grocery delivery platforms to provide a seamless experience for users to purchase these ingredients within the application.*

### *What2Eat Community*

*Advocating the culture of sharing and hopping on the bandwagon of social media platforms, What2Eat will provide a community platform for users to share photos and reviews of the dishes they have tried, as well as their own modified recipes.Within the platform, users could also pay a small fee to "follow" renowned invited chefs for regular recipes and cooking tips. In addition, advertisements of food dishes could too be put up by shortlisted restaurants. Acknowledging the growing importance placed on food globally, the What2Eat Community platform aims to fill the gap in existing social media platforms in the aspect of food.*

8. *Appendix A: Project Proposal*

***GRADUATE CERTIFICATE: Intelligent Reasoning Systems (IRS)***

***PRACTICE MODULE: Project Proposal***

| |
|---|
| ***Date of proposal:***<br><br>***02 May 2021*** |
| ***Project Title:***<br><br>***What2Eat – Intelligent Food Recommendation Platform*** |
| ***Sponsor/Client: (Name, Address, Telephone No. and Contact Name)***<br><br>***Institute of Systems Science (ISS) at 25 Heng Mui Keng Terrace, Singapore***<br>***NATIONAL UNIVERSITY OF SINGAPORE (NUS)***<br>***Contact: Mr. GU ZHAN / Lecturer & Consultant***<br>***Telephone No.: 65-6516 8021***<br>***Email: zhan.gu@nus.edu.sg*** |

***Background/Aims/Objectives:***

***The proposed intelligent food recommendation system will leverage the use of various machine reasoning techniques and components to obtain recommendations of food dishes tailored to the user's taste preference and cravings, saving the user time and the dilemma of choosing amongst the panoply of food dishes available. The system is to be kept updated and relevant through users' ratings of the recommended dishes.***

***Requirements Overview:***

- ***Research ability***
- ***Programming ability***
- ***System integration ability***

***Resource Requirements (please list Hardware, Software and any other resources)***

***Hardware proposed for consideration:***

- ***Standard PC with web browser***

***Software proposed for consideration:***

- ***Data-preprocessing - Python3, Jupyter Notebook***
- ***Reasoning systems - Scipy, Sci-kit Learn***
- ***Pertained machine learning models - NLP(nltk, Spacy) for ingredient tag extraction from ingredient lists***
- ***Application Framework: Django REST Framework, Angular Typescript-based Web application Framework***

***Number of Learner Interns required: (Please specify their tasks if possible)***

***a team of four to six project members (or individual work upon lecturer approval)***

## ***Methods and Standards:***

| ***Procedures*** | ***Objective*** | ***Key Activities*** |
|---|---|---|
| ***Requirement Gathering and Analysis*** | ***The team should meet with ISS to scope the details of the project and ensure the achievement of business objectives.*** | ***1. Gather & Analyze Requirements***<br>***2. Define internal and External Design***<br>***3. Prioritize & Consolidate Requirements***<br>***4. Establish Functional Baseline*** |
| ***Technical Construction*** | • ***To develop the source code in accordance to the design.***<br>• ***To perform unit testing to ensure the quality before the components are integrated as a whole project*** | ***1. Setup Development Environment***<br>***2. Understand the System Context, Design***<br>***3. Perform Coding***<br>***4. Conduct Unit Testing*** |
| ***Integration Testing and acceptance testing*** | ***To ensure interface compatibility and confirm that the integrated system hardware and system software meets requirements and is ready for acceptance testing.*** | ***1. Prepare System Test Specifications***<br>***2. Prepare for Test Execution***<br>***3. Conduct System Integration Testing***<br>***4. Evaluate Testing*** |

| | | |
|---|---|---|
| | | 5. *Establish Product Baseline* |
| *Acceptance Testing* | *To obtain ISS user acceptance that the system meets the requirements.* | 1. *Plan for Acceptance Testing*<br>2. *Conduct Training for Acceptance Testing*<br>3. *Prepare for Acceptance Test Execution*<br>4. *ISS Evaluate Testing*<br>5. *Obtain Customer Acceptance Sign-off* |
| *Delivery* | *To deploy the system into production (ISS standalone server) environment.* | 1. *Software must be packed by following ISS's standard*<br>2. *Deployment guideline must be provided in ISS production (ISS standalone server) format*<br>3. *Production (ISS standalone server) support and troubleshooting process must be defined.* |

## ***Team Formation & Registration***

| |
|---|
| ***Team Name:***<br>***What2Eat*** |
| ***Project Title (repeated):***<br>***What2Eat*** |
| ***System Name (if decided):*** |
| |
| ***Team Member 1 Name:***<br>***Tan Jun Ray Wister*** |
| ***Team Member 1 Matriculation Number:***<br>***A0229984J*** |
| ***Team Member 1 Contact (Mobile/Email):***<br>***+6592307860 / e0687392@u.nus.edu*** |
| |
| ***Team Member 2 Name:***<br>***Toh Jia Hui Shaun*** |

| |
|---|
| ***Team Member 2 Matriculation Number:***<br>***A0229961U*** |
| ***Team Member 2 Contact (Mobile/Email):***<br>***+6582189666/ e0687369@u.nus.edu*** |
| |
| ***Team Member 3 Name:***<br>***Liang Mengfei*** |
| ***Team Member 3 Matriculation Number:***<br>***A0125994R*** |
| ***Team Member 3 Contact (Mobile/Email):***<br>***e0689796@u.nus.edu*** |
| |
| ***Team Member 4 Name:***<br>***Jia Kai*** |

| |
|---|
| ***Team Member 4 Matriculation Number:***<br><br>***A0180502U*** |
| ***Team Member 4 Contact (Mobile/Email):***<br><br>***e0283988@u.nus.edu*** |
| |

| ***For ISS Use Only*** | | |
|---|---|---|
| ***Programme Name:*** | ***Project No:*** | ***Learner Batch:*** |
| ***Accepted/Rejected/KIV:*** | | |
| ***Learners Assigned:*** | | |
| ***Advisor Assigned:***<br>***Contact: Mr. GU ZHAN / Lecturer & Consultant***<br>***Telephone No.: 65-6516 8021***<br>***Email: zhan.gu@nus.edu.sg*** | | |

9. *Appendix B: Mapped System Functionality*

- ***(MR) Machine Reasoning:*** *Applying rule-based for each variety of diet style using simple logical statements to assign different selections according to different preferences.*

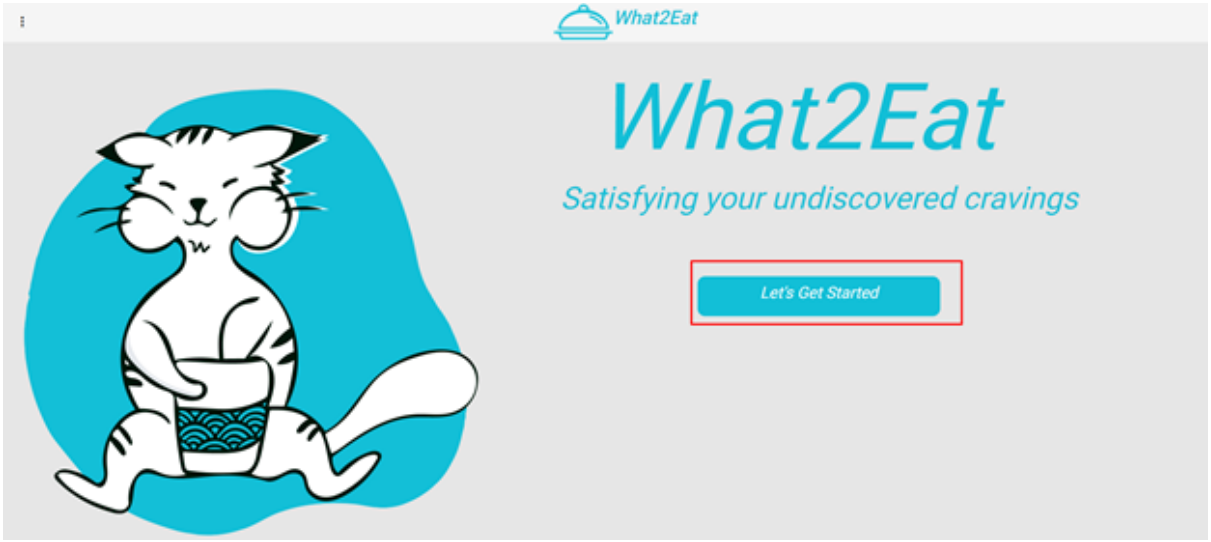
- ***(RS) Reasoning Systems:*** *A content-based filtering recommender system was used to compare user's ratings across previously rated recipes & ingredients within the datasets. Using cosine distance to calculate proximity of the user's preference across other recipes.*

- ***(CGS) Cognitive Systems:*** *A knowledge discovery method using Natural language Processing was used to gather ingredient information. Using a pre-trained model that uses a Name-Entity-Recognition technique to extract tags from an unstructured text.*

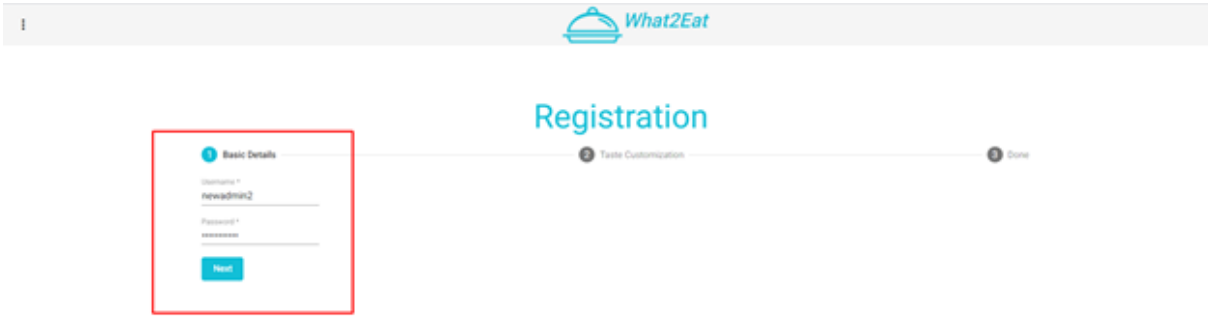
10. *Appendix C: Installation and User Guide*

***User guide:***

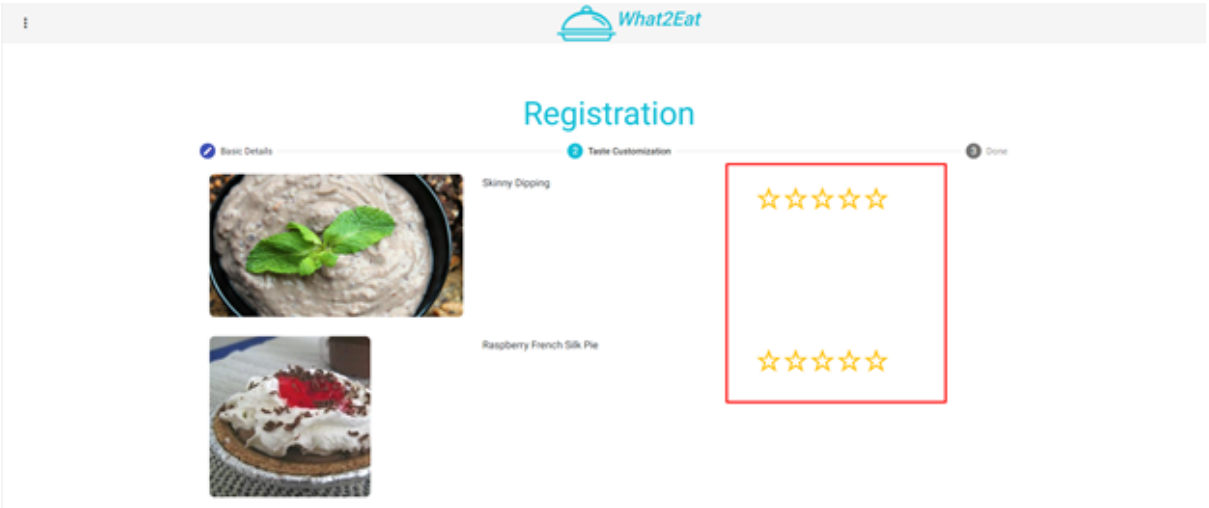
*Getting started*



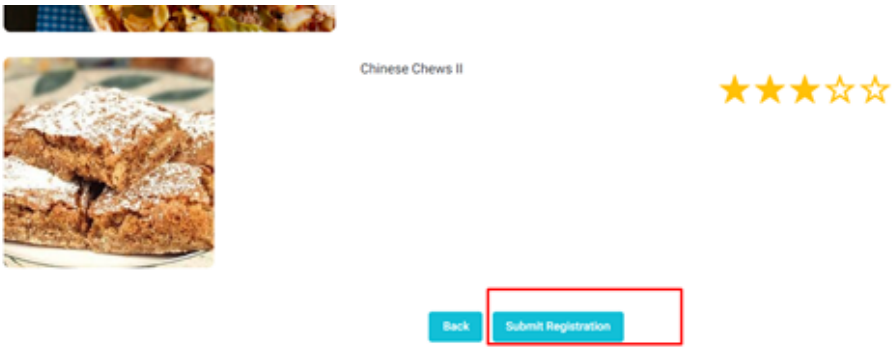

*Fill in password:*



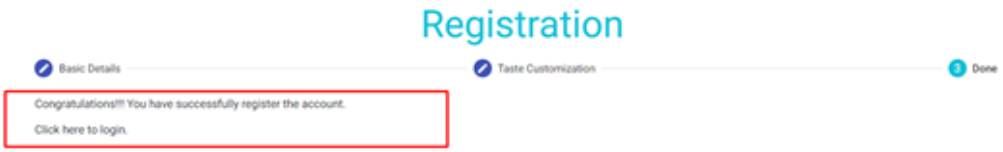

*Taste customization, this will be the initial taste customization:*




*Submit registration*

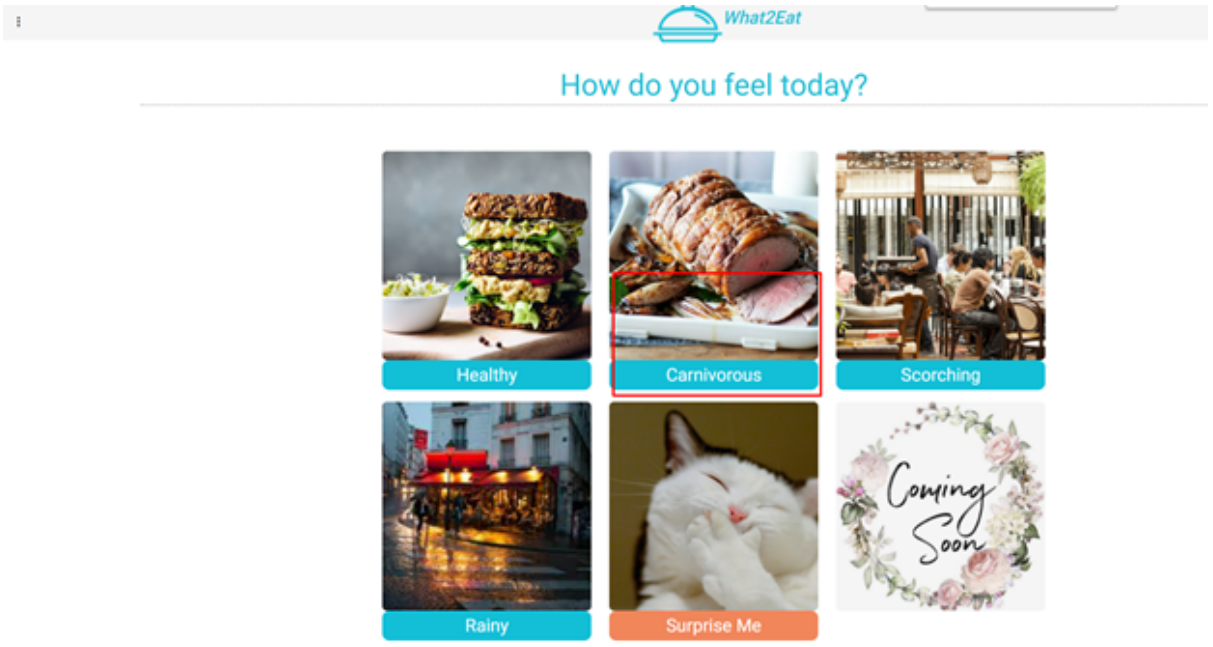



*Registration success*

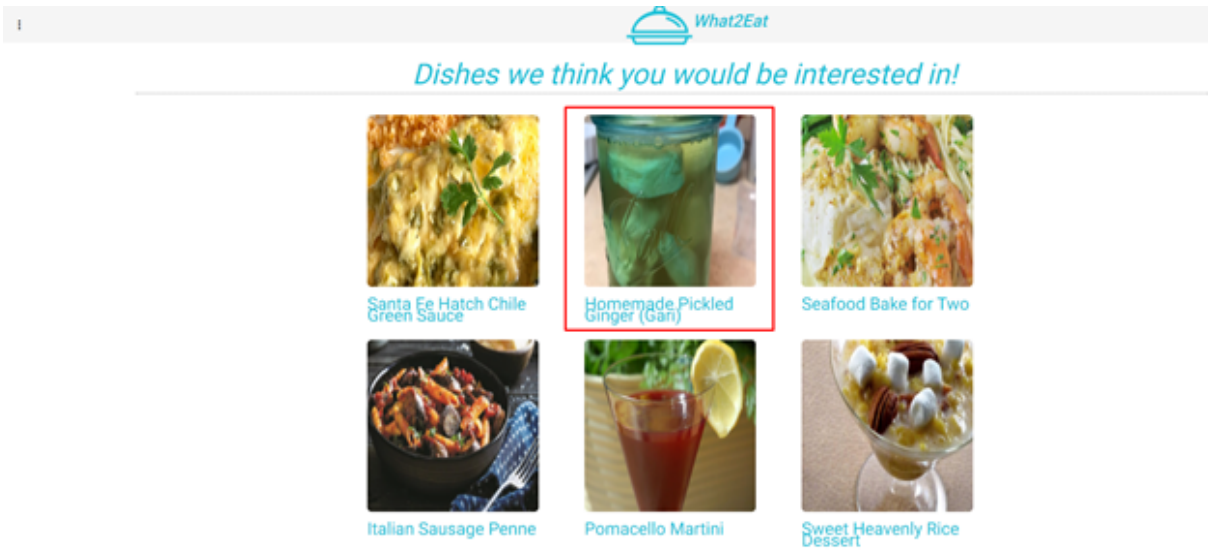



*Login*

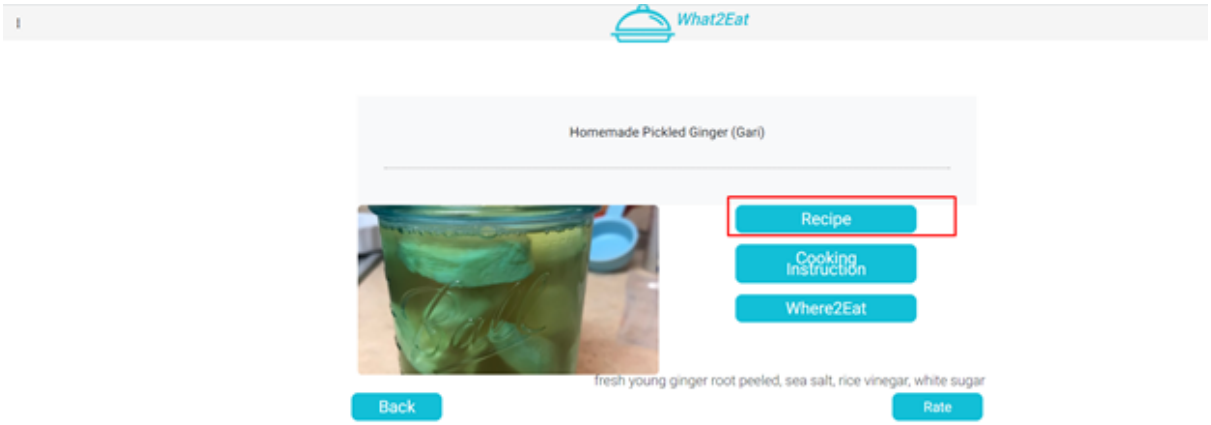

*Choose mood:*



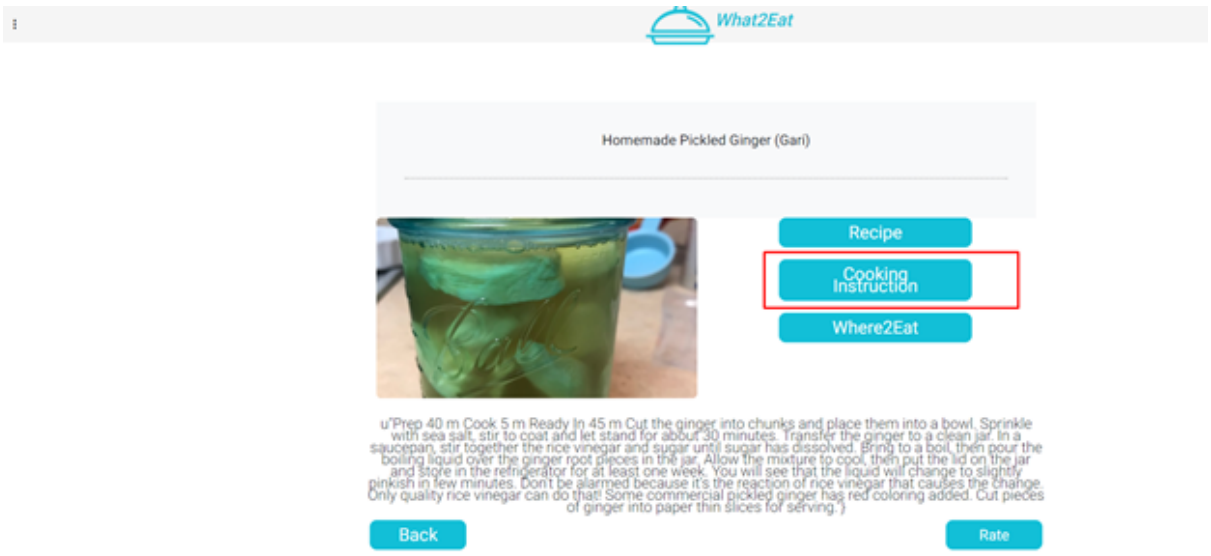

*Decide on recommended dishe (our app recommendation will be displayed):*



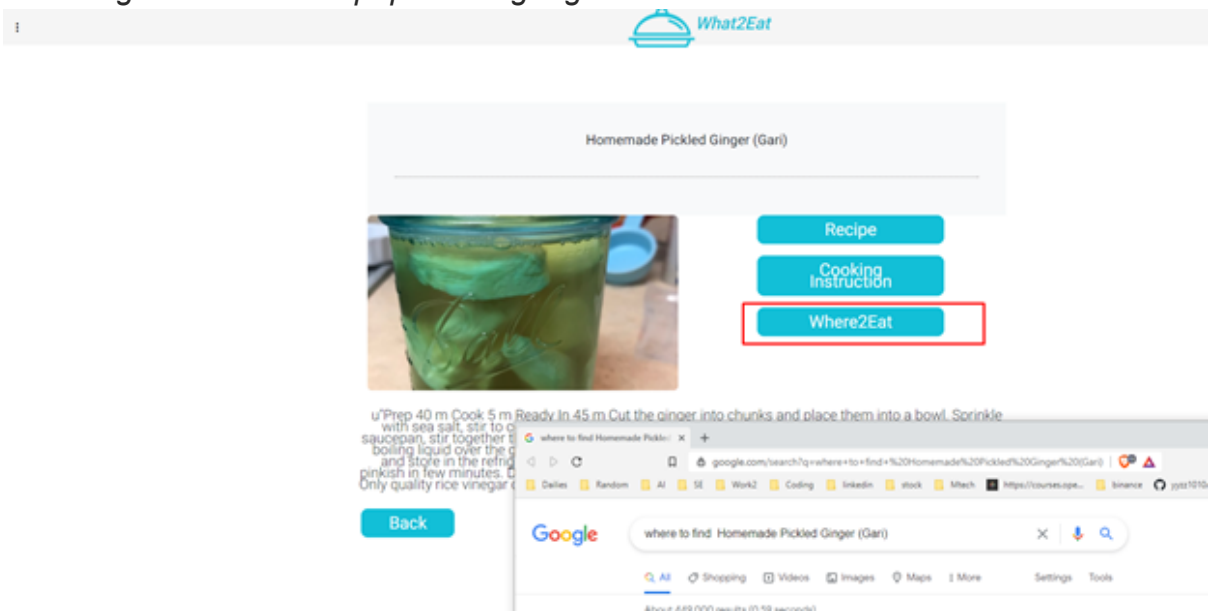

*Recipes:*



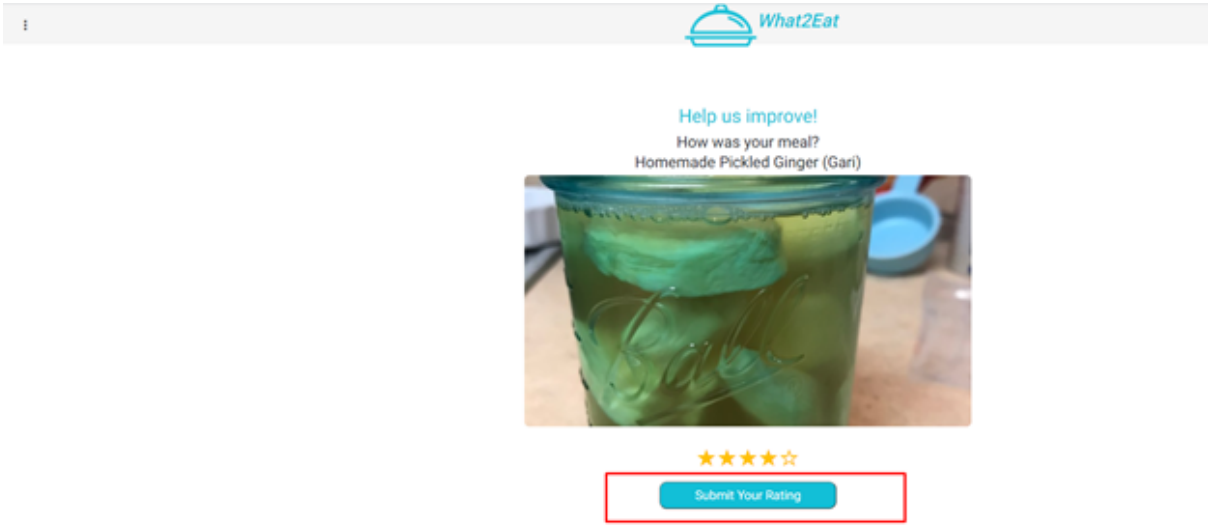

*Cooking instructions:*




*Choosing where2eat will pop a new google search:*



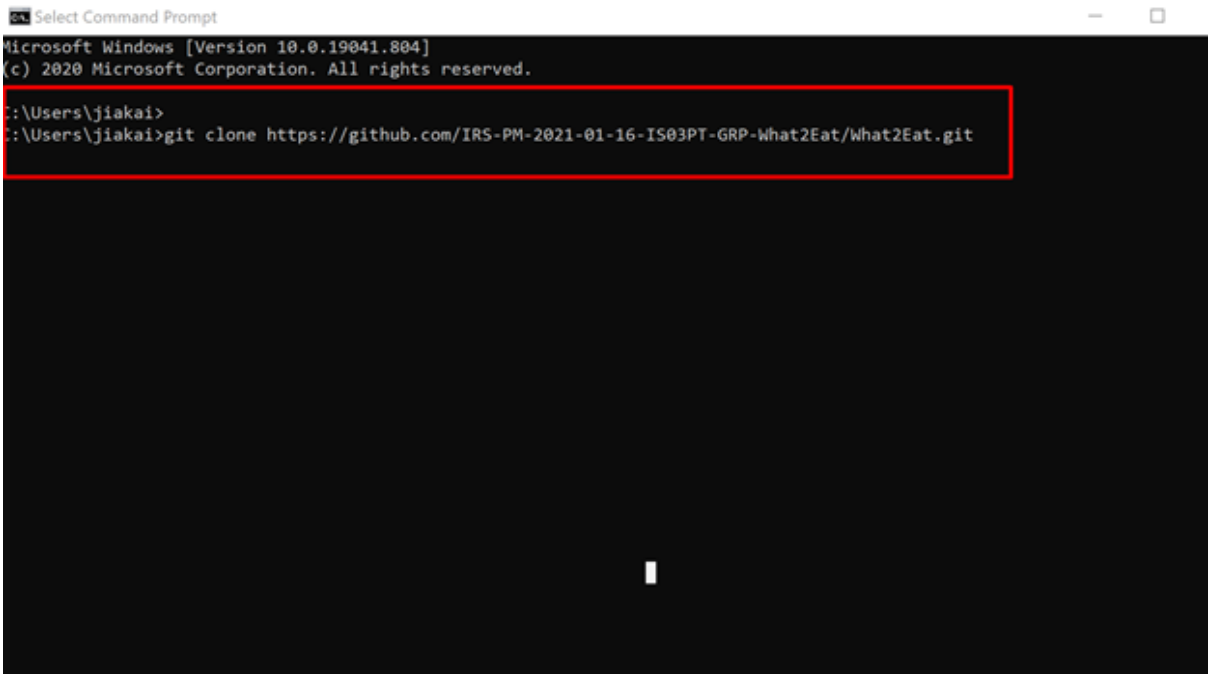

*Rate your meal (this rating will serve as a feedback rating):*



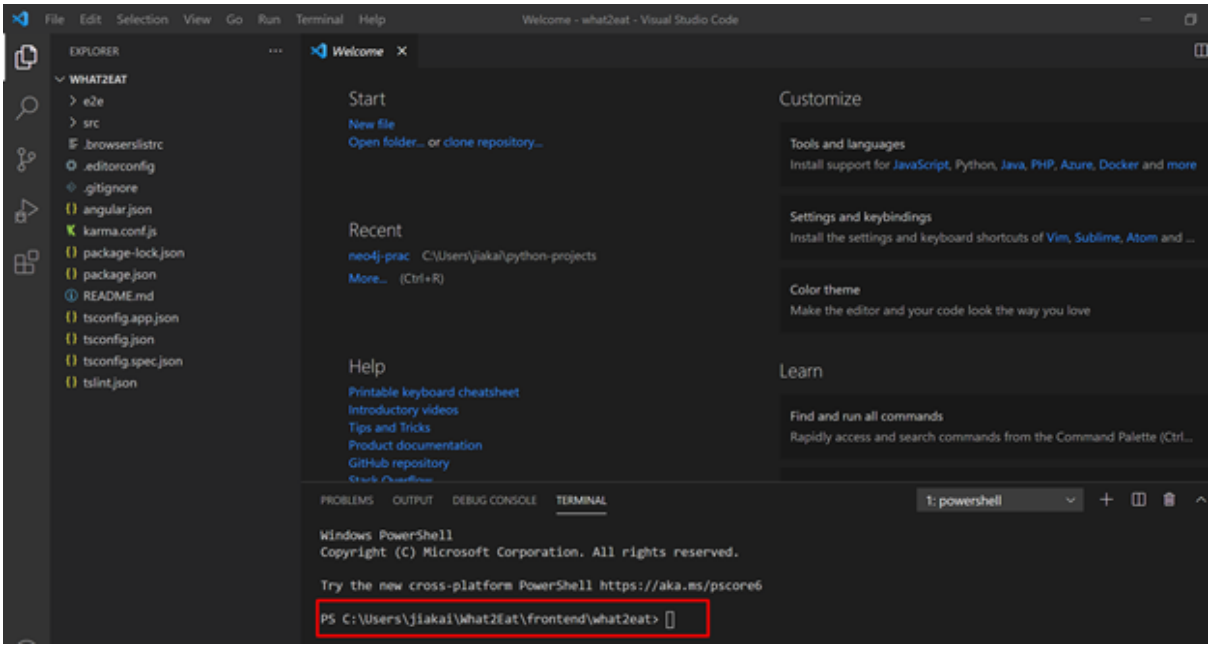

*We hope you enjoyed our app!*

***Installation:***

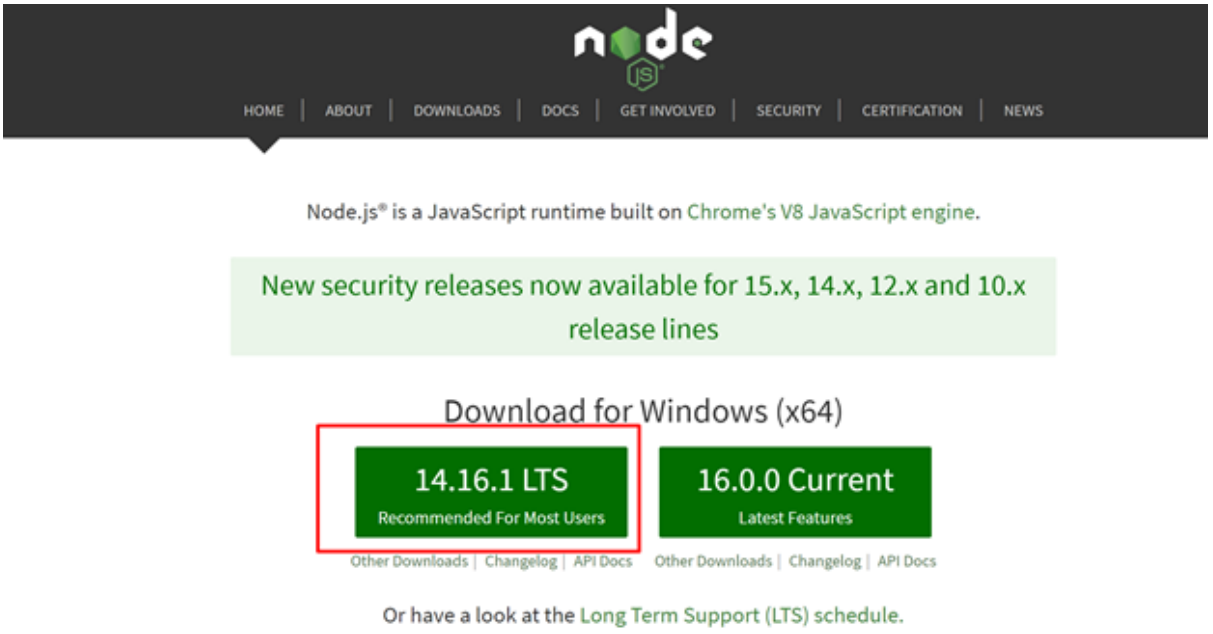
Start off by cloning the application from git



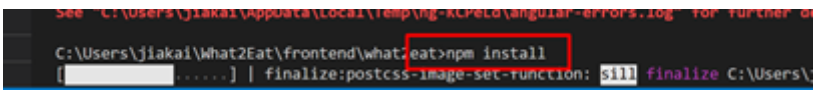

Launch VSCode and open our frontend




Install node




Run npm install:



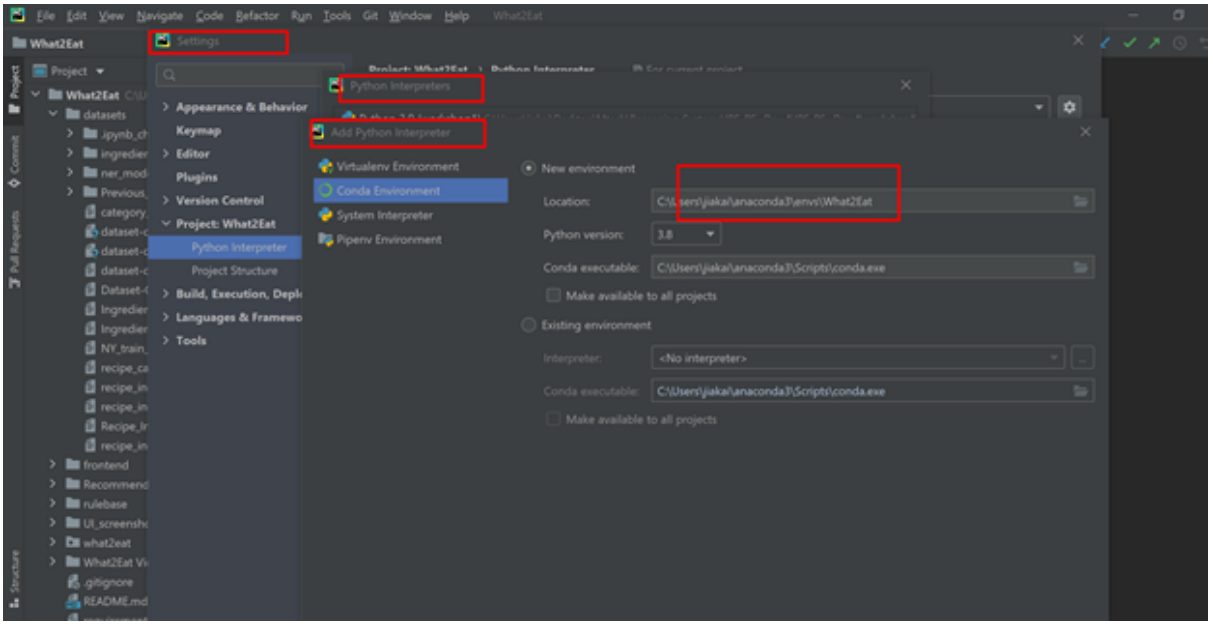

Run ng serve:

```
C:\Users\jiakai\What2Eat\frontend\what2eat>ng serve
Your global Angular CLI version (11.2.11) is greater than your local versio
n.
```

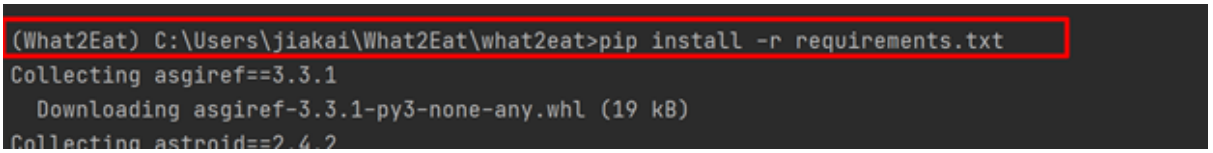
At this point, frontend should start running.

Launch pycharm and open our project:

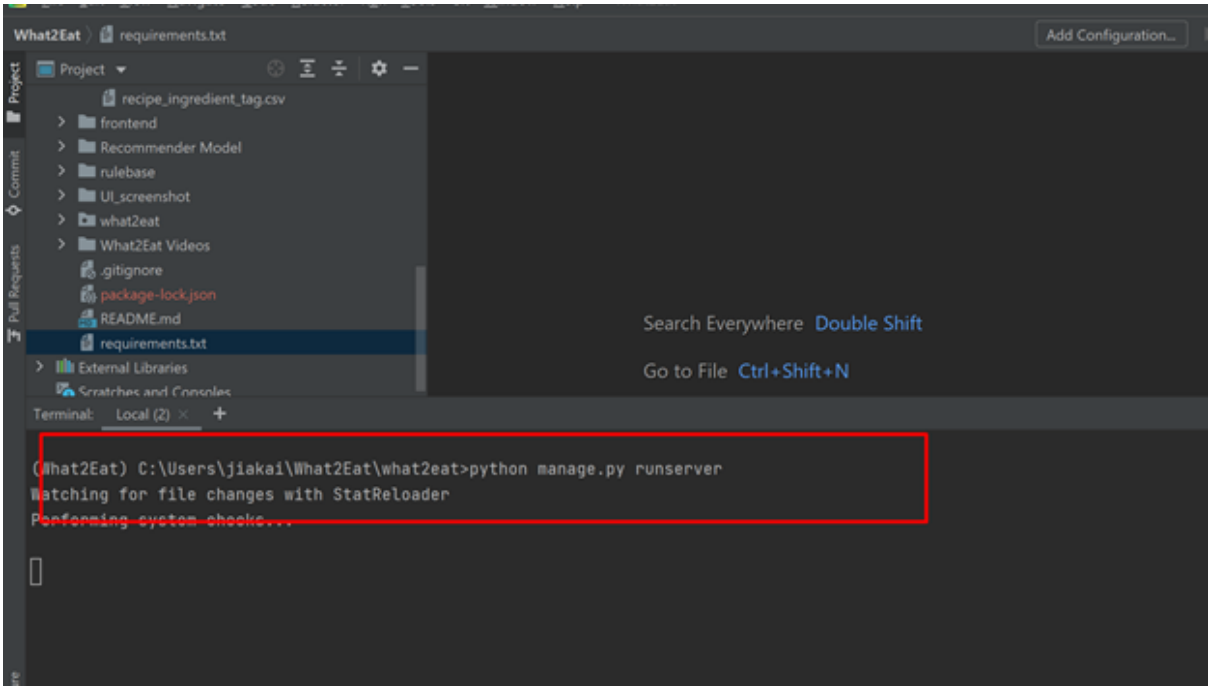
Create new conda environment and activate:




Go to our App and run pip install -r requirements.txt




Run: python manage.py runserver




At this point backend should also be running

## 11. Appendix D: Individual Reports

*Tan Jun Ray Wister (A0229984J)*

### *Personal Contribution*

A. *Project idea generation - problem statement and product solution*
B. *Business flow and overarching system architecture development*
C. *Video creation and UI prototype design using Figma*
D. *Development of the recommender model to output recipes based on ratings using content based filtering*
E. *Contributing to the project report, particularly on the problem statement, solution, and future improvement portion.*

### *Learning Outcome*

A. *Learned the use of web scraping tools for extraction of web information*
B. *Experienced the practical usage of NLP (and Spacy) for retrieval of information within a unorganized text*
C. *Usage of Github for collaboration and tracking of changes*
D. *Teamwork, communication and delegation. Despite the hectic schedule of everyone, the constant communication and openness of the team ensured the smooth delivery of the project.*
E. *Practical usage of Python and implementation of content based filtering for building of the recommendation system. Coming from a background with completely no exposure to coding, my team members have been extremely helpful in providing guidance on coding-related queries, allowing me to experience first-hand the process of collaborating on an IT project.*
F. *Process of a full stack development of a web application and the roles involved*

### *Knowledge and Skill Application*

A. *Project management in the IT field*
B. *Web page prototype design using Figma*
C. *Recommendation systems using Python*
D. *Natural Language Processing using Spacy*
E. *Collaboration tools - github, Google Docs, Google Meet.*

*Shaun (A0229961U)*

## *Personal Contribution*

A. *Data gathering and research of various other datasets for recipes*
B. *Preprocessing data for What2Eat's recipes & rating table, this involves data cleaning, transforming relevant data usable tables.*
C. *Data scraping for ingredient lists in order to categorize the recipe dataset.*
D. *Develop recommender model to output recipes based on ratings*
E. *Integrating the recommender model to the application*
F. *Contributing to the project report, particularly on the data processing and the recommender model.*

## *Learning Outcome*

A. *Learn to make use of NLP to extract information from the ingredient's list, the use of Spacy was particularly useful in training the model to extract information.*
B. *The use of GitHub in collaborating with each other, prior to this I have only used GitHub to store my own code. This project exposed me to learning how to code with others and the nature of developing applications as a team rather than just an individual project.*
C. *Integrating into web frameworks such as Django, as of our course in learning intelligent systems it is important to have knowledge of existing frameworks that allow models to be deployed in a useful manner.*
D. *Django, Angular web application frameworks, prior to this project I have not worked on these frameworks. Working on this project gave me a crash course into learning how to integrate into a framework.*
E. *Teamwork, despite everyone's busy schedule we made it a point to organize various meetings. Our group members come from very diverse backgrounds and learning how to fit each part of the project to everyone's strengths is incredibly important in completing the project.*

## *Knowledge and Skill Application*

A. *The use of Django & Angular web-application framework, as I come from a SME creating custom software, the knowledge of such a framework is important to increase my capability at work.*
B. *The use of NLP to extract information from unstructured text, this could be potentially useful in implementing various Optical Character Recognition (OCR) applications.*
C. *Developing a recommender system, which is useful in applying what we learnt during the course. This also prompts more study into this area and how we could better evaluate such recommendation systems for future applications.*

## *Liang MengFei - A0125994R*

*Personal Contribution*
*Below are the list of my contribution to the group:*

A. *Setup the initial github repo + organization for team members.*
B. *Research on the overall framework and compatible technologies for frontend and backend.*
C. *Data scraping for the initial Singapore recipes dataset.*
D. *Develop the front end page using Angular and the backend framework using Django.*
E. *Make sure of figma to get the design of the webpage and implement into the UI design using bootstrap.*
F. *Integrate recommendation model into Django framework.*
G. *Contributing to the report.*

## *Learning Outcome*

A. *Learn web scraping to extract content and data from a website.*
B. *Python and Django REST framework. As in my workspace, we are using Java and Spring framework and this is my first time doing a python project with Django framework.*
C. *Get understanding of the content based filtering approach and the algorithm to calculate the similarities when providing the recommendations.*
D. *Importance of teamwork. Each of the team member's strengths makes up for other team member's weaknesses and at the end everybody is contributing towards the success of the project.*
E. *Time management as my company is currently in the peak period and i need to learn how to prioritize my work and study to avoid over stress.*
F. *Hands on experience in developing a recommendation system.*

## *Knowledge and Skill Application*

F. *Time management, to plan and start early to avoid rushing at the last minute.*
G. *Web page development - Angular, Bootstrap and Figma*
H. *Python and Django rest framework.*
I. *Collaboration tools - github, Google Docs, Google Meet.*

*Kwong Jia Kai (E0283988)*

## *Personal Contribution*

*A. I built the initial project front end (Angular), back end (Django Rest framework) and database (Sqlite).*

*B. I built the initial login and register function which uses JSON web token (jwt) to help track user authentication and sessioning.*

*C. I created scrapy tool to help the team scrape data and download images from website.*

## *Learning Outcome*

*A .Learnt about data scraping and how to get information from websites*

*B. Python and Django REST framework.*

*C. Understand recommender systems and advantages and shortcomings:*

*Recommender systems often return similar results based on past user preferences. One part missed by recommender systems is serendipity. How do we decide that we want to eat something that surprises us? This is a key challenge in recommender systems – how do we return results that are surprising yet acceptable.*

## *Knowledge and Skill Application*

*A .Learnt about how to create rule based expert systems and rule engine*

*Business applications often contain many rules. We can make use of the rule-based techniques in this course and apply it to business applications. For instance, in what2eat, in selecting the right food for a user, a filter of rules is sequentially applied, until the user is left with a few remaining choices. It is the same for business applications that try to sell something. For instance, in insurance, if we can profile and categorize the user, we can sequentially apply a set of rules, and return the user the remaining right choice.*

*A .Learnt about data science techniques such as curate new raw data, load, clean, process, format and test output and data algorithms*

*A decision tree is one solution to the data deluge. If we can create a good rule engine, we can leverage on compute, to help us parse through the data deluge in our lives, by suitably generating a decision tree to categorize and group transactions, leaving us with the right choices.*

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