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Diet Recommendation System using Machine Learning

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***Abstract**:* Understanding health and lifestyle is a global concern in today's society. A balanced and healthy diet, coupled with regular physical activity, plays a crucial role in maintaining good health. This type of diet, tailored to factors such as height, weight, and age, is essential for promoting a healthy lifestyle. It aids in achieving and sustaining a healthy weight, reducing the risk of chronic diseases such as heart disease and cancer, and supporting overall well-being. A healthy diet ensures that the body receives essential nutrients for optimal function. Calories, the measure of energy in food, are expended through everyday activities such as breathing, walking, and running. While the average person requires around 2,000 calories daily, actual calorie needs vary based on individual factors like body size, weight, height, age, and gender.

The prevalence of fast food presents a significant challenge, often leading to unhealthy dietary habits. This unhealthy eating pattern can result in various health issues including obesity, diabetes, and high blood pressure. Consequently, prioritizing nutritious eating habits and overall wellness has become increasingly imperative for individuals.

Keywords: Nutrition, calories, BMI, recommended diet, machine learning, deep learning.

I. INTRODUCTION

In the era of global health awareness, the need for a positive approach to health is undeniable. This paper examines today's health problems, mostly caused by fast food. The foundation focuses on environmental personalized nutrition recommendations that use contextual filtering and machine learning algorithms to provide health recommendations. This study highlights the need to address health problems caused by fast food and supports the 70/30 eating rule, confirming the need to control health in a fast-paced world. In this process, content filtering is used to customize recommendations according to personal behavior and preferences. This approach, highlighting its pivotal role in offering nuanced guidance for optimal health outcomes. Departing from generic recommendations, this methodology aims to address the intricacies of individual dietary choices. The surge in fast-food consumption has precipitated health crises, necessitating a fundamental shift in dietary habits. This report delves into the repercussions of unhealthy eating and proposes a scalable solution—an innovative, personalized nutritional recommender system. Rooted in technology, this approach directly confronts the challenges posed by the modern pace of life, providing accessible and tailored health recommendations for individuals.

Medical research has revealed that consumption of healthy foods helps to build up the immune system and fight against diseases Dharkar and Rajavat. Food provides the energy, vitamins and other essential substances the body needs to function properly and for sustenance for day-to-day activities. A healthy diet enhances body growth, promotes good mental function, boosts body beauty and promotes healthy long life. According to the American Diabetes Association, and the American Heart Association, poor dietary lifestyle are key contributors in the development and progression of preventable chronic diseases, such as obesity, type 2 diabetes, high blood pressure, heart diseases and several types of cancer. Nutrition therapy could be used to manage chronic diseases by managing the diet based on the belief that food provides vital medicine and helps to maintain a good health Phanich. It is important to note that a healthy eating lifestyle helps to reach and maintain a healthy mind and body weight, lowers health risks, such as obesity, heart disease, type 2 diabetes, hypertension and cancer Psychosis. In Medline Plus.

II. PROBLEM DEFINITION

The widespread consumption of fast food has become a dominant feature of modern life, with its convenience often overshadowing its negative impact on health. This concerning trend has created a ripple effect, contributing to a host of health problems such as obesity, diabetes, hypertension, and more. As individuals increasingly rely on quick and easily accessible meals, the nutritional quality of their diets suffers, paving the way for chronic health conditions that can significantly impact quality of life.

Recognizing this pressing issue, the call for a shift towards a more balanced and nutritious diet has never been more urgent. However, the reality is that in our fast-paced society, the demands of work, family, and other commitments often leave little time for individuals to prioritize their nutritional needs. Moreover, the financial burden of hiring a personal dietitian or nutritionist is prohibitive for many.

In light of these challenges, this report seeks to delve into the root causes of unhealthy eating habits and offer practical, accessible solutions to promote a healthier lifestyle. By understanding the factors driving the prevalence of fast-food consumption, we can begin to develop strategies to counter its negative effects. Through education, awareness campaigns, and community initiatives, we can empower individuals to make informed choices about their diet and overall well-being.

Moreover, this report explores innovative approaches to making healthy eating more attainable for everyone. From meal planning tips tailored to busy schedules to budget-friendly recipes that prioritize nutrition without compromising on taste, the goal is to provide actionable steps that individuals can easily incorporate into their lives. By promoting the accessibility of healthy food options and towards prioritizing nutrition, we can work towards a future where everyone has the opportunity to lead a healthier and more fulfilling life.

II. LITERATURE SURVEY

Several works have been proposed for different recommendation systems related to diet and food. These systems are used for food recommendations, menu recommendations, diet plan recommendations, health recommendations for specific diseases, and recipe recommendations. Majority of these recommendation systems extract users' preferences from different sources like users' ratings.

A Food Recommendation System (FRS) is proposed to assist diabetic patients, employing K-mean clustering and Self-Organizing Map for food clustering analysis. This system suggests substitute foods based on nutritional and food parameters. However, it does not adequately address the fluctuating levels of diabetes, which can vary hourly and affect food recommendations. Since nutritious diets are crucial for good health, it is essential for everyone to consume a healthy diet. This paper introduces a recommendation system focusing on nutrition therapy as a vital remedy for diabetic patients with diverse food restrictions. The author utilizes clustering analysis and Self-Organizing Map methods to develop FRS for diabetes patients, offering tailored suggestions for their food intake (Phanich, et al. [1]).

The system suggests personalized recipes to users based on provided tags and ratings in user preferences. Using latent feature vectors, the proposed system balances the user's diet according to matrix factorization in their algorithm. Prediction accuracy is achieved through tags that closely match users' preferences. However, the authors do not consider nutrition to balance the user's diet according to their needs. Tags and latent factors are employed for an Android-based food recommender system [2].

A content-based food recommender system is proposed, recommending food recipes based on user-provided preferences. User-preferred recipes are broken down into ingredients, which are rated according to stored user preferences. The system recommends recipes with matching ingredients. However, the authors do not consider nutrition factors or diet balance. Additionally, there's a chance of repeated recommendations as user preferences may not change daily [3].

Celestine Iwendi et al. (2020) explore the data collection potential of their system, focusing on machine and deep learning algorithms such as Naive Bayes, Logistic Regression, Multilayer Perceptron (MLP), Gated Recurrent Units (GRU), Recurrent Neural Networks (RNN), and Long Short-Term Memory (LSTM). They collected information on 30 people with 13 different illnesses and 1000 items from the internet and hospitals for inclusion in the clinical dataset. The system features eight product area attributes. Before applying deep learning and machine learning techniques, the characteristics of this Internet of Medical Things (IoMT) data were examined and encoded [4].

The USDA nutrition dataset will determine the user's suggested diet, incorporating grocery shop information based on the user's preferred food intake. This database contains nutritional data for every food item, using a USDA ID as the baseline value for input values per 100 grams. Since these values are crucial for estimating the suggested diet, BMI data must be provided. This approach is discussed by Butti Gouthami and Malige Gangappa (2020) [5].

The aforementioned diet recommendation systems address specific diseases or aim to balance diet plans. However, systems recommending foods for specific diseases may not account for varying disease levels, which could have severe effects on patients. Similarly, systems focusing on diet balance often ignore crucial nutrition factors necessary for recommending food and achieving a balanced diet. A brief overview of the algorithms that are used in the project is as follows:

Algorithm	**Accuracy (%)**	**Precision (%)**	**Recall (%)**	**F1 Score (%)**
Random Forest	85	82	88	85
K-Means	72	75	69	72
Long-Short-Term Memory	91	88	94	91
Logistic Regression	78	79	77	78

Algorithm	Type	Problem	Accuracy	Strength	Weakness
K-Means	Unsupervised learning	Clustering	not typically evaluated in terms of classification accuracy	Simple to understand and implement, fast, scalable to large datasets	Sensitive to outliers, not suitable for non-numerical data
Random Forest	Supervised learning	Classification, regression	above 90% on various classification tasks	Robust to overfitting, can handle missing data, good accuracy	Can be computationally expensive, requires more data than other algorithms
Logistic Regression	Supervised learning	Classification	70-80% range	Simple to understand and implement, interpretable, good accuracy	Not as accurate as other algorithms for complex problems, can be sensitive to Outliers
LSTM	Supervised learning	Sequence Modelling	90% or more	Can handle long sequences of data, good at capturing temporal Dependencies	Can be computationally expensive, requires a lot of data to train, difficult to interpret

IV. System Design

A Problem Statement

The consumption rate of fast food is alarmingly high, leading to the intake of unhealthy foods and resulting in various health issues such as obesity, diabetes, and increased blood pressure. It has become essential for individuals to maintain a balanced and nutritious diet. However, in this fast-paced generation, not everyone has the time or resources for a personal dietitian or nutritionist to guide them towards a healthy lifestyle. This report addresses unhealthy eating habits and aims to provide a viable solution for a healthier life.

B. Proposed System

The proposed system operates within a Machine Learning Environment, employing advanced algorithms to analyze user data and offer personalized diet plans. The primary goal is to cater to diverse dietary needs and preferences by segmenting the dataset into three distinct categories: Lunch data, Breakfast data, and Dinner data, corresponding to different meal times throughout the day.

The System operates within a Machine Learning Environment, processing user data to generate recommended diet plans. The dataset is divided into three categories:

1. Lunch Data
2. Breakfast Data
3. Dinner Data

Utilizing machine learning algorithms, the system aims to deliver personalized diet recommendations tailored to individual user needs and goals. By segmenting the dataset and employing K-Means and Random Forest algorithms, the system ensures the generation of relevant and effective diet plans for different meal categories. Furthermore, through user interaction, dynamic adaptation, and integration of external data sources such as USDA nutrition data, the system seeks to enhance user satisfaction, engagement, and long-term success in achieving optimal health and wellness.

C. **Algorithm**

- **K-Means Algorithm** is an iterative algorithm that tries to partition the dataset into pre-defined distinct nonoverlapping subgroups (clusters) where each data point belongs to only one group. It tries to make the intra-cluster data points as similar as possible while also keeping the clusters as different (far) as possible. It assigns data points to a cluster such that the sum of the squared distance between the data points and the cluster's centroid (arithmetic mean of all the data points that belong to that cluster) is at the minimum. The less variation we have within clusters, the more homogeneous (similar) the data points are within the same cluster. The way k-means algorithm works is as follows:

1. Specify number of clusters K.
2. Initialize centroids by first shuffling the dataset and then randomly selecting K data points for the centroids without replacement.
3. Keep iterating until there is no change to the centroids. i.e assignment of data points to clusters isn't changing.
4. Compute the sum of the squared distance between data points and all centroids.
5. Assign each data point to the closest cluster (centroid).
6. Compute the centroids for the clusters by taking the average of the all data points that belong to each cluster.

In my project report the data set is divided into three categories lunch, breakfast, dinner with the help of k-means clustering algorithm the below diagram shows how all three categories are separated from the cluster a dataset This helps us to finally divide the dataset into train and test dataset for all three categories and further the model is built in using the random forest algorithm.

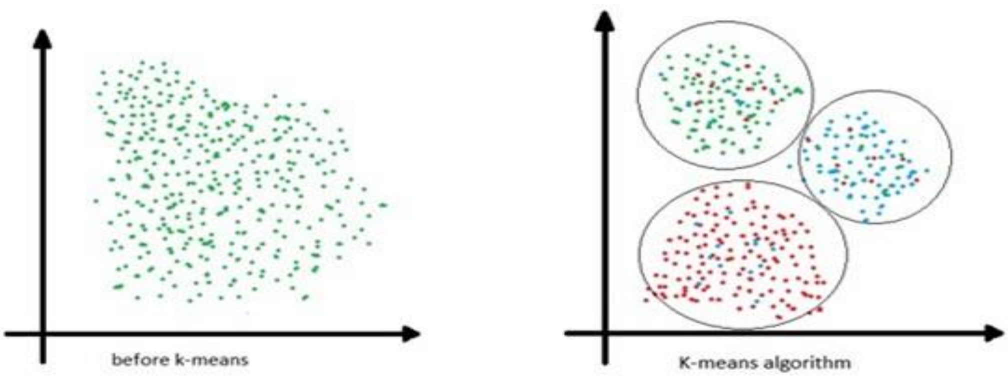


Figure 1: K-Means

- **Random Forest Algorithm** algorithm is a supervised classification algorithm. We can see it from its name, which is to create a forest by some way and make it random. There is a direct relationship between the number of trees in the forest and the results it can get: the larger the number of trees, the more accurate the result. But one thing to note is that creating the forest is not the same as constructing the decision with information gain or gain index approach. The decision tree is a decision support tool. It uses a tree-like graph to show the possible consequences. If you input a training dataset with targets and features into the decision tree, it will formulate some set of rules. These rules can be used to perform predictions.

When we have our dataset categorized into 3 category so now Random forest helps to make classes from the dataset. Random forest is clusters of decision trees all together, if you input a training dataset with features and labels into a decision tree, it will formulate some set of rules, which will be used to make the predictions.

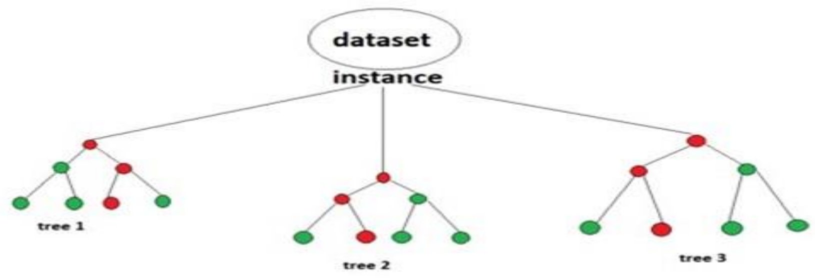


Figure 2: Random Forest

D. **System Architecture**

The system architecture outlines the overall structure and organization of your diet recommendation system. It defines how different components interact, ensuring a cohesive and efficient flow of data and functionalities. A well-designed system architecture facilitates modularity, scalability, and maintainability.

1. User's will enter the necessary information like their age, gender, weight etc. on the website.
2. The information will then go through the ML model in following manner:
    - K-Means is used for clustering to cluster the food according to calories
    - Random Forest Classifier is used to classify the food items and predict the food items based on input
3. After analyzing all the data the system will respond by showing user's BMI and their current state (Overweight, Underweight, Healthy).
4. The System will then recommend diet to the users into three categories (breakfast, lunch, dinner) based on input.
5. The Users can choose from multiple recommended items and make their diet plan.
6. After selecting food items the system will calculate selected food calories and show user's comparison between how much calories they chosen against how much they need to consume daily.
7. Accordingly then the User's will make its diet plan.

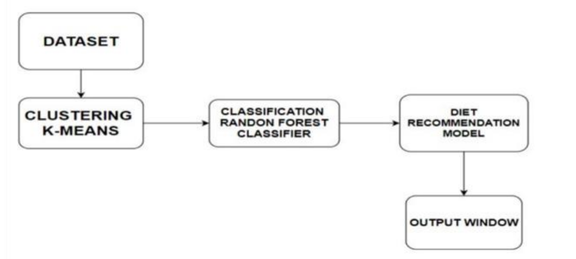


Figure 3: System architecture

E. **User flow**

The user interface (UI) of your diet recommendation system is crucial for providing a seamless and user-friendly experience. It’s the bridge that connects users with the underlying recommendation algorithms and data. Designing an intuitive and visually appealing UI enhances user engagement, trust, and satisfaction with the system. User’s will request to system by providing their physical information and after analyzing the data as a response the system (ML model) will recommend a diet which include (breakfast, lunch, dinner) based on the user information accordingly.

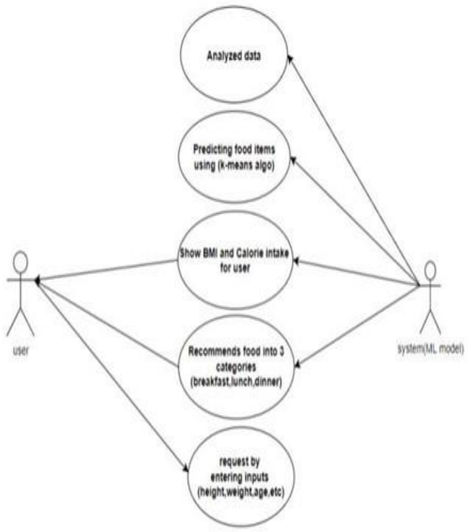


Figure 4: User Flow

F. Data flow

In our proposed diet recommendation system, the user engagement process begins as the individual arrives at the dedicated diet recommendation page. Upon entering essential personal details such as weight, age, height, meals per day, gender, and weight loss plan preferences, the system processes this information. Unlike traditional systems that generate default plans, our innovative approach emphasizes personalized user experiences. The system leverages the processed user details to dynamically generate a personalized diet plan tailored to the unique characteristics of each user. Users are then provided with the flexibility to further customize their diet plans, including selecting specific dishes, specifying portion sizes, and indicating food preferences. The system, in turn, updates the diet plan based on these customizations. The final stage involves presenting the user with a comprehensive display of the selected dishes and portions, accompanied by detailed statistics showcasing the nutritional breakdown, including protein, carbs, and minerals. Users are encouraged to review and, if necessary, adjust their personalized diet plans, thereby ensuring a highly adaptive and user-centric approach to dietary recommendations. This system aims to enhance user satisfaction and adherence by aligning closely with individual preferences and nutritional goals.

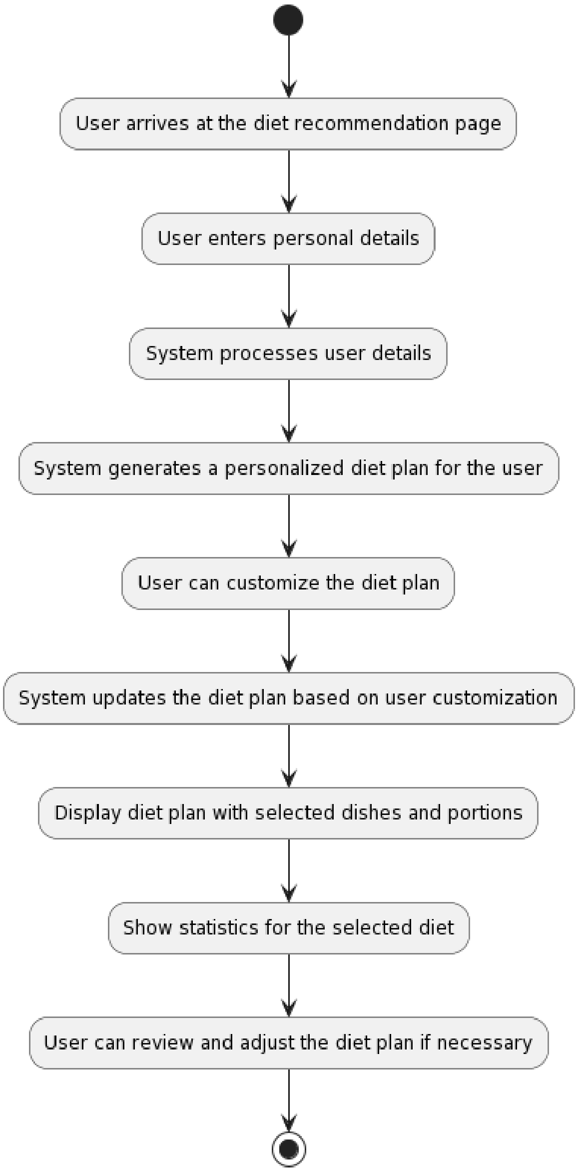


Figure 2 – Data flow diagram

G. Mathematical Model

Break down an unrated target recipe rt into different ingredients.

Assign the rating value for each ingredient in the target recipe rt . Particularly, the rating value of the user u a for a specific ingredient in the target recipe rt is calculated by using rating values of the user u a for all other recipes rl which contain the ingredient. The value l mentioned in is the number of recipes containing the ingredient.

$$\text{rat}\ (u_a, ingr_i) = \frac{\sum_{l\ s.t\ ingr_i\ \in\ r_l} rat(u_a, r_l)}{l}$$

Equation 1: Rating Value

Predict the rating value of the user u a for the target recipe r t (i.e., pred(u a , r t)) based on the average of all the rating values of all ingredients.

$$\text{pred}\ (u_a, r_t) = \frac{\sum_{j\ \in\ r_t} rat(u_a, ingr_j)}{j}$$

Equation 2: Predict Value

Recipes with a high predicted rating value will be recommended to user u a . An illustration for predicting a rating value for a target recipe is presented in the following diagram:

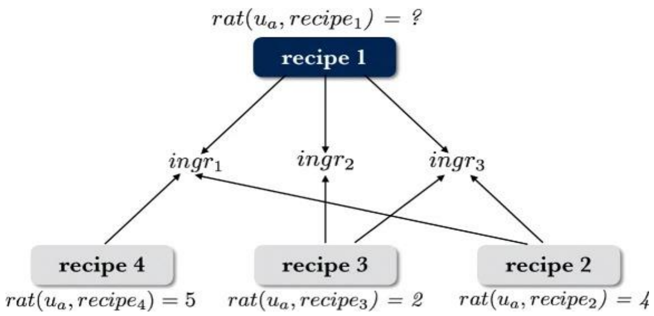


Figure 1: Mathematical Model

According to (1), rating values for ingredients of recipe 1 will be evaluated as follows:

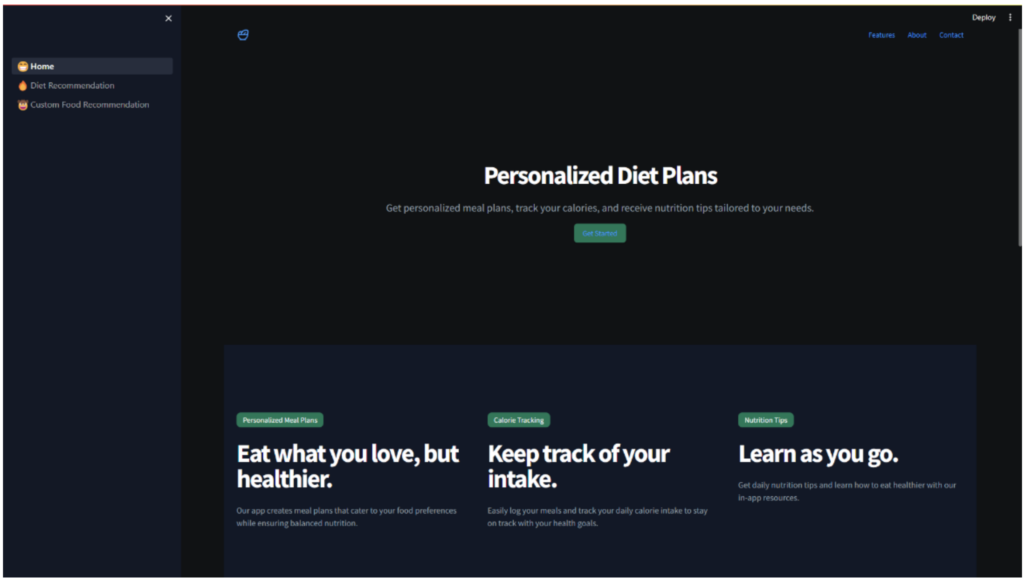
$$\text{rat}\ (u_a, ingr_1) = \frac{rat(u_a, recipe_4) + rat(u_a, recipe_2)}{2} = \frac{5+4}{2} = 4.5$$
$$\text{rat}\ (u_a, ingr_2) = rat(u_a, recipe_3) = 2$$
$$\text{rat}\ (u_a, ingr_3) = \frac{rat(u_a, recipe_2) + rat(u_a, recipe_3)}{2} = \frac{4+2}{2} = 3$$

Prediction value of $recipe_1$ for user u_a is calculated by applying (2) as follows:

$$\text{pred}\ (u_a, recipe_1) = \frac{rat(u_a, ingr_1) + rat(u_a, ingr_2) + rat(u_a, ingr_3)}{3} = \frac{4.5+2+3}{3} = 3.166$$

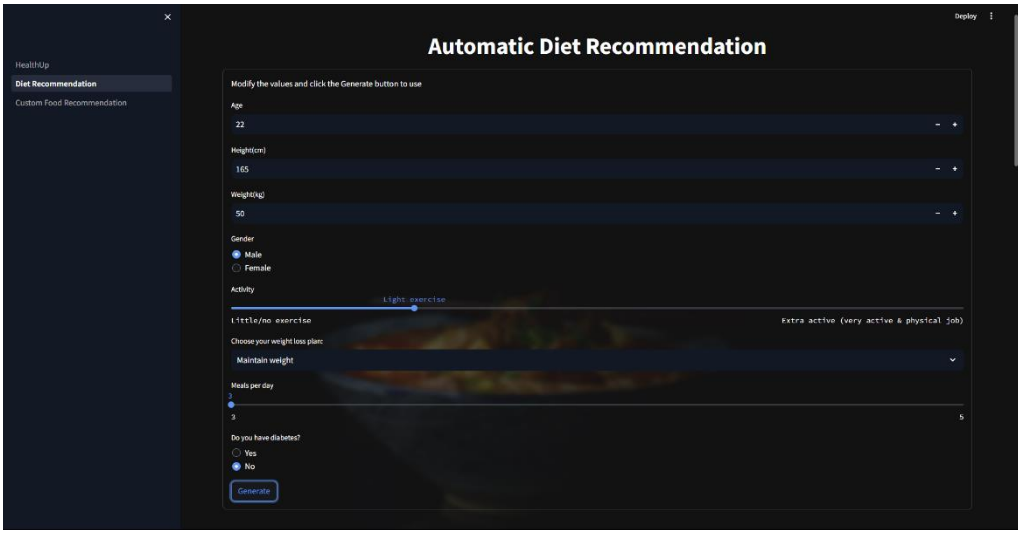
Recently, some new approaches have been included to food recommender systems, such as using labels for different cluster of users.

V. APPLICATION INTERFACE



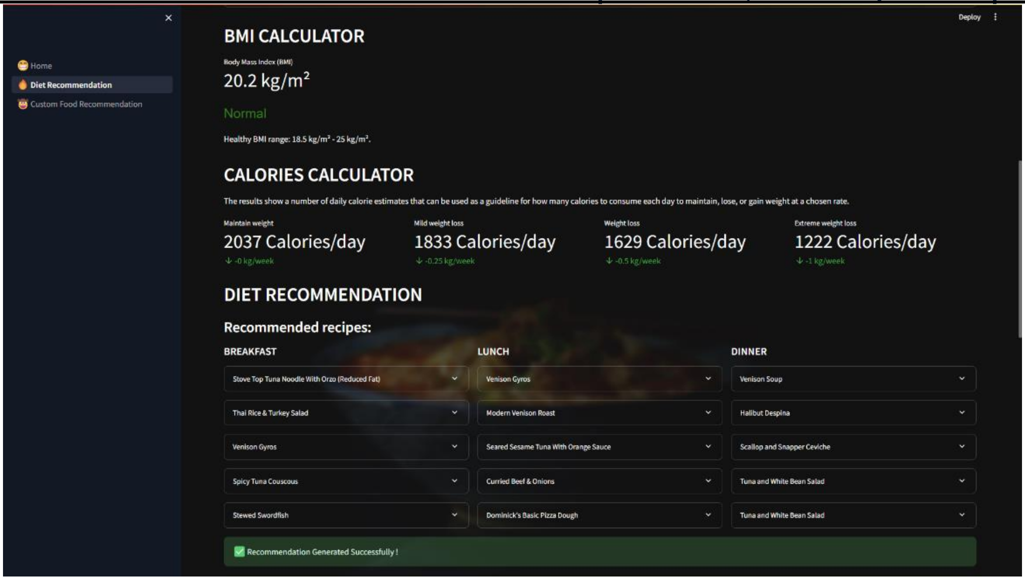
Screenshot 1: Landing page

The Landing Page serves as the welcoming hub for users as they enter the application. Here, users are greeted with a personalized dashboard showcasing their dietary preferences, health goals, and recommended meal plans. It provides an intuitive interface for users to explore and manage their profile information, ensuring a tailored and engaging experience from the start.



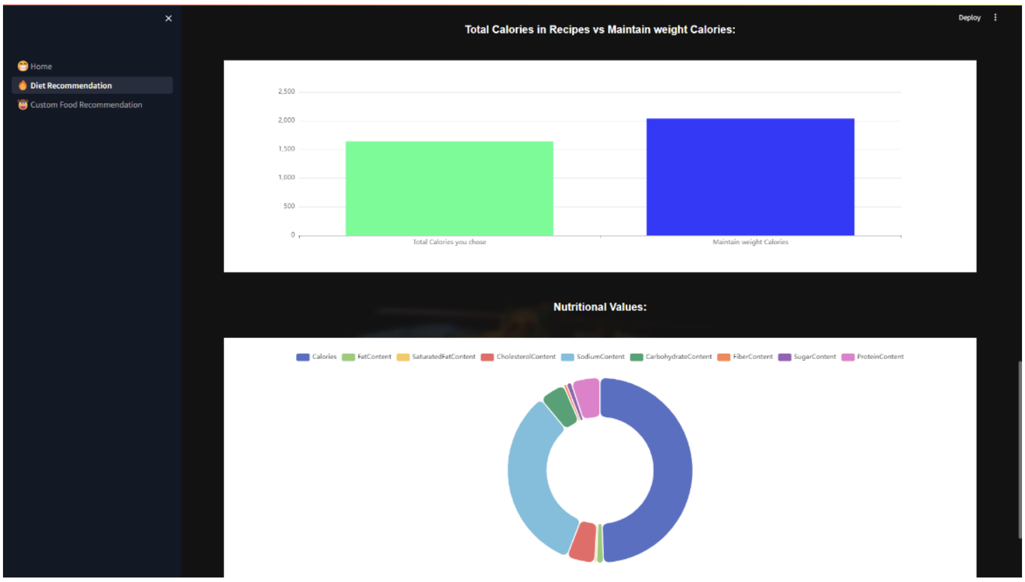
Screenshot 2: Meal Recommendation

The Meal Recommendation Page is where users input their health details and preferences, such as dietary restrictions, fitness goals, and preferred cuisines. Based on these selections, the system generates personalized meal plans and dietary recommendations tailored to the user's needs. Users can explore a variety of meal options, each accompanied by detailed nutritional information, making it easier for them to make informed decisions about their diet and health.



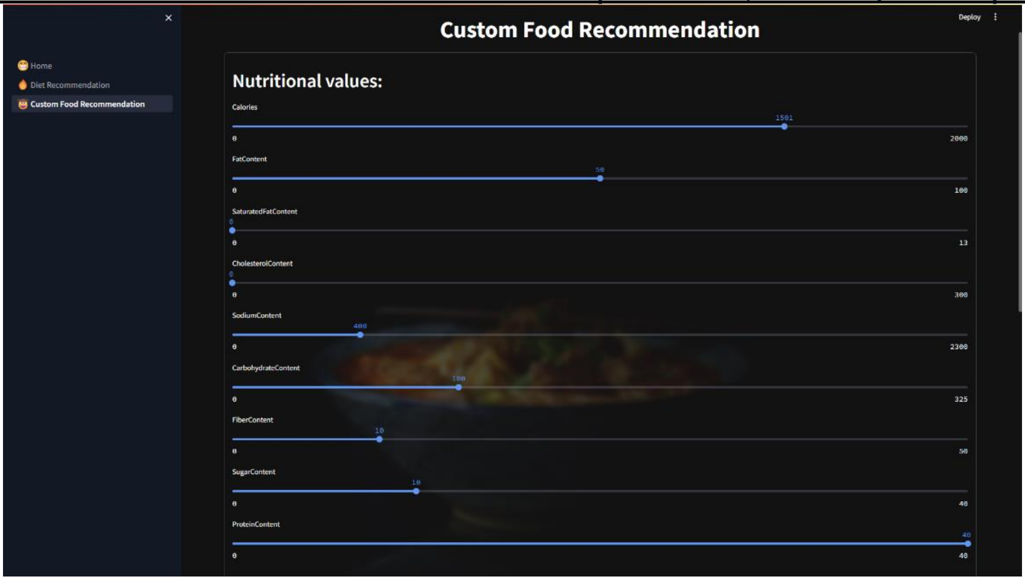
Screenshot 3: Personalized Recommendation

The Recommended Meal as shown in displays that system processed this information to generate five meal options for each mealtime, ranging from breakfast to dinner. Users have the flexibility to adjust the quantity of each meal according to their appetite. Additionally, detailed nutritional information accompanies each recommendation, empowering users to make informed choices for a balanced and nourishing diet.



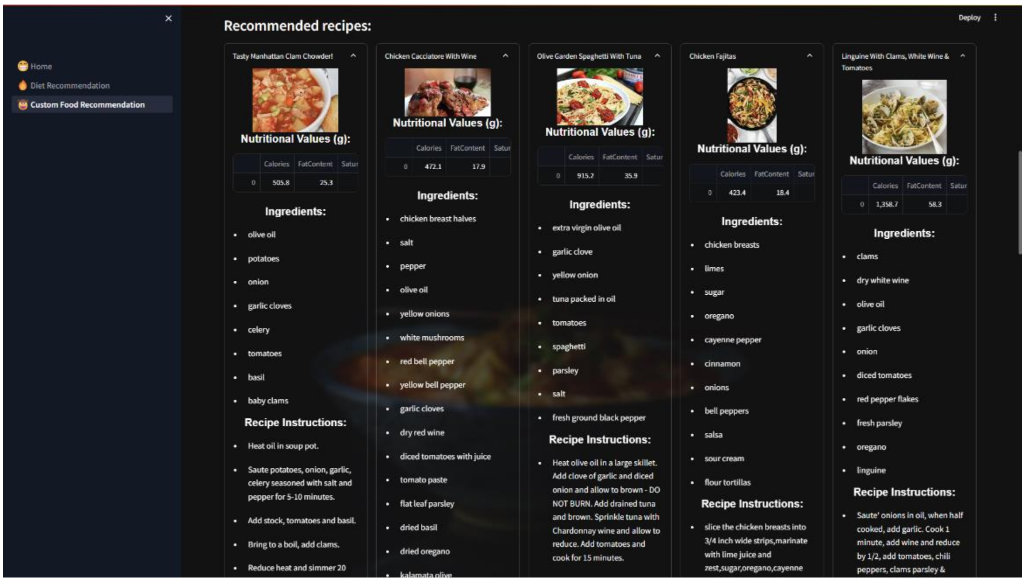
Screenshot 4: Meal Macros

Continuing from the Meal Recommendation Page, users are presented with Meal Statistics for the selected meal options. This section provides valuable insights into the nutritional content of the chosen meal, including calorie intake, macronutrient distribution, and other key metrics. Users can easily track how well they are meeting their dietary goals and make informed decisions about their food choices. It’s a comprehensive overview that helps users maintain a balanced diet and stay on track towards their health objectives.



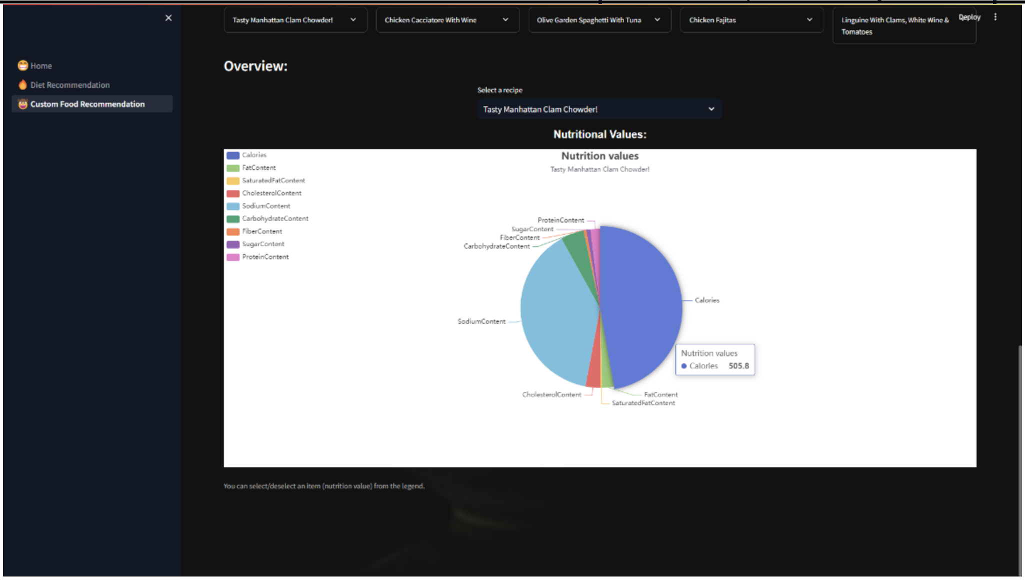
Screenshot 5: Macro Based Recommendation

Introducing the Macro Adjustment Page, where users can fine-tune their meal plans with precision. This interactive page features sliders that allow users to adjust the macro-nutrient content of their meals. Whether it's protein, carbohydrates, or fats, users have the flexibility to select the desired quantity for each macro. This level of control empowers users to tailor their meals according to their dietary needs and preferences, ensuring a balanced and personalized approach to their diet.



Screenshot 6: Macro Specific Recipe Generation

The recipes list showcases a curated list of meal options tailored to your macro adjustments. Each recipe includes detailed ingredients, preparation steps, and nutritional information, empowering users to make informed choices about their meals. From hearty breakfasts to nutritious dinners, this page offers a variety of delicious and balanced options to suit your dietary preferences.



Screenshot 7: Recipe Overview

In the Recipe Overview and Statistics section, users get a comprehensive view of the generated recipes along with vital statistics. This section provides detailed information on the macro content of each recipe, including protein, carbohydrates, and fats. Users can easily compare the nutritional value of different meal options to make informed choices. Additionally, the section offers an overview of the recommendations, highlighting key points such as calorie range and meal variety. It's a valuable tool to help users plan their meals effectively and achieve their dietary goals.

VI. FUTURE SCOPE

- ❖ Integration with Wearable Devices: Future iterations of the diet recommendation system could integrate with wearable devices such as smartwatches or fitness bands. By leveraging real-time health data captured by these devices, the system can offer more dynamic and responsive recommendations
- ❖ Genetic Data Analysis: Incorporating genetic data analysis into the system can enable even more personalized dietary recommendations based on individual genetic predispositions to certain health conditions or dietary preferences.

VI. CONCLUSION

Machine learning algorithms have shown great promise in personalized diet recommendation systems. Motivating people to consume a healthy diet is the aim of nutrition education. Dietary interactions that are crucial for developing dietary guidelines are given special consideration. a health-based medical dataset that uses features like age, gender, weight, and height to automatically identify which foods should be given to which patients based on their conditions. The machine learning and deep learning algorithms used in this project report include Random Forest and K-Means. The optimum eating strategy that yields positive effects are found in all of the models presented in this study. The development of personalized food advice systems could be furthered by investigating new important data sources and thinking about how to incorporate important variables like physical activity, lifestyle, and disease history.

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