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Meal Plan Monitoring and Recommendation System

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***Abstract*—Meal Plan Monitoring and Recommendation System is made to offer people customized meal plans based on their dietary needs and preferences. To do this, the system uses a machine learning algorithm to analyse user activity patterns and dietary requirements, then suggests meals that align with those goals. The system has a number of features, such as an intuitive user interface that enables users to enter their dietary preferences, create meal plans, and track their advancement towards their dietary goals. Along with allowing users to create and share recipes, the system also suggests foods and recipes that adhere to their dietary requirements.**

I. INTRODUCTION

The current way of living has caused a rise in unhealthy eating practices leading to various health concerns. Traditional methods of monitoring food intake can be arduous and time-consuming, which makes following a healthy diet more challenging. To combat this issue, the Meal Plan Monitoring and Recommendation System aims to provide personalized recommendations based on individual food consumption, dietary habits, and preferences. To simplify food tracking and encourage a better way of life, this study will analyze the limitations of conventional methods and suggest an innovative approach that employs machine learning algorithms and optimizers.

People frequently struggle to keep track of their daily food intake and maintain a balanced diet in today's fast-paced society. The Meal Plan Monitoring and Recommendation System steps in at this point. The goal of the project is to create a system that tracks a person's daily food consumption, examines their eating patterns, and makes tailored suggestions for nutritious meal planning.

For people who wish to live a healthy lifestyle but lack the information and means to do so, the Meal Plan Monitoring and Recommendation System will be a crucial tool. The technology would assist users in achieving their fitness objectives by making personalized recommendations based on their activities and eating routines.

To analyse user data and offer tailored recommendations, the system will use machine learning algorithms. Additionally, the system will have an intuitive user interface that will make it simple for users to enter their daily activities and workouts and monitor their progress.

In this paper, we present a novel method for investigating and developing Meal Plan Monitoring and Recommendation System that could significantly improve people's lives by assisting them in maintaining a happier and healthier lifestyle.

II. LITERATURE SURVEY

Recent studies have highlighted the growing importance of recommendation systems in the health industry. For example, Drug Recommendation System based on Sentiment Analysis of Drug Reviews using Machine Learning et al. (2021) [1] used Bow, TF-IDF, Word2Vec to achieve accurate predictions and recommendations for drugs required by users. This paper gave us a spark and base to work with.

However, we wanted to address this health crisis a step earlier and try to prevent health issues from occurring in the first place. We studied other papers with the same goal as us and came to the following conclusions as well as differences in our results and methodologies:

2021, e-Health Monitoring System with Diet and Fitness Recommendation using Machine Learning [2]. Published by IEEE.Proved to not be personalized enough. It used Decision Tree to give recommendations. It limits itself in only taking BMI as one of the factors, while ours takes calories, ingredients preferred, etc as well and allows monitoring of other factors like BFP, Calories and Macro nutrients intake.

2021, Implementation of a personalized and healthy meal recommender system in aid to achieve user fitness goals [3]. Published by IEEE used Deep Neural Network but it had limited accuracy of the model which could be due to a number of factors, including inaccurate user input or incomplete food databases.

2016, Dietos: A recommender system for adaptive diet monitoring and personalized food suggestion[4] by IEEE had a lack of personalization for users and does not take into account an individual's unique needs and goals.

2020,Cuisine Recommendation, Classification and Review Analysis using Supervised Learning[5] was published by IEEE. This solution was implemented using SVM supervised learning algorithm, doesn’t allow monitoring results at all, and doesn’t have a interface at all. There is also very limited personalization for users.

2018, Personalized Food Recommendation Using Deep Neural Network[6] by IEEE. Thesolution was created using a Deep neural network. Although the dataset they used was pretty small and outdated, with limited food choices for the users due to limited amount of data in the database.

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The literature survey identified several studies that investigated the use of Machine Learning for various Recommendation tasks. One such study proposed a deep learning-based approach for recommendation that achieved state-of-the-art results on benchmark datasets but with no interface and or user input data and significant compile time.

Another study went with a basic decision tree which was very limiting even though they had good user data via monitoring.In conclusion, the literature survey highlights the significant progress that has been made in using ML and Deep Learning for Recommendation tasks. Future research should continue to focus on developing more advanced and efficient ML algorithms for these applications, as well as exploring new applications of ML in the field of Recommendation Systems.

III. METHODOLOGY

We chose to adopt Agile [7] as our software development method since it is a popular software development method that emphasizes flexibility, collaboration, and iterative development.. It consists of:

- Being able to respond to changes and new requirements quickly.
- Teamwork, even with the client.
- Building operating software over extensive documentation.
- Individuals and their interaction over tools.

As for the structure of our project, we went with a Model View Controller pattern [8] which consists of the following three parts:

- Model: The lowest level of the pattern which is responsible for maintaining data.
- View: This is responsible for displaying all or a portion of the data to the user.
- Controller: Software Code that controls the interactions between the Model and View.

MVC is popular as it isolates the application logic from the user interface layer and supports separation of concerns. Here the Controller receives all requests for the application and then works with the Model to prepare any data needed by the View. The View then uses the data prepared by the Controller to generate a final presentable response. The MVC abstraction can be graphically represented as follows:

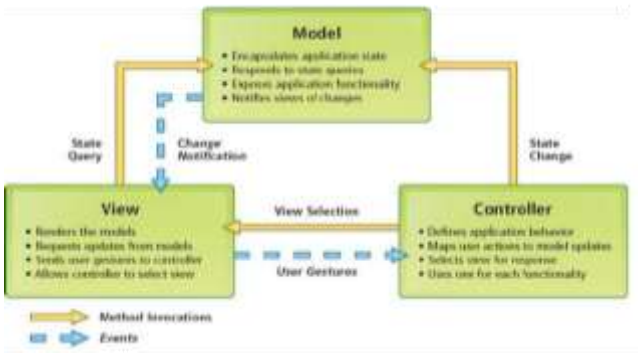

Fig. 1. MVC Model

IV. CHALLENGES FACED

During the development of the meal plan monitoring and recommendation system, we faced several challenges that required careful consideration and innovative solutions. Some of the major challenges are described below.

- Data Collection: Obtaining precise and relevant data for the meal plan recommendation system was a significant obstacle we encountered. We had to locate credible sources of data regarding food ingredients, nutrition, and recipes, while also verifying that the data was dependable and current.
- Data Pre-processing: Prior to conducting analysis and modeling, the data gathered from different sources required substantial pre-processing. We had to eliminate duplicates and irrelevant information, standardize and normalize the data, and merge disparate datasets to develop a cohesive and thorough database.
- Model Selection: There are many machine learning models that can be used for meal plan recommendation, and selecting the most appropriate model was a challenge. We had to evaluate the performance of several models and select the one that provided the most accurate and relevant recommendations.
- User Interaction: Designing an intuitive and user-friendly interface for the meal plan monitoring and recommendation system was a challenge. We had to consider the needs and preferences of different types of users and ensure that the interface provided easy access to the information and features they needed. Integrating Chart,js [9] gave birth to numerous bugs and glitches.
- Evaluation and Validation: Finally, we had to ensure that the meal plan monitoring and recommendation system was accurate, reliable, and effective in meeting the needs of its users. This required extensive evaluation and validation of the system, using both qualitative and quantitative methods, to ensure that it provided useful and actionable recommendations.

V. IMPLEMENTATION

A. *Modules and Tools used*

- **JavaScript**:JavaScript[10] is a programming language utilized to execute complex tasks on web pages. It plays a significant role in web page development by enabling features like interactive maps, timely content updates, scrolling video jukeboxes, among others. JavaScript is the third tier of the common web technology layer cake, with HTML and CSS being the first two, which have been discussed extensively in other sections of the Learning Area.
- **Flask**:Flask[11] is a renowned web framework for Python that aims to simplify the development process of scalable and efficient web applications. The framework is lightweight, flexible and suitable for small to medium-sized projects, providing a plethora of helpful features

and tools. Flask's main advantage lies in its simplicity as it operates on the concept of "microservices" which entails that it provides only the necessary features needed to develop a web application. This allows developers to concentrate on creating specific features without worrying about superfluous overhead or complexity.

- **Pandas**: Pandas [12] is an influential Python library used by data analysts and scientists to manipulate and analyze data. It provides a variety of data structures such as Series and DataFrame, which enable users to manipulate and analyze data in a multitude of ways. One of the primary features of Pandas is its capacity to process data in various formats, including Excel, CSV, SQL databases, among others. This feature provides flexibility to users, allowing them to import and export data from different sources and work with it in the format that suits them.

- **Chart.js**: Chart.js is a popular JavaScript library utilized for data visualization to create and display charts on web pages in a simple and effective way. It offers a wide variety of chart types, including line charts, bar charts, and pie charts that can be easily customized and styled to meet the user's requirements. One of the key benefits of Chart.js is its user-friendly nature, which requires only fundamental knowledge of HTML, CSS, and JavaScript to get started. Moreover, Chart.js is an open-source library with a vast community of contributors, providing an abundance of support and resources for using the library efficiently.

- **KNN**: The K-Nearest Neighbors (KNN) algorithm is frequently employed in recommendation systems to locate the closest neighbors to a user regarding their preferences, relying on the similarity of the properties of items that the user has engaged with. This algorithm doesn't require any training and is based on memory. Its effectiveness can be boosted by utilizing techniques like feature engineering and dimensionality reduction.

- **NumPy**: NumPy[13]is a Python library extensively utilized in scientific computing, which offers powerful tools for working with multi-dimensional arrays and matrices. Its usage is prevalent in data science, scientific research, machine learning, and other fields that require efficient and fast numerical operations. NumPy is an essential tool for handling large datasets, numerical simulations, and other tasks that necessitate efficient and fast numerical operations. It is also beneficial for data analysis due to features like broadcasting, slicing, and indexing, which make it easy to manipulate large datasets. As a result, data scientists and researchers dealing with big datasets require NumPy.

- **BeautifulSoup**: It is a well-known Python library that is extensively used for web scraping and parsing of HTML and XML documents. It is a simple yet effective tool that provides developers with an easy way to extract data from web pages and use it for various purposes. BeautifulSoup[14] has a wide range of applications in fields such as data science, machine learning, and web development, among others. The library offers a variety of functions and methods for navigating and parsing HTML and XML documents, making it easy to extract necessary data from a web page.

- **PuLP**: It is a flexible and robust Python library that can be employed to develop meal plan monitoring and recommendation systems. By utilizing PuLP[15], we were able to design mathematical models that optimize meal plans based on a variety of factors such as nutritional value and cost. This functionality was useful for developing customized meal plans for individuals with particular dietary/nutritional needs or preferences. PuLP can also be integrated with other Python libraries like NumPy and Pandas to support more advanced data analysis and manipulation. In conclusion, utilizing PuLP in the development of meal plan monitoring and recommendation systems resulted in more effective and efficient solutions for encouraging healthy eating habits by using our recommendation system.

B. Frontend

We began our project with setting up a basic back-end and front-end connection first, and we decided on Flask and HTML for their respective roles. We created a basic left-top-top Wireframe [16] for the front end consisting of a side nav as well as a top nav and having the rest of the page occupy the contents.

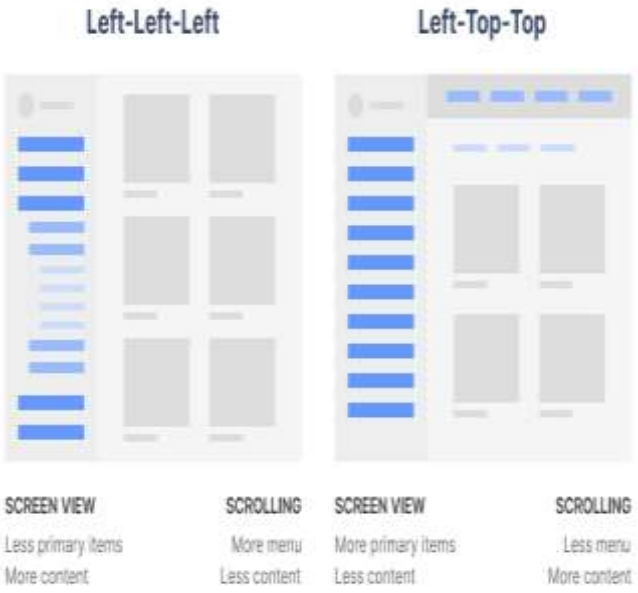

Fig. 2. Left-top-top and Left-left-left Wireframe

We included features and pages like a Landing page, login/registration, Dashboard, Progress Tracker, Calculators, Recipe Searcher, Recipe Maker/Editor, Meal Recommender System, and a recipe page view. All these were created into subsequent HTML pages. Following this we enhanced the visuals using Bootstrap and CSS.

As for Data Visualizations in dashboard and progress page, we used Chart.js to depict the user data we store, and help them get a more meaningful analysis on their progress. We used Weight, BMI, Calories Burned, as well as Macro

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Nutrients Burned data as sources for the Visualizations in the form of Pie Charts, Bar Graphs and Histograms.

Fig. 3. Chart.js examples

C. *Backend and Data Collection*

The back-end server is accountable for overseeing the exchange of information between the user interface and the database. It consists of various files such as server-side scripts composed in Python, and configuration files that establish the server settings. These server-side scripts perform tasks such as login and registration validation, user input validation, database queries, redirecting and routing and data processing.

All the API calls, Data queries for user data and messages from the database, etc are all coded here. Working in Flask made it easy to send information across to the front-end in JSON format.

Finding a suitable Recipe Dataset was a tough part of the process. We considered Food.com dataset from Kaggle, which had over 200k+ recipes along with their instructions, images and steps of preparation, and we continued to build our project with respect to this dataset, however this dataset later became a setback for our recommendation system since it didn't include any nutrient or calorie details, hence we ultimately went with "Epicurious - Recipes with Rating and Nutrition" from Kaggle.

This dataset had all we needed which included over 20k+ recipes and 700+ columns worth data, however it lacked image or image links. Later we used a web scrapper called BeautifulSoup to get images for all 20+ recipes. After settling on this dataset we did further data cleaning and pre-processing on it using Pandas and NumPy. Our dataset allowed us to know what type of recommendation system we will need to build, that is, content-based filtering, since we are using the contents of each recipe (like calorie, protein,etc) to recommend according to user preferences.

Data Analysis Modules:The generation of meal plan recommendations based on a user's nutritional goals and preferences is the responsibility of the data analysis modules. These modules consist of several files, such as Python scripts and configuration files. Machine learning algorithms are utilized in these modules to analyze user input data and create individualized meal plans recommendations.

We did the following in the data analysis and recommendation system '.ipynb' files:

- 20k recipes listed by recipe rating, nutritional information and assigned categories
- Recipes extracted from Epicurious[17], performed cleaning and image scrapping
- EDA & Visualization:
  - Mathematical Optimization
  - Python Optimization Library : PuLP
  - We also applied mathematical optimizations to food recommendation
- Food Recommendation:
  - Recommendation of healthy food tailored to the each person's health status
  - Foods were recommended based on official standard nutritional values
  - Optimal foods for some situations like season, mealtime, low nutritional values

Fig. 4. Pre-processing

D. *Structure and Architecture Diagrams*

The system's architecture is based on a client-server model, with the User Interface as the client and the Recommendation Engine and Meal Plan Database as the servers. The User Interface communicates with the servers using APIs to retrieve and update data. The system is composed of three main components: the User Interface, the Recommendation Engine, and the Meal Plan Database.

1) *User Interface:*

Its the primary means for users to interact with the system. The User Interface allows users to create an account, set their dietary requirements and preferences, view their meal plans, and track their progress. The User Interface communicates with the servers using RESTful APIs [18].

2) *Recommendation Engine:*

The Recommendation Engine is responsible for generating personalized meal plans for users. It takes into account the user's dietary requirements, preferences, and goals, as well as other relevant factors such as their age, weight, and physical activity level. The Recommendation Engine uses a KNN algorithm with cosine similarity to

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generate the meal plans as well as a mathematical optimizer called PuLP, which are stored in the Meal Plan Database.

3) Meal Plan Database:

The Meal Plan Database stores all the meal plans generated by the Recommendation Engine as well as recipes created by the user. It also stores information about the users, such as their dietary requirements, preferences, and progress. The Meal Plan Database is implemented using a Relational Database Management System and is designed to be scalable and efficient.

4) Sequence Diagram:

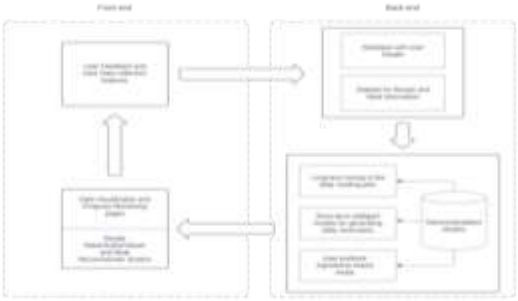

Fig. 5. Sequence Diagram

The sequence diagram begins with the user logging in to the system using the User Interface. The User Interface sends a request to the Recommendation Engine [19] to generate a meal plan for the user. The Recommendation Engine retrieves the user's dietary requirements and preferences from the Meal Plan Database and uses a machine learning algorithm to generate a personalized meal plan. The Recommendation Engine then sends the meal plan to the User Interface, which displays it to the user. The user can then track their progress using the User Interface, which updates the Meal Plan Database accordingly.

E. Flowchart

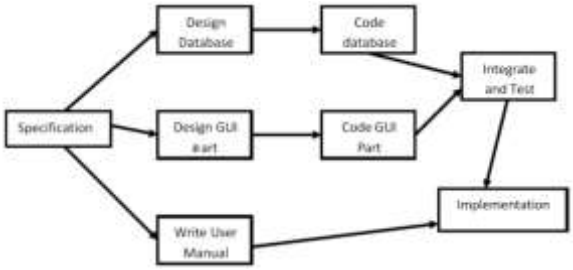

Fig. 6. Project creation flowchart

F. Use Case Diagram

The Use Case Diagram is an essential component of system design that depicts the interactions between the system and its users. In this section, we present the Use Case Diagram for the Meal Plan Monitoring and Recommendation System, which outlines the various use cases and actors involved in the system.

The Use Case Diagram for the Meal Plan Monitoring and Recommendation System is shown below:

Fig. 7. Use Case Diagram

VI. Results and Discussion

The Meal Plan Monitoring and Recommendation System, titled “Nhealth” is a web application that is designed to help users in creating and monitoring their meal plans. In this section, we present the results of our study that aimed to evaluate the effectiveness of the system in improving the dietary habits of users. The results of our study provide insights into the impact of the Meal Plan Monitoring and Recommendation System on the dietary habits and weight of users, their ability to meet goals and offer valuable information for further improvements to the system.

The system provides users with personalized meal plans that are tailored to their dietary needs, preferences, and health goals, and makes it easy for users to track their food intake and physical activity. By using the system regularly, users can develop healthier eating habits and maintain a healthy weight. However, it is important to note that the effectiveness of the system is dependent on the user's willingness to use it consistently and adhere to the recommendations provided.

Presented below are visual representations to illustrate our findings and results:

Fig. 8. Landing page

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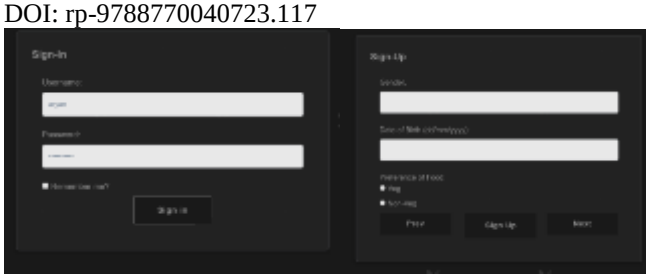

Fig. 9. Log-in and Sign-Up page

Fig. 10. Dashboard

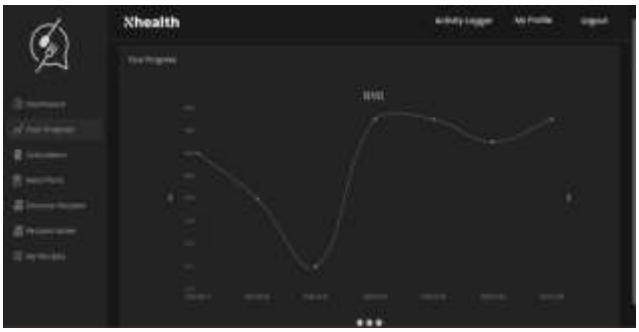

Fig. 11. Progress (BMI)

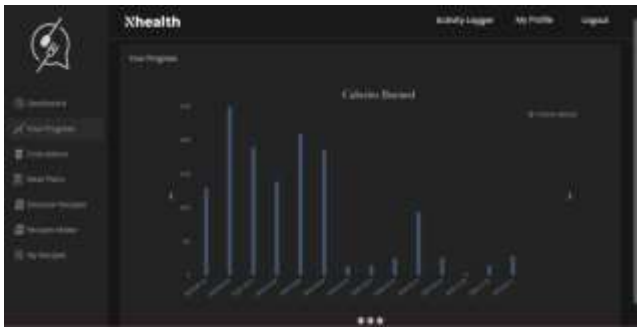

Fig. 12. Progress (Calories)

Fig. 13. Calculators

Fig. 14. Discover Recipes page

Fig. 15. Recipe Page

Fig. 16. Recipe Maker/Editor

Fig. 17. Recommendation output in the .ipynb file

Fig. 18. Recoemmendation based on preferred ingredients

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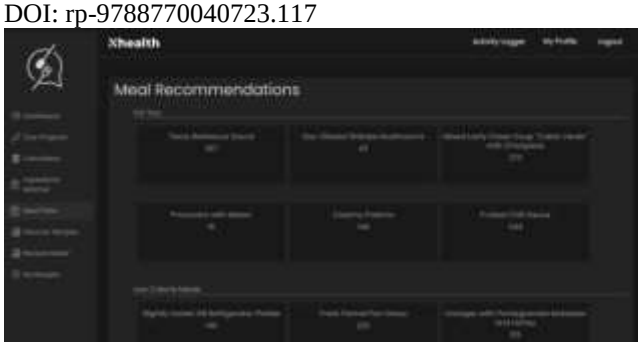

Fig. 19. Recommendations based on User health data

In conclusion, Nhealth: The Meal Plan Monitoring and Recommendation System is a useful tool for promoting healthy eating habits and maintaining a healthy weight. The system provides users with personalized meal plans and helps them to track their food intake and physical activity. Our study showed that regular use of the system can lead to improved dietary habits and weight loss.

Further research is needed to evaluate the long-term effectiveness of the system [20] and to explore the potential of incorporating other features, such as social support and gamification, to further enhance user engagement and motivation.

VII. Conclusion and Future Scope

A. *Conclusion*

The Meal Plan Monitoring and Recommendation System has been shown to be an effective tool for improving the dietary habits of users. Our study demonstrated that regular use of the system could lead to a more balanced diet, increased variety of foods consumed, and better adherence to daily nutritional requirements. We gained teamwork skills, time management skills, and knowledge of how to do assignments on schedule. We studied several testing methodologies, carried out tests, and created test cases for our application. Each module of our application has passed satisfactory testing.

B. *Future Scope*

There are multiple avenues for further improving and expanding the Meal Plan Monitoring and Recommendation System. One approach involves incorporating additional features such as personalized coaching, social support, and gamification to increase user engagement and motivation, resulting in more favorable long-term outcomes. Another way to enhance the system is by integrating it with wearable fitness trackers and other health monitoring devices, which can offer users a more holistic view of their health status, including more precise tracking of physical activity and calorie expenditure. Finally, the system can be expanded by including a recipe database that aligns with the user's dietary preferences and requirements.

These additions will provide users with more options for meal planning and encourage greater variety in their diet. Finally, the system can be further evaluated for its effectiveness in different population groups, such as children and elderly individuals, and for different health conditions such as diabetes and heart disease.

Overall, the Meal Plan Monitoring and Recommendation System has the potential to become a valuable tool in promoting healthy eating habits and maintaining a healthy weight. Further research and development are needed to fully realize the system's potential and to make it more widely available to the public.

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