GRADUATE CERTIFICATE

ISY 5001

INTELLIGENT REASONING SYSTEM (IRS)

PROJECT MODULE

PROJECT REPORT

GROUP 6

AI-POWERED HEALTH CONDITIONING MONITORING & NUTRITION PLANNING

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1. EXECUTIVE SUMMARY

Traditional healthcare services often adopt a one-size-fits-all approach that relies on generic diagnosis procedures and provides standardized medical advice for most cases. The advice is also usually limited to simple medication instructions without considering holistically factors such as rest and nutrition which are equally important factors for recovery. This approach falls short when it comes to addressing the unique individuality, lifestyle, and personal preferences, hence may not effectively serve the needs of different patients.

As individuals increasingly become more health-conscious and with preventive care trends gaining momentum, our AI-Powered Health Condition Monitoring and Nutrition Planning platform is well-positioned to cater to this growing demand.

With the symptom detection and evaluation feature developed, our platform offers a quick and convenient tool to help users identify potential health concerns early based on emerging symptoms. This is performed through the use of text preprocessing to extract specific single or multi-word symptoms accurately from user inputs and the use of fuzzy string matching and semantic similarity to match with relevant symptoms on our database. To enhance prediction accuracy, conditional probabilities are calculated based on the co-occurrence of symptoms through historical records of symptom-disease association to intelligently suggest and check if users may have missed out on other possible symptoms. Finally, a multi-label classification strategy was adopted alongside a Support Vector Machine classifier to predict potential disease.

Not merely focused on treating diseases, our platform also considers overall well-being by offering personalized nutritional meal planning in consideration of diet restrictions associated with the identified disease. This feature operates by first filtering the extensive food database in accordance with user-specific dietary preferences and relevant diet restrictions linked to the identified disease. The filtering process ensures that only appropriate food items are considered for inclusion in the meal plan. To optimize meal planning, a genetic algorithm is employed to determine the most suitable meal plan for three meals across the recovery period. Its objective is to minimize a fitness function that aligns with the user’s targeted calorie goals and offers a sensible combination within the meal plan. A standalone customized meal planner leveraging the food database is also developed to offer flexibility for users to craft their own meal setups in recognition of the potential challenge of strictly adhering to the recommended food item generated in the meal plan.

To continually engage users and support their recovery by adhering to the meal plan recommendations, reminders through Telegram is set up.

There is also tremendous potential for scaling such as collaborating with hospitals or clinics to elevate patient experience by positioning our platform as a post-care monitoring system. Users could input their health conditions and symptoms during post-treatment where automatic rule-based alerts could be built-in for healthcare providers to promptly follow-up. Affiliate marketing could be implemented in collaboration with health supplement suppliers to earn commissions through sales on our platform. The platform could be easily scaled to offer specific health supplements based on the customer profiles.

In essence, our current MVP has successfully met our initial requirements of creating a personalized and holistic healthcare solution. Its demonstrated capabilities and future expansion plans position it as a platform with significant potential for scalability and growth.

2. BUSINESS CASE AND MARKET RESEARCH

2.1 Market Needs and Opportunities

In the realm of traditional healthcare, services often adopt a one-size-fits-all approach, where for most cases, generic diagnosis procedures are undertaken, and generic medical advice and prescriptions are given. This may not be particularly effective or suitable for certain patients since it doesn't consider individual variations in genetics, lifestyle, and preferences.

Additionally, for most, the only proper medical advice and touchpoint would only take place during the clinic or hospital appointments, which typically are infrequent and possibly scheduled months apart. For the most part of the recovery journey, the patient would have to be self-reliant to feel for themselves if they are on the right track of recovery. Patients may resort to online sources for additional information about their illness, but this may not be reliable or accurate as well. Online information sources can be overwhelming with varying conflicting information and often generic advice that makes it difficult to discern the most relevant advice.

Furthermore, most patients, in particular the elderly, could have challenges in understanding medical advice. New medical information advised during the short medical appointments would be challenging to digest and understand for most. Moreover, different interpretations from doctor's advice could arise based on the patient's own perspective or experience, which could lead to misunderstandings that can hinder their recovery rates. An example would be the need to ensure adequate rest and having a proper diet, which are amongst the most important factors for recovery aside from medication. The interpretation of terms like "sufficient rest" and "proper diet" can vary significantly among different patients.

Thereby, herein highlights the need for a patient-centric approach to healthcare and lies the opportunity to develop a personalized companion alongside the patient's recovery journey. Such a companion can encourage and provide patients with the necessary support of health condition monitoring and nutrition planning during their recovery process.

2.2 Industry Trends

2.2.1 <u>Preventive Healthcare</u>

Many contemporary healthcare systems in developed nations are rooted deeply in classical education paradigms like the Flexner report and philanthropic endeavours, confining contemporary medical practices to rely on laboratory investigations [2]. During their inception, these standards were sufficient, as the medical arena predominantly addressed acute infectious diseases in younger individuals. However, with the elevation of global health benchmarks, the central concern of medicine and healthcare has transitioned towards chronic conditions, given that cardiovascular issues, diabetes, and cancer account for about 70% of U.S. fatalities and 75% of its healthcare spending [3]. Such health trends are increasingly noticeable in the developing world as well, emphasizing the need for a more prevention-oriented medical approach [4]. In essence, the pivot for the medical field should be from merely treating diseases (sick care) to promoting overall well-being (healthcare).

2.2.2 Data Availability and Lack of Utilization

In the context of widespread digitalization, the healthcare sector has become increasingly flooded with data that can be leveraged to improve care. According to a Stanford University study, it was determined that health-related data is expanding at an annual rate of 48%[1], with technological integration contributing to this exponential growth at each phase of the care process. Furthermore, the study found that 30% of the world's data generated annually is within the healthcare industry [5]. This surge in information allows for more comprehensive analyses, yielding enhanced accuracy and insights, ultimately facilitating cost reduction and better care quality. While industries such as banking, retail, aviation, and insurance have swiftly evolved their paradigms to become data-centric, optimizing both their operational and strategic dimensions, the healthcare sector has been somewhat hesitant. Many of these industries have reaped the benefits of digital adaptation, witnessing enhanced efficiency, greater return on investment, and superior product offerings. Conversely, healthcare remains conspicuously behind the curve, revealing a sedated evolution in systems and technologies that capitalize on emerging data. Specifically, the healthcare industry was given a score of 28/100 in the McKinsey Digital Quotient, a cross-industry digitalization study, scoring second to last, only to industrials. This slow adaptation hinders the potential to foster a deeper understanding, elevate standards, and improve the overall quality of care [1].

2.3 Quantitative/Qualitative Impacts

[1] Compound Annual Growth Rate, 2013-2020

2.3.1 Total Addressable Market (TAM)

The Total Addressable Market (TAM) for our AI-Powered Health Condition Monitoring and Nutrition Planning system can be computed by examining the prevalence of chronic diseases in Singapore, considering diseases such as diabetes as a representation. With a 9.4% prevalence rate and the population at 5.9 million (as of 2023), the TAM is estimated at 555,000[2] individuals who could potentially benefit from the system. [9][10]

2.3.2 Serviceable Available Market (SAM)

The Serviceable Available Market (SAM) is a segment of TAM accessible through our system, given the technological infrastructure and user adoption rates. If we assume the system can cater to 50% of the TAM, the SAM would be 277,500 individuals.

2.3.3 Serviceable Obtainable Market (SOM)

The Serviceable Obtainable Market (SOM) is the portion of SAM that we realistically can capture, considering the competitive landscape, marketing, and sales capabilities. Capturing 10% of the SAM would translate to a SOM of 27,750 individuals, presenting a more immediate market opportunity for the system.

2.3.4 Implications

The TAM, SAM, and SOM estimations provide a layered understanding of the market potential for our AI-Powered Health Condition Monitoring and Nutrition Planning system within Singapore. This market sizing analysis serves as a fundamental step in illustrating the prospective reach and impact of the system in addressing the healthcare needs of individuals coping with chronic diseases. By strategically navigating the market, there lies a significant opportunity to foster a tailored healthcare journey for users, contributing to a larger narrative of enhanced healthcare delivery.

2.3.5 Cost Savings and Efficiency Improvements

The introduction of our system could lead to considerable cost savings and efficiency improvements within the healthcare sector in Singapore. By providing personalized health monitoring and nutritional planning, the system can potentially reduce the frequency of hospital visits and healthcare consultations, thus saving costs for both healthcare providers and patients. Moreover, by facilitating timely intervention and promoting adherence to personalized nutrition

[2] 5.9 million residents * 9.4% prevalence rate

and health plans, the system can contribute to better health outcomes, reducing the long-term economic burden of chronic diseases. Furthermore, the system's continuous monitoring and real-time feedback could expedite the identification and management of health issues, thereby improving the efficiency of healthcare delivery. This is particularly relevant in a setting where timely access to healthcare resources is crucial for managing chronic conditions and ensuring better recovery outcomes.

2.4 Competitive Landscape

2.4.1 Competitors

Multiple resources on the internet are available that could provide medical information based on symptoms and illness, and two of the bigger competitors are WebMD and Symptomate. WebMD provides a comprehensive symptom checker application supplemented with health information, health articles, news and videos. Symptomate boasts of having a doctor-developed symptom checker that advises the probable conditions with care recommendations.

WebMD and Symptomate have positioned themselves as reliable online resources for individuals seeking initial medical guidance based on their symptoms. However, their offerings are largely static and don't extend beyond providing a probable diagnosis and general medical information.

These limitations underscore a significant opportunity for a more integrated and personalized digital health solution. The gap in continuous monitoring, personalized dietary planning, and real-time engagement with users represents a tangible need in the market. Our proposed system is designed to address these specific needs, providing a more holistic and personalized healthcare experience. Through real-time monitoring and personalized meal planning, it aims to support individuals in managing their health conditions and aiding recovery in a more engaged and proactive manner. Moreover, the envisioned collaboration with healthcare providers and supplement partners could further enhance the value proposition, offering a seamless and holistic health management solution.

2.4.2 SWOT Analysis

To help navigate the complex terrain of healthcare technology, we can examine our positioning across four strategic dimensions: strengths, weaknesses, opportunities, and threats.

Starting with strengths, our system thrives on personalization, setting it apart in a market saturated with one-size-fits-all solutions. By offering customized health monitoring and meal plans, we address a fundamental consumer need for tailored healthcare interventions. The system's ability to provide continuous support fills a critical gap in the healthcare journey, especially during intervals between formal medical consultations. Additionally, our reliance on high-quality data and easily updatable data inflow, ensures that our recommendations are both accurate and relevant. The platform itself is designed for maximum user engagement, with a straightforward interface, easy access via Google Sign-On, and real-time feedback mechanisms. Finally, the inclusion of an end-to-end meal planning system creates a relevant and practical connection to users' recoveries and lives.

However, there are a few areas that we are looking to handle with care. Primary among these is the issue of data privacy. Handling sensitive user health data requires rigorous security measures and compliance with privacy laws, which can be challenging and costly. The advanced technology that powers our system, while a significant asset, also introduces complexity that could be a barrier for less tech-enabled users. Additionally, the system's effectiveness hinges on accurate user input — a variable that introduces an element of unpredictability. Also, the operational demands associated with continuous data management and system updates necessitate a robust allocation of resources.

Looking outward, several market trends work in our favour. The rising tide of health-conscious consumers represents a growing market for our services. This trend, combined with an industry shift toward preventive care, presents a significant opportunity for customer acquisition and retention. Partnerships with established healthcare providers could lend additional credibility to our platform and expand our user base. Moreover, there's substantial potential for geographic expansion and adaptation to local market preferences. Integrating with wearable technology could further solidify our position in the market, offering users a more comprehensive health monitoring solution.

One potential threat the business is faced with is that we operate within a highly regulated industry, and compliance with healthcare regulations will be a constant focus area. We also face stiff competition from both established online health resources and new entrants in the health-tech space. Security risks pose another significant threat; a single data breach could severely damage user trust. Lastly, there's always a risk that users may misinterpret the health information provided, underscoring the need for clear, accessible communication.

2.5 Core Value Proposition

2.5.1 Strategic Positioning and Competitive Advantage

Our proposed AI-powered health condition monitoring and nutrition planning system aims to enable a tailored health journey catered uniquely to the User's needs and provide personalized meal-planning to accompany the User throughout their recovery journey.

It is envisaged to be a system that would provide necessary information on their probable medical condition, advise meal plans based on medical condition and food preference as well as provide reminders on meal plans.

As a holistic companion application, future development could be developed further to include integration with medical health and healthcare supplement partners. Our system would serve as a post-care medium for clinics and hospitals to track their valued patients' recovery progress through in-app feedback on conditions after clinical consultations and provide the necessary alerts to doctors if there were further complications against the norms of expected recovery. For the healthcare supplement partners, our system would help promote their products targeted specifically for the benefit of patients with specific illnesses.

2.5.2 Outline Value Proposition

Our system's value proposition is anchored in personalized, continuous healthcare, utilizing advanced technology to provide proactive support. This strategy meets the growing demand for individualized, accessible health solutions beyond traditional settings. This system is strategically developed to go beyond the usual sporadic healthcare model, turning it into a continuous, interactive process tailored to each user's distinct health requirements.

At its heart, the system focuses on personalization. It moves away from broad health solutions, instead paying close attention to individual health conditions, food choices, and daily living patterns. This detailed strategy is key in developing health and nutrition plans that connect with users on a personal level, building trust, and encouraging consistent use.

2.6 Pricing Strategy

During the launch phase, our primary goal is to establish a robust user base and demonstrate the value of our platform. To achieve this, we have adopted a strategic pricing model tailored to different user segments: Consumers, Healthcare Facilities, and Supplement Suppliers. This multi-faceted approach ensures that we can build a sustainable business model while providing value to a diverse set of segments.

2.6.1 Consumers

Initially, consumers will have free access to the platform. This strategy is designed to attract a substantial number of users and encourage widespread usage. By experiencing the benefits of personalized health monitoring and meal planning, we anticipate strong organic growth driven by user recommendations.

After establishing a value proposition with the free version, we will introduce a premium tier that offers additional benefits. These benefits could include priority in appointment queues, discounts on health supplements, and advanced customization options for meal planning. A monthly or annual subscription fee will provide users with these enhanced services, generating a steady revenue stream and improving customer loyalty.

2.6.2 Healthcare Facilities

We aim to forge partnerships with healthcare facilities, allowing us access to medical data (within privacy regulations) that can refine our disease prediction models. Instead of a direct monetary transaction, this symbiotic relationship will provide healthcare facilities with a sophisticated tool for patient care, while we enhance our system's accuracy and credibility.

Our collaboration with healthcare facilities will also include a performance-based pricing model. Here, fees will be determined by customer satisfaction metrics and the number of referrals generated through our platform. This ensures that our goals are aligned with healthcare providers, emphasizing high-quality service and patient satisfaction.

2.6.3 Supplements Suppliers

We will charge supplement suppliers advertising fees to feature their products on our platform. However, we will maintain a strict vetting process to ensure that only supplements safe and beneficial for our users' health and respective conditions are advertised. This not only creates a revenue stream but also ensures that our users receive trustworthy recommendations and can trust the supplements they purchase.

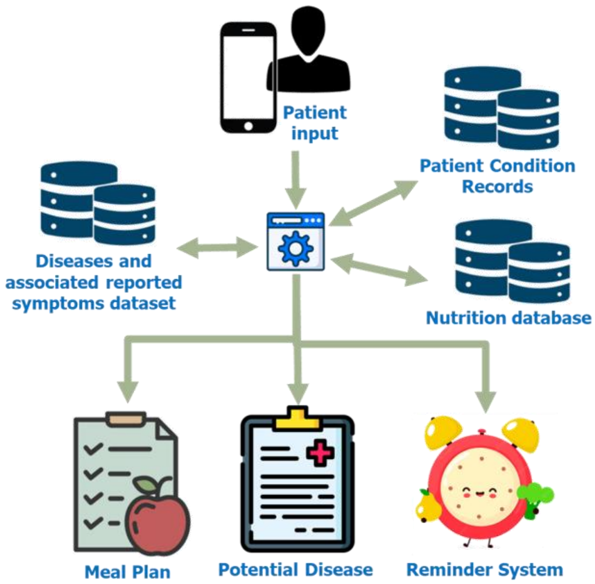
An additional revenue stream will be commissions earned through sales made on our platform. When users purchase supplements through our system, a percentage of the sale price will be earned as commission. This encourages us to feature products that truly benefit our users, aligning our business success with our customers' health outcomes.

This pricing strategy is designed to balance short-term growth with long-term sustainability. By offering initial free access, we can build a substantial user base, gather valuable data, and refine our services. Subsequent premium services, partnerships, and advertising opportunities create diverse revenue streams while ensuring that our platform remains valuable and trustworthy to all users.

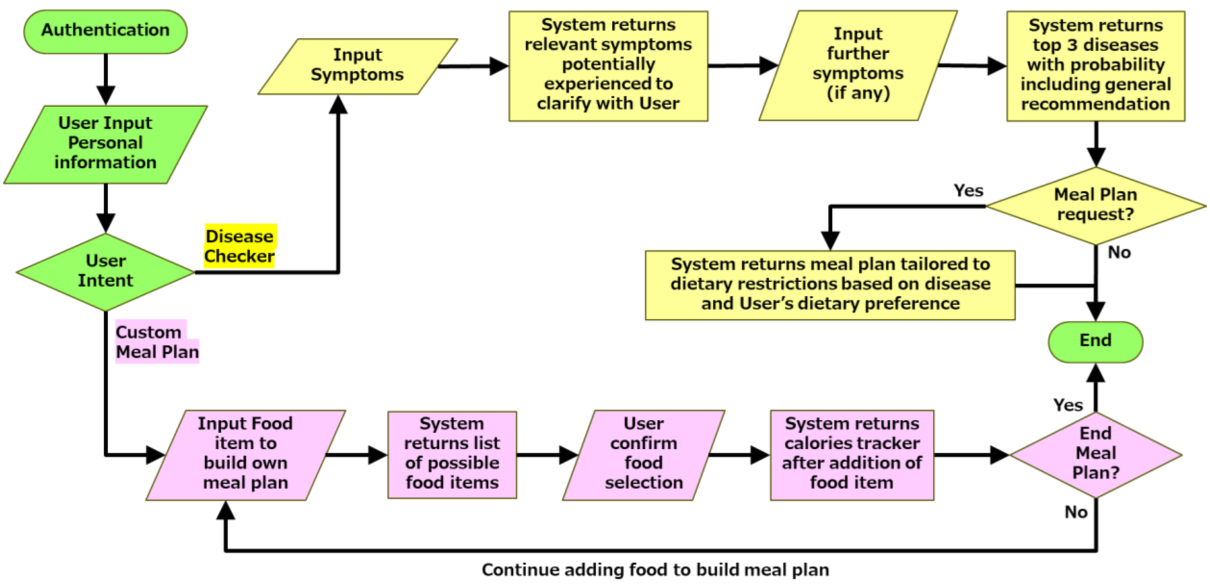
3. SYSTEM DESIGN AND MODEL

3.1 Architecture Overview

The system provides a user-friendly interface for identifying the probable diseases on their symptoms and provides an option to generate meal plans tailored for the diseases. Google Oauth login is used for authentication, thereafter users can access the NLP chatbot which facilitates interaction for symptom analysis and diagnosis. The meal planner operates in two distinct modes: as a standalone application, where users can generate meal plans custom to their requirements, and in the post-disease diagnosis mode where the generated meal plan considers diet restrictions associated with the predicted diseases.



3.2 Detailed Workflow



1. **User Authentication:**

The user logs into the system using Google Sign-On, if the user is already logged into their Google account, they are automatically redirected to the chatbot page. For initial log-in, the user would be prompted to input their personal information and preferences. This information would be used to guide and develop the meal plans.

2. **Symptom Analysis via Chatbot:**

Post-login, the user interacts with a chatbot, which gathers information about their symptoms through a series of questions. The chatbot utilizes Natural Language Processing (NLP) and Natural Language Understanding (NLU) to process the user input and extract symptoms from it. If valid symptoms are provided, the chatbot will suggest some relevant symptoms based on the existing knowledge base that the user might be facing. The user can select from the suggested symptoms or continue describing their condition for a more precise diagnosis.

3. **Disease Diagnosis, Recommendation, and Meal Planning:**

Upon finalizing the symptoms, the chatbot processes the information and returns a set of potential diseases that the user might be experiencing. The chatbot currently returns the top three most probable diseases along with the likelihood probability. In addition to this, it also suggests recommendations that imply general preventive measures to be taken for the disease. If the user expresses interest in receiving further assistance, the system generates and displays a meal plan tailored to the disease and the user's food preferences, leveraging Genetic Algorithms and a comprehensive nutrition dataset. This meal plan considers dietary restrictions and suggestions related to the diagnosed disease.

4. **Standalone Meal Planner:**

Users can access the meal planner independently of the disease diagnosis process. From the particulars provided such as sex, age, height, weight, activity level, weight goal, and meal type, the system computes the Total Daily Energy Expenditure (TDEE) from the Basal Metabolic Rate (BMR). This value will help guide the allocation of calories across the meals of the day. Upon selection of the custom meal planner option, the user could key in their desired food choice. Based on the keyword input, the system will check against the database to return a list of possible food items with the input keyword. Upon confirmation of the food item, the nutritional information of the food will be printed. The remaining calories after deducting the selected food will also be presented to the user, which can help guide the user if he wishes to proceed to add more food items. The process will iterate again if the user requests to add additional food items, where the total calories will be summed to check against the user's target calorie count for the meal.

3.3 Technical Stack and Architecture

3.3.1 Frontend:

- **Technologies:** Vue.js
- **Interface:** User interfaces are presented as web pages utilizing Vuetify, a framework with Vue UI components that implement the TelegramFluent Design proposed by Google.
- **Interaction:** The front end communicates with the backend via API calls and WebSocket connections.

3.3.2 Backend:

- **Technologies:** Django
- **Authentication:** Google OAuth 2.0 API for user authentication.
- **WebSocket:** Utilized for real-time bidirectional communication between the client and server, ensuring instant data transfer and state management.
- **State Management:** Employed to maintain the user's session data (symptoms, identified diseases, meal plans, etc.) throughout the WebSocket connection.
- **NLP Engine:** Processes user inputs and manages chatbot interactions.
- **Disease Prediction Model:** A machine-learning model that predicts potential diseases based on input symptoms.
- **Meal Plan Generator:** An algorithm that leverages Genetic Algorithms to generate meal plans based on user input and the nutrition dataset.
- **Notification:** Telegram API for sending notifications to users

3.3.3 Database:

- **Technologies:** SQLite
- **Purpose:** Storing user data, historical symptoms, disease information, meal plans, and nutrition data.

3.3.4 Security:

- **API Security:** Utilize tokens and OAuth for secure API calls.

3.4 Data Management

3.4.1 Data Sources

Primarily, two sets of data were required, with one for the symptoms checker, and the other for the meal planning.

The disease-symptoms and symptoms precaution reference dataset from Kaggle consists of 41 diseases with 120 entries of reported symptoms for each of the identified diseases [6]. The dataset consists of a total of 128 unique symptoms and each of the reported diseases contains between 3 to 17 symptoms such as itching, cough, chest pain, anxiety, etc. Some examples of the diseases within the dataset are the common cold, migraine, pneumonia, AIDS, gastroenteritis, and drug reactions.

The food nutrition dataset was retrieved mainly from HPB's Energy and Nutrient Composition of Food and Github comprising a total of 3718 and 3238 food choices respectively with information of key nutritional information of each food including weight, calories, protein, fat, carbohydrates and etc. [7][8].

3.4.2 Data Preparation

Additional information to supplement the dataset is required to achieve better personalization. An important aspect was to understand the recommended food intake and food to avoid for the respective diseases. The information is collated through extensive research to supplement the disease dataset. Correspondingly, the assessment of nutritional value with respect to the diet restrictions imposed by the respective diseases was required to be updated for the nutrition dataset.

Additional labels to categorize breakfast choices, lunch/dinner choices, drinks, and fruits were added so that appropriate meal selection could be achieved. Uncommon food and raw ingredients from the dataset were also excluded as we deliberately designed the meal planner to recommend food that is readily available, for the convenience of the Users.

Furthermore, there was a need to enrich the finalized nutrition and meal dataset with additional categorical values, which are leveraged to define optimal meal recommendations. When a User is diagnosed with a condition, there are certain medical recommendations given, for example low-fat diet, which need to be generated in the dataset. This was done by calculating the concentration of the component in focus, relative to the weight. Therefore, the diet recommendation from the disease diagnosis can be added as an additional constraint to the meal plan generation.

Assumptions for Nutritional Content Classification:

Assumption	Criteria	Classification
Protein Content	< 5%: Low 5-15%: Medium >15%: High	Low: 1 Medium: 2 High: 3
Fat Content	< 4%: Low 4-10%: Medium >10%: High	Low: 1 Medium: 2 High: 3
Easily Digestible	≤ 1% of meal weight is carbohydrates	Yes: 1 No: 0
High Carb Content	≥ 50% of meal weight is carbohydrates	Yes: 1 No: 0
Low acid	High-protein (type 3) and low-carb (not High Carb)	Yes: 1 No: 0
High-fibre Content	≥ 4 grams of fibre in the meal	Yes: 1 Unknown: 0

Finally, the disease dataset was enriched with additional context on the diseases via research from WebMD, which allowed recovery-times, general recommendations, and dietary precautions to be integrated into our database. This is used as another point of reference for the Users when they are provided their diagnosis.

4. SYSTEM DEVELOPMENT AND IMPLEMENTATION

4.1 Tools / Techniques

4.1.1 Multi-label Classification Using Machine Learning

Overview:

Multi-label classification refers to the technique where data records can belong to more than one class at the same time depending on the context being viewed. For instance, many diseases have mild fever, and high fever as a common symptom hence if someone is having fever that implies the possibility of many diseases. The disease prediction using the symptoms is an example of multi-label classification. Some of the techniques employed for multi-label classification are OneVsRest Classifier, Binary Relevance, and Classifier Chain.

OneVsRest Classifier:

Train N binary classifiers for each class N.

The binary classification predicts positive outcomes for that class and negative for all the other classes. For instance, for class Ci, we have the classifier Ni which treats Ci as a positive class and all other than Ci as a negative class.

While prediction we use all the N classifiers and take their positive outcomes. Only those classifiers are considered to give a positive outcome and the labels corresponding to the classifier are extracted.

Classifier Chain:

During the training phase, there are N binary classifiers for each label. However, the original input features are fed only to the first classifier. The output of the first classifier is used as a feature and appended to all the other features and fed to the second classifier. This process is then repeated.

While doing predictions the same pattern is followed, that is first classifier predicts based on input, second based on the output of first and the input features, and the process continues.

Selected Strategy:

Since diseases can have associations and this is taken care of by the classifier chain, that approach is used for disease predictions. SVM (Support Vector Machine) is used alongside the classifier chain strategy.

Strategy	Model	Log Loss	ROC AUC Score (Average)	Accuracy	Macro Average	Weighted Average
One Vs Rest	Decision Tree	0.99	0.87	0.98	0.98	0.98
	Logistic Regression	1.52	1	0.69	0.69	0.67
	Multinomial Naive Bayes	0.22	1	0.98	0.98	0.98
	SVM	0.03	1	0.98	0.98	0.98
Binary Relevance	Decision Tree	0.99	0.87	0.98	0.97	0.98
	Logistic Regression	1.52	1	0.69	0.69	0.67
	Multinomial Naive Bayes	0.22	1	0.96	0.98	0.98
	SVM	0.04	1	0.98	0.99	0.98
Classifier Chain	Decision Tree	0.99	0.87	0.98	0.98	0.98
	Logistic Regression	1.52	1	0.69	0.69	0.67
	Multinomial Naive Bayes	0.22	1	0.98	0.98	0.98
	SVM	0.03	1	0.98	0.98	0.98

4.1.2 Disease Prediction Chatbot

Overview:

The chatbot is designed to diagnose potential diseases based on user-provided symptoms. It employs advanced natural language processing techniques, fuzzy string matching, and machine learning models to achieve this. The process can be broken down into three main steps: symptom extraction, symptom suggestion, and disease prediction.

Symptom Extraction:
The chatbot begins by processing the user's input to extract potential symptoms. This involves tokenizing the input text and filtering out common stopwords and punctuation. The tokenized words are then refined by grouping related terms together, ensuring that multi-word symptoms are captured accurately. For instance, if the user mentions "chest pain," the system recognizes it as a single symptom rather than two separate words.

To ensure the accuracy of symptom detection, the system employs a combination of fuzzy string matching and semantic similarity calculations. Fuzzy string matching quantifies the similarity between the user's input and a predefined list of symptoms. If a potential match is found, its semantic similarity with the user's input is computed. This is achieved using vector representations of words, where the cosine similarity between vectors represents the semantic similarity between terms.

Symptom Suggestion:
Once the user's symptoms are identified, the chatbot suggests additional relevant symptoms. This is based on conditional probabilities derived from historical symptom-disease associations. The conditional probability of a symptom given the user's symptoms is computed by analysing the frequency of co-occurrence of symptoms in the historical data. The system then suggests the top N symptoms that have the highest conditional probabilities, ensuring that these suggestions are relevant to the user's condition.

Disease Prediction:
After gathering a comprehensive list of symptoms from the user and the suggested symptoms, the chatbot predicts potential diseases. It first transforms the symptoms into a multi-label binary format, where each symptom corresponds to a column in a data frame, and the presence or absence of a symptom is represented by 1 or 0, respectively.

Using this binary representation, the system employs a trained machine-learning classifier to predict the probabilities of various diseases. The classifier used in this case is the Support Vector Machine (SVM). The classifier's output is a list of probabilities corresponding to different diseases. To provide the user with the most relevant information, the system selects the top N diseases with the highest probabilities that exceed a predefined threshold.

For each predicted disease, the system also provides associated precautions. These precautions are retrieved from a separate dataset that maps diseases to their recommended precautions.

Mathematical formulas:

- **Conditional Probability**:

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

  - Used to compute the probability of each symptom given the user's symptoms.
- **Semantic Similarity**:

$$similarity(A, B) = \frac{\sum_{i=1}^{n} A_i \times B_i}{\sqrt{\sum_{i=1}^{n} A_i^2} \times \sqrt{\sum_{i=1}^{n} B_i^2}}$$

  - Used to compute the cosine similarity between two vectors, representing the semantic similarity between terms.

4.1.3 Meal Planner

Overview:

Two distinct applications were built for the meal planner. The first application acts as a follow-up to the disease prediction chatbot, recommending appropriate meals in consideration of dietary restrictions associated with the predicted illness over the expected recovery period. The second application operates as a standalone meal planner providing Users with the flexibility to customize their own meal plans according to their calorie intake goal for each meal.

Determining Calorie Goals - Total Daily Energy Expenditure (TDEE):

The calorie goals play an important role in shaping the meal plans, aiming to establish a well-rounded diet that aligns with the User's unique profile, activity levels, and weight goals. The calculations are based on the Basal Metabolic Rate (BMR) formulas derived from the Harris-Benedict equations, refined by Miffin and St Jeor in 1990. These BMR values are then multiplied by activity factors to account for the User's day-to-day energy expenditure as illustrated in the Table below to derive the Total Daily Energy Expenditure (TDEE). However, if the User's weight goals involve gaining or losing weight, an additional 500 kcal is either added or subtracted from the TDEE for a more tailored approach.

Men	BMR = (10 × weight in kg) + (6.25 × height in cm) – (5 × age in years) + 5
Women	BMR = (10 × weight in kg) + (6.25 × height in cm) – (5 × age in years) – 161

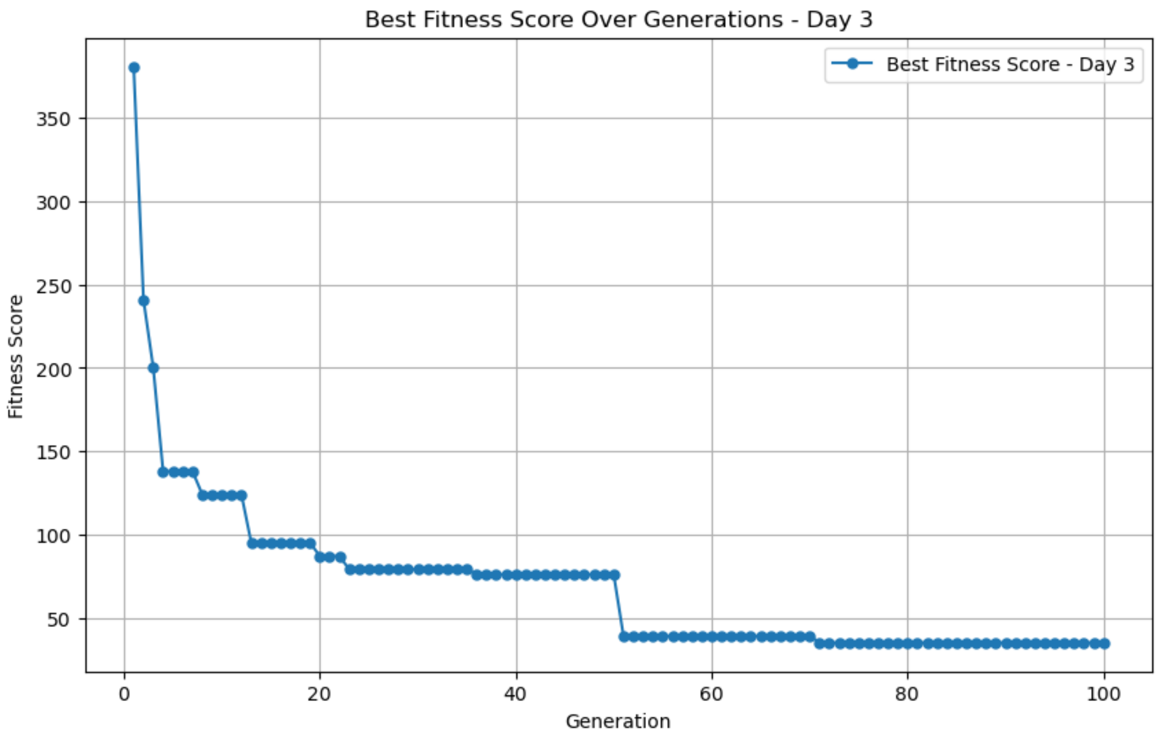
Amount of Exercise/Activity	Description	TDEE (BMR x Activity Factor)
Sedentary	Little or no exercise	BMR x 1.2
Lightly Active	Light exercise (1-3 days per week)	BMR x 1.375
Moderately Active	Moderate exercise (3-5 days per week)	BMR x 1.55
Very Active	Heavy exercise (6-7 days per week)	BMR x 1.725
Extremely Active	Extremely active (twice per day, extra heavy workouts)	BMR x 1.9

Determining Allowable Range of Food for Meal Planning Selection:

User preferences on diet restrictions as well as illness-related diet restrictions were built into the model to retain only the appropriate list of food to be recommended. User preferences encompass choices of vegetarian, halal, and non-beef options to allow personalization. Additionally, illness-related diet restrictions are integrated, encompassing considerations for appropriate oil/fat content, carbohydrate levels, protein content, fiber content, and ease of digestibility. These constraints are implemented at the outset to filter the dataset, ensuring that the subsequent meal planning recommendations adhere to the User's dietary needs.

Meal Plan Recommendation for Illness Recovery:

A genetic algorithm was used to determine the most suitable meal plan based on the respective food data and with the goal of minimizing a fitness function to meet the targeted calorie goals. To ensure that a sensible meal plan is recommended such that the calorie is proportionally distributed between the mains, drinks, and fruit choices, a high penalty was enforced within the fitness function to ensure that at least 50% of the meal's allowable calories is allocated to the mains. An overview of the fitness score of the meal plan across generations running the GA is shown in the below plot.



Custom Meal Plan by User:
The customizable meal plan leverages the existing food database to enable users to craft their own meal setups based on their specific calorie requirements. Users begin by inputting keywords to search for desired foods and the system responds with a list of matching items from the database. The user can then review this list and choose the appropriate food item. Upon selection, the system will display the nutritional values of the chosen food and calculate the remaining calories for the meal.

Subsequently, users have the option to build up their meal plan by adding further items, where the process repeats to prompt users for keywords of desired addition. The count of total calories remaining will be updated after each addition.

Recognizing the challenges of strictly adhering to recommended food items, this iterative and interactive approach acknowledges that users may want flexibility. It allows users to design their meal plans to meet specific dietary preferences and caloric targets, offering a balanced and personalized approach to meal planning.

4.1.4 Backend

Web Sockets:

Web sockets have been used to facilitate real-time communication between the client and the server. Web sockets are a communication protocol that enables bidirectional, full-duplex communication channels over a single, long-lived connection. This ensures that both ends can send and receive data at any time, eliminating the need for re-establishing connections.

Advantages:

1. **Real-time Interaction**: The use of web sockets ensures that our chatbot interacts with users in real time, providing immediate feedback and responses.
2. **Efficiency**: Unlike traditional HTTP requests, which require a new connection for each request-response cycle, web sockets maintain a single connection, reducing overhead and latency.

State Management:

State management is an integral part of our system. It pertains to the practice of managing and preserving the state or context of an application. By keeping track of the user's journey and interactions, our system can provide contextually relevant responses and ensure a coherent user experience.

Advantages:

1. **Contextual Responses**: By understanding the current state of the conversation, our system can understand the context of the conversation and hence it becomes easy to track the progress of the user's request at any point in time.
2. **Error Handling**: Due to the robust nature of state management, we can introduce fallback paths for error handling and can have states that exclusively represent any errors that can arise due to the user input.

Implementation of the above concepts in the code:

Web sockets and asynchronous programming form the backbone of the chatbot used for disease diagnosis and the meal planner. For a chatbot-based system, real-time interaction is of utmost importance, and hence we chose to use the web sockets approach due to its full duplex bi-directional nature. Further, the state management combined with the web sockets, serves as a guide to map the user request into a set of tasks and iteratively complete them.

4.1.5 Frontend and Others

About frontend frameworks

To make the user interface developing process less complex and more efficient, we utilized Vue and Vuetify. Vue is a JavaScript framework for building user interfaces. Its declarative rendering and reactivity abilities allow developers to efficiently build web interfaces. Vuetify offers pre-designed Vue components, enabling developers to create Fluent Design-styled user interfaces rapidly, even without any design skills.

The main UI of the system, the chatbot, mimicked the one of ChatGPT and included interactive components in the chat message boxes to better present the chatbot's responses and enable users to interact with the system.

The front end utilizes Axios for making Ajax HTTP requests as API calls, mainly for user information editing and chat history loading. Routing is used for page switching and is based on the official router plugin of Vue.

About third-party authentication and notification

Using Google OAuth for user registration and authentication is simple and effective. A Django plugin is utilized to integrate this login feature with the backend of the system.

There were several options for ways to send notifications to users, such as social apps, Email, SMS, etc. Taking effectiveness, cost, and technical difficulties into consideration, we decided to utilize Telegram as a demonstration of this feature. Users will be able to receive meal reminders from the system once they have set up and subscribed to our Telegram Bot as instructed. Note that the Telegram approach is also temporary, as the final goal is to serve the whole system as an application that sends notification to users itself.

4.2 Challenges and Solutions

4.2.1 Interactive Communication through Web Sockets

Leveraging web sockets for real-time communication and asynchronous operations presents its set of challenges. A primary concern is synchronizing conversation states with user interactions. To address this, we adopted an inheritance-driven method to define states, mirroring the principles of the factory design pattern.

4.2.2 Parsing user input for the NLP Chatbot

Given the dependency of NLP on user intent, it became imperative to refine user input to extract pertinent details (in our scenario, symptoms). Based on this refined input, the system identifies known symptoms for subsequent predictions.

This identification process harnesses both syntactic (through fuzzy string comparisons) and semantic (via cosine similarity scores) approaches.

4.2.3 Meal Planner Algorithm

In the development of the recommended meal plan from a pool of over 6000 potential food items, the choice of algorithm is critical. It is essential to recognize that for the meal planner, achieving the absolute optimal solution (global optimal) is not paramount. This is particularly so as the algorithm could be required to generate multiple solutions catering to different meals and days. Computational efficiency on the other hand is crucial to ensure a seamless user experience, avoiding prolonged waiting times for the generation of meal recommendations.

The backtracking algorithm, with its exhaustive search through the solution space, was deemed unacceptable due to its prolonged computation time. Given the need for a quick and efficient model, the Genetic Algorithm (GA) emerged as a more viable alternative. GA allows for quick iteration as it selects only the best-performing solutions for reproduction. This approach strikes a balance between computational speed and the generation of diverse and suitable food combinations for the recommended meal plan.

5. RISK ANALYSIS AND NEXT STEPS

5.1 Risk Analysis

In our order to reduce risk in launching our solution, we have streamlined our risk analysis into three primary categories. This is mainly to prepare for, anticipate, and mitigate risks that are facing the solution.

5.1.1 Technical and Compliance Risks

Data security stands at the forefront, necessitating stringent measures to protect sensitive health information and ensure compliance with global data protection regulations. The system's reliability and accuracy are equally vital, demanding flawless performance to maintain user trust and provide precise health assessments. The ability to scale effectively while maintaining this accuracy and compliance is a challenge that requires advanced, adaptable solutions.

5.1.2 Market and Operational Risks

Our market environment is highly competitive, emphasizing the need for relentless innovation and differentiation. User adoption hinges on trust in AI, making transparency and education pivotal. Operationally, the focus is on efficiency and talent retention, ensuring that our system evolves with technological advancements and that our team maintains the expertise to innovate continually.

5.1.3 Financial and Reputational Risks

Financial health hinges on sustained funding and user adoption, both influenced by market perception and the actual value provided. Our reputation is tied directly to both data integrity and the accuracy of health advice; any misstep can result in user attrition and diminished trust. Proactive financial planning and a commitment to user education and transparent communication are crucial in mitigating these risks.

5.2 Roadmap for Future

5.2.1 Future Considerations

As the system developed is positioned as an MVP, further enhancements listed below are recommended to improve the system. Prioritized, are four main areas, which include the expansion of disease data, food choices, and hospital interaction infrastructure.

Firstly, expanding our database of diseases and symptoms is imperative for a more comprehensive health platform. Recognizing potential limitations in our current list, we propose forging collaborations with clinics and hospitals to enrich the dataset. By tapping into their clinical expertise, a more exhaustive resource could be created that better serves users. This collaborative approach ensures a broader spectrum of health conditions is covered, empowering users with enhanced knowledge for improved health management.

Secondly, while our current dataset is comprehensive, there's an opportunity to augment it by incorporating suggested health supplements within the meal planning process. This inclusion can prove advantageous for patients undergoing recovery, providing them with a more holistic approach to nutrition. Furthermore, greater personalization and flexibility could be introduced into our meal recommendations. Unlike the current standard suggestion of a typical meal comprising mains, a fruit, and a drink, we propose exploring options that allow users to customize their meal types. This could involve breaking down a meal into smaller mains spread throughout the day, providing users with the flexibility to adapt their eating patterns according to their preferences and dietary requirements. This approach not only adds a layer of customization but also aligns with evolving preferences for varied and adaptable meal plans.

Finally, we have prioritized creating an integrated health management system designed for collaboration with clinics or hospitals. This post-care solution could be developed in partnerships with healthcare facilities, fostering a collaborative effort to create a unique and personalized experience for patients. The system could be enhanced to go beyond clinical appointments by consistently checking in on patients' well-being during recovery. This extended monitoring allows healthcare providers to stand out from others by displaying their commitment to patient well-being. Additionally, the system can be optimized to include medication information and reminders, offering patients convenient access to medical details and prescribed treatments from their consultations.

6. CONCLUSIONS

The minimal viable product (MVP) developed has successfully demonstrated its ability to achieve our defined outcomes. These include symptom-based disease detection, providing preventive care advice from identified diseases, recommending nutritional meal plans in consideration of dietary restrictions from both personal preference and disease-specific concerns, and lastly sending reminders to users directly via telegram on recommended meal plans to ensure users are continually engaged. These features helped form the basic personalized healthcare solution that offers a holistic recovery plan through proper nutrition throughout the recovery process.

As outlined in our roadmap for the future, there is tremendous potential for scaling. Disease detection can be further improved with the expansion of our databases of diseases and symptoms which could be done through collaboration with clinics and hospitals.

The food dataset can easily be expanded with additional food items including health supplements and with proper categorization and filtering, they can be offered to specific customer profiles. Greater flexibility on the number of meals per day could also be easily developed to suit the different needs of each individual (e.g. fasting period, slots for healthy snacking, etc.).

The developed platform can also easily be integrated with hospitals or clinics to function as their post-care system, offering their clients service beyond clinical appointments. Health condition monitoring making use of algorithms developed from our disease detection could be utilized to consistently check in on patients' well-being during recovery, allowing these healthcare providers to enhance overall patient experience.

In essence, our current MVP has successfully met our initial requirements of creating a personalized and holistic healthcare solution. Its demonstrated capabilities and future expansion plans position it as a platform with significant potential for scalability and growth.

APPENDIX A – PROJECT PROPOSAL

GRADUATE CERTIFICATE: Intelligent Reasoning Systems (IRS)

PRACTICE MODULE: Project Proposal

Date of proposal:

21 September 2023

Project Title:

ISS Project – **AI-Powered Health Condition Monitoring and Nutrition Planning**

Sponsor/Client: *(Name, Address, Telephone No. and Contact Name)*

Institute of Systems Science (ISS) at 25 Heng Mui Keng Terrace, Singapore

NATIONAL UNIVERSITY OF SINGAPORE (NUS)

Contact: Mr. GU ZHAN / Lecturer & Consultant

Telephone No.: 65-6516 8021

Email: zhan.gu@nus.edu.sg

Background/Aims/Objectives:

Background: In the realm of traditional healthcare, services often adopt a one-size-fits-all approach, with limited medical support available only during infrequent appointments scheduled months apart. But what if healthcare could be a personalized and constant companion? Imagine having an AI-Powered Health Condition Monitoring and Nutrition Planning that caters uniquely to your needs, available whenever you require assistance.

Aim: Our mission is to lead a healthcare revolution by creating an AI-Powered Health Condition Monitoring and Nutrition Planning system. This is more than just another health solution; it's a transformative endeavour. Our goal is to empower individuals with a tailored health journey, arm them with tools for physical and mental well-being, and provide a wealth of personalized resources.

Objectives:

1. **Personalized Health Monitoring and Diagnosis Enhancement:** Create a personalized health monitoring and diagnosis system meticulously crafted for each user. Empower individuals to not only track their health goals and celebrate milestones but also provide them with tailored health recommendations that align precisely with their unique needs and health conditions. Bid farewell to generic advice, and usher in a system that seamlessly connects users to a wealth of health knowledge, uniquely customized to enhance their well-being.
2. **Harness the Power of AI in Nutrition Planning:** Picture an AI-powered nutrition planner that offers personalized meal plans, considering your health conditions, dietary preferences, and allergies. It's like having a personal nutritionist who understands your unique needs, guiding you toward healthier dietary choices seamlessly.

Features overview:

1. Health Condition Monitoring:

- **Building Blocks:**

○ Data Integration
○ Alerts and Notifications
● **Algorithms:**
○ Time Series Analysis: For monitoring of health status (duration of symptoms) and recovery progress.
○ Decision Trees: Disease/Illness identification based on user input symptoms predicted through illness and associated reported symptoms datafile. For risk assessment and recommending appropriate actions based on health data.

2. AI-Powered Nutrition Planning:

● **Building Blocks:**
○ Nutrition Database
○ User Dietary Profile
○ Meal Plan Generation
● **Algorithms:**
○ Collaborative Filtering: To suggest meal plans based on similar user dietary profiles.
○ Genetic Algorithms: For optimizing meal plans based on dietary preferences and health conditions.
○ Food Recommender System: Using item-based collaborative filtering to recommend foods based on dietary restrictions.

3. Personalized Medication Reminders:

● **Building Blocks:**
○ Medication Database
○ User Medication Schedule
○ Notifications System
● **Algorithms:**
○ Rule-based Systems: For scheduling medication reminders based on user prescriptions.
○ Bayesian Networks: To estimate the likelihood of medication adherence and optimize reminder timing.

Requirements Overview:

❖ **<u>Research ability</u>**
❖ **Importance:** Research ability is crucial for staying updated with the latest advancements in healthcare, artificial intelligence, and data science. It enables the team to make informed decisions, select appropriate algorithms, and adapt to evolving medical guidelines.
❖ **Key Responsibilities:**
➢ **Literature Review:** Regularly review academic papers, articles, and industry reports related to healthcare, AI, and decision support systems.
➢ **Clinical Understanding:** Develop an understanding of medical concepts, terminologies, and healthcare regulations to design a system that aligns with healthcare standards.
➢ **Data Analysis:** Analyze healthcare data to identify trends, patterns, and correlations that can enhance decision support.

❖ **<u>Programming ability</u>**
❖ **Importance:** Programming ability is the foundation for developing and maintaining the AI-Driven Personal Health Assistant. It's essential for implementing algorithms, building user interfaces, and ensuring system reliability and scalability.
❖ **Key Responsibilities:**
➢ **Software Development:** Write clean, efficient, and maintainable code for the various components of the system, including the front-end and back-end.

➢ **Algorithm Implementation:** Implement machine learning and AI algorithms for health monitoring, recommendation engines, and data analysis.

➢ **Testing and Debugging:** Perform rigorous testing and debugging to ensure the system's functionality and security.

❖ **<u>System integration ability</u>**

❖ **Importance:** System integration ability is crucial for ensuring that the AI-Driven Personal Health Assistant can seamlessly connect with various data sources, third-party services, and healthcare systems.

❖ **Key Responsibilities:**

➢ **Data Integration:** Integrate data from wearables, medical records, and other sources into a unified system.

➢ **API Integration:** Connect with external APIs for services like telehealth, content delivery, and medication databases.

➢ **Security Integration:** Implement robust security protocols to protect user data during transmission and storage.

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

Hardware proposed for consideration:

- GPU

Software proposed for consideration:

- Web GUI
- NLP tools
- **Machine Learning Models:** For vision, speech, and NLP tasks.
- Databases, e.g SQL, NoSQL
- Chat-bots, e.g. ChatterBot
- Cloud computing/server, e.g. Amazon, Google, IBM, Azure, etc.
- Application container, e.g. Docker

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

A team of four to six project members.

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 2. Define internal and External Design 3. Prioritize & Consolidate Requirements 4. Establish Functional Baseline
Technical Construction	· To develop the source code in accordance with the design. · To perform unit testing to ensure the quality before the components are integrated as a whole project	1. Setup Development Environment 2. Understand the System Context, Design 3. Perform Coding 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 2. Prepare for Test Execution 3. Conduct System Integration Testing 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 2. Conduct Training for Acceptance Testing 3. Prepare for Acceptance Test Execution 4. ISS Evaluate Testing 5. Obtain Customer Acceptance Sign-off
Delivery	To deploy the system into the production (ISS standalone server) environment.	1. Software must be packed by following ISS's standard 2. Deployment guideline must be provided in ISS production (ISS standalone server) format 3. Production (ISS standalone server) support and troubleshooting process must be defined.

Team Formation & Registration

Team Name: **AI-Powered Health Condition Monitoring and Nutrition Planning**
Project Title (repeated): **AI-Powered Health Condition Monitoring and Nutrition Planning**
System Name (if decided): **AI-Powered Health Condition Monitoring and Nutrition Planning**
Team Member 1 Name: YATHARTH MAHESH SANT
Team Member 1 Matriculation Number: A0286001R
Team Member 1 Contact (Mobile/Email): e1221813@u.nus.edu
Team Member 2 Name: KRISTOFER ROOS
Team Member 2 Matriculation Number: A0285949A
Team Member 2 Contact (Mobile/Email): e1221761@u.nus.edu
Team Member 3 Name: CHUA KIAN YONG KENNY
Team Member 3 Matriculation Number: A0056377W
Team Member 3 Contact (Mobile/Email): e1216683@u.nus.edu
Team Member 4 Name: ZHANG YUSEN
Team Member 4 Matriculation Number: A0285839H
Team Member 4 Contact (Mobile/Email): e1221651@u.nus.edu
Team Member 5 Name: HAO ZHENMAO
Team Member 5 Matriculation Number: A0285960R
Team Member 5 Contact (Mobile/Email): e1221772@u.nus.edu

APPENDIX B – MAPPED SYSTEMS FUNCTIONALITIES AGAINST KNOWLEDGE, TECHNIQUES AND SKILLS OF MODULE COURSES

MODULE COURSE	KNOWLEDGE/TECHNIQUES/SKILLS APPLIED
Machine Reasoning (MR)	Decision Automation techniques: - Abductive Reasoning (conditional probabilities): Symptom suggestions based on symptom-disease associations - Knowledge Elicitation (rule based system): Providing associated precautions with diseases
Reasoning Systems (RS)	Knowledge Discovery techniques: - Analytic Tasks (retrieval reasoning system) - Symptom checker Business Resource Optimization techniques: - Synthetic Tasks (generative reasoning system) - Meal plan generation utilizing evolutionary computing techniques
Cognitive Systems (CS)	Cognitive Techniques: - NLP - semantic similarity - Chatbot interface

APPENDIX C – INSTALLATION AND USER GUIDE

Installation of Vue.js front end:

1) Download Node.js from the official website.
2) Check the installation using command prompt “npm –v”
3) In the frontend directory, run the command: “npm i”
4) To start the development server, run the command: “npm run dev”. This will start the development server at localhost:3000. Visit localhost:3000 using browser.

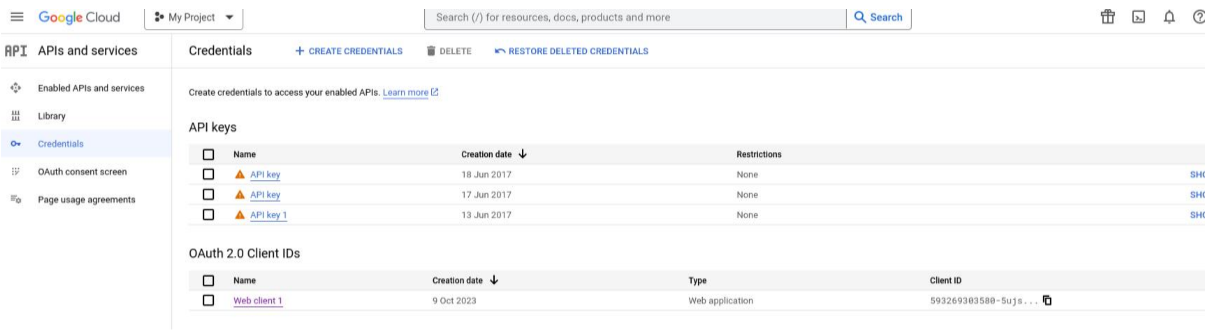
Installation of Django backend:

1) Download SQLite and Anaconda from the respective websites.
2) (Optional) Create a new virtual environment using the command: “conda create –name ENVNAME python=PYTHON-VERSION”, here ENVNAME is your environment name and PYTHON-VERSION is the desired python version (for example: conda create --name myenv python=3.8).
3) (Optional) clone an existing environment, use the command: “conda create –name ENVNAME python=PYTHON-VERSION –clone EXISTING”.
4) Activate the virtual environment as: “conda activate ENVNAME”
5) Install pip if not installed already using command: “conda install pip”
6) In the backend directory, install all the required packages using the command: “pip install -r requirements.txt”
7) Install the spacy language model using the command: “python -m spacy download en_core_web_md”.
8) Run the following commands to do the database migrations:

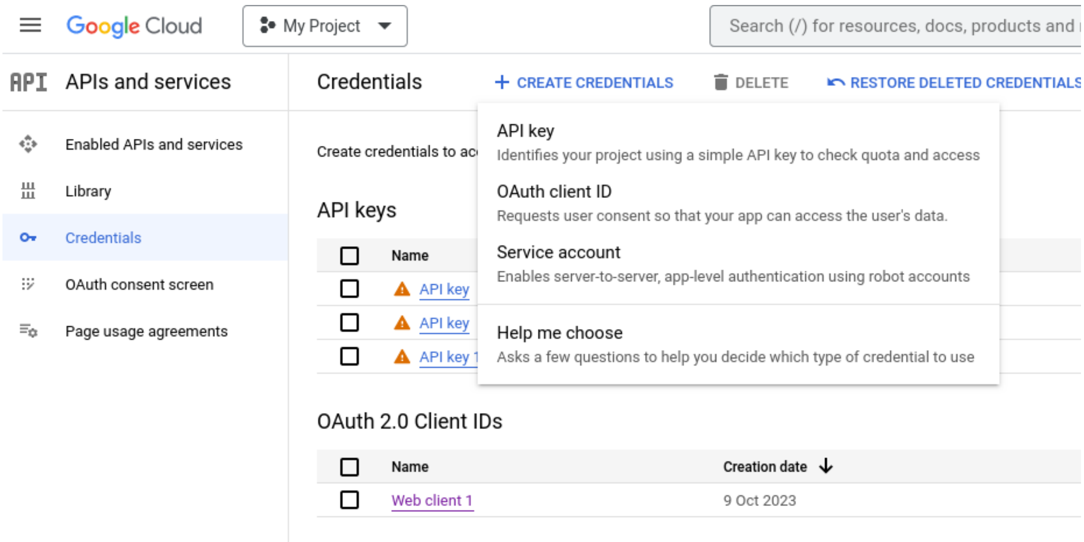
   python manage.py makemigrations

   python manage.py migrate

9) Create a superuser using the command: “python manage.py createsuperuser” and follow the prompts ahead.
10) Setup the Google Oauth locally as follows:
    a. Go to the URL: https://console.cloud.google.com/apis/ and create a new project.
    b. Under the APIs and Services tab click on Credentials:



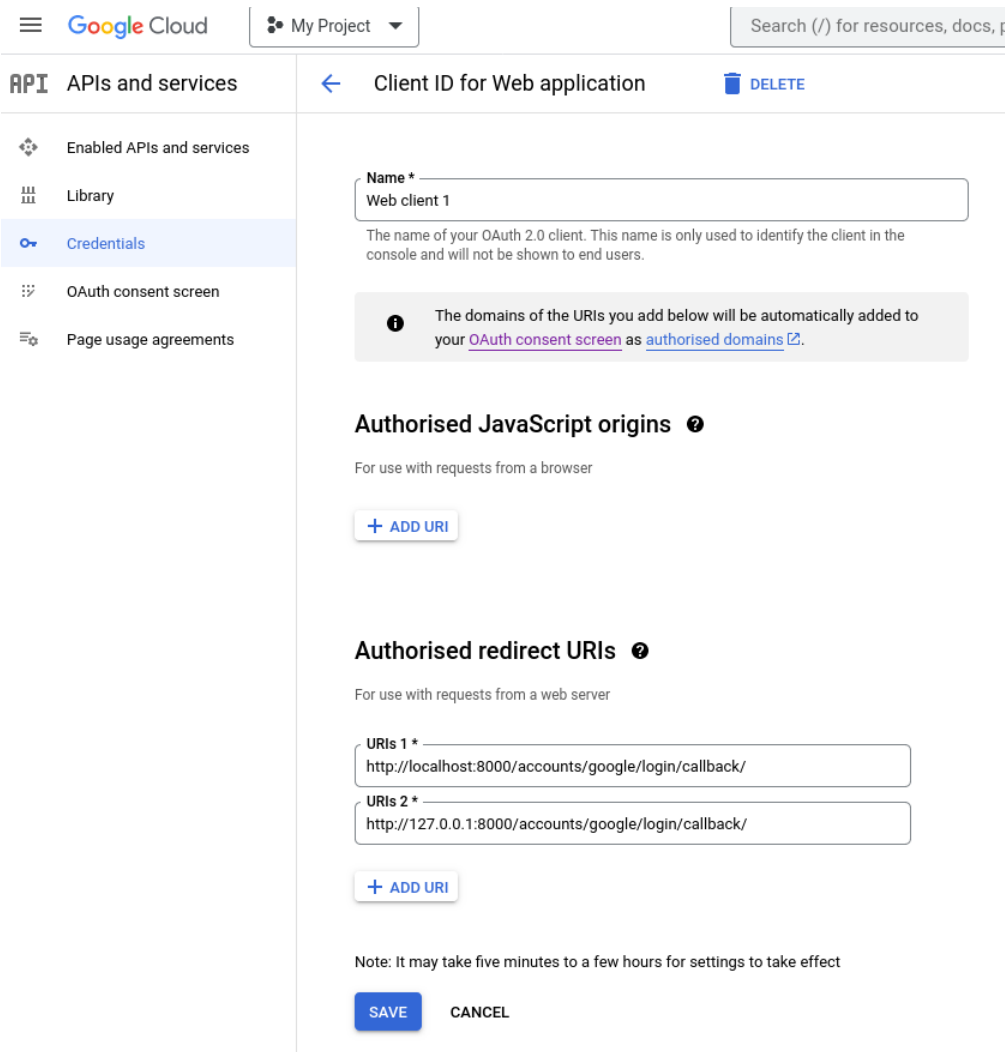
c. Then click the Create Credentials button at the top and select the Oauth Client ID:



d. Select the application type as web application, give a suitable name and in the Authorised redirect URIs, add the following URLs:

http://127.0.0.1:8000/accounts/google/login/callback/

http://localhost:8000/accounts/google/login/callback/



Take a note of the OAuth of the Client ID and Client Secret (would be on the right of the page)

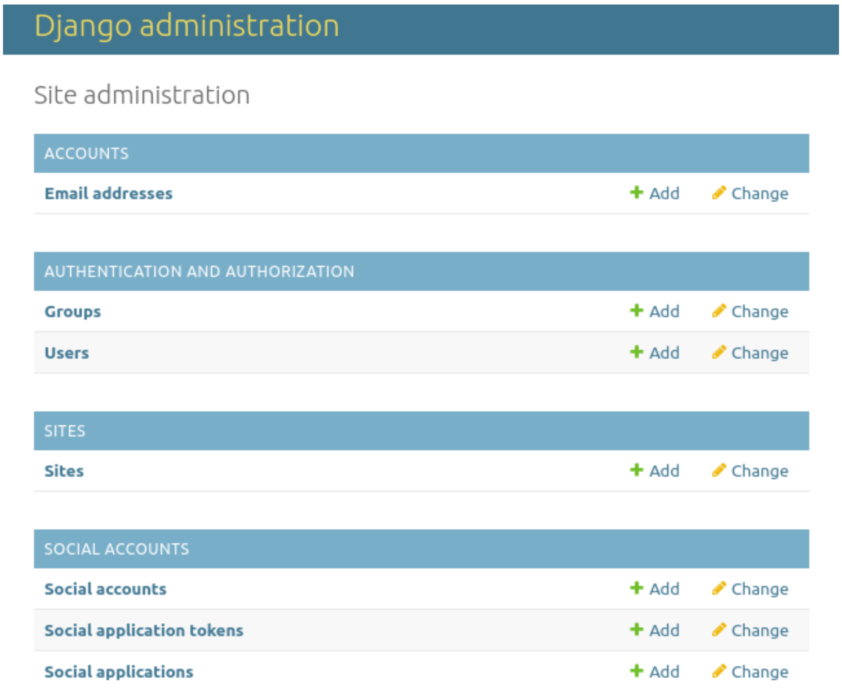
11) Add the client ID and the Client Secret in the settings.py file inside ai_health_monitoring directory as follows:

```
SOCIALACCOUNT_PROVIDERS = {
    'google': {
        'APP': {
            'client_id': '<<YOUR-CLIENT-ID>>',
            'secret': '<<YOUR-SECRET-KEY>>',
        }
    }
}
```

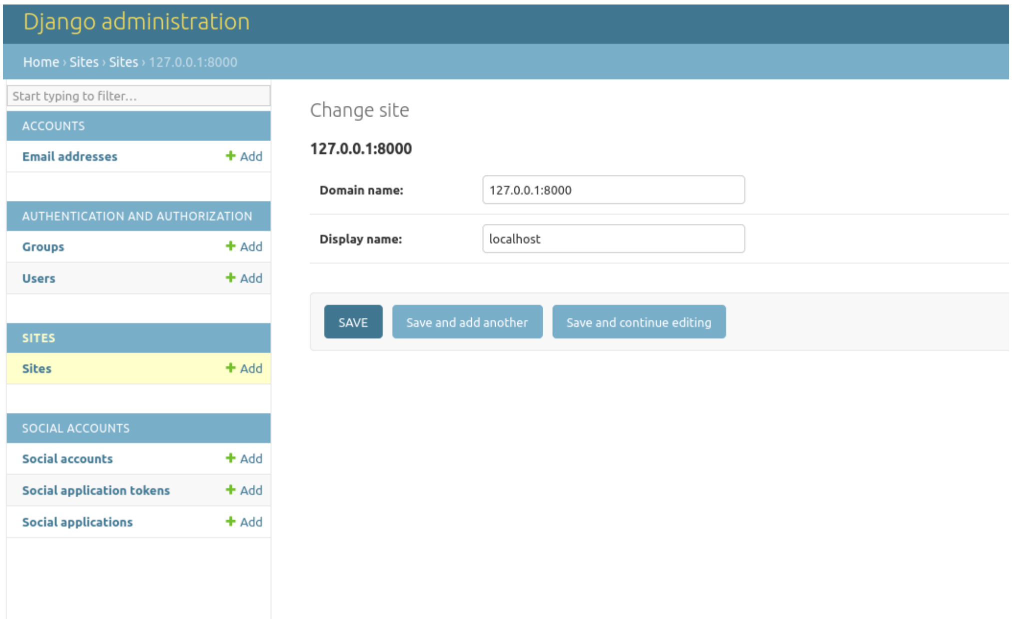
12) Launch the local development server for django using the command: "python manage.py runserver"

13) Navigate to the admin url: localhost:8000/admin OR 127.0.0.1:8000/admin

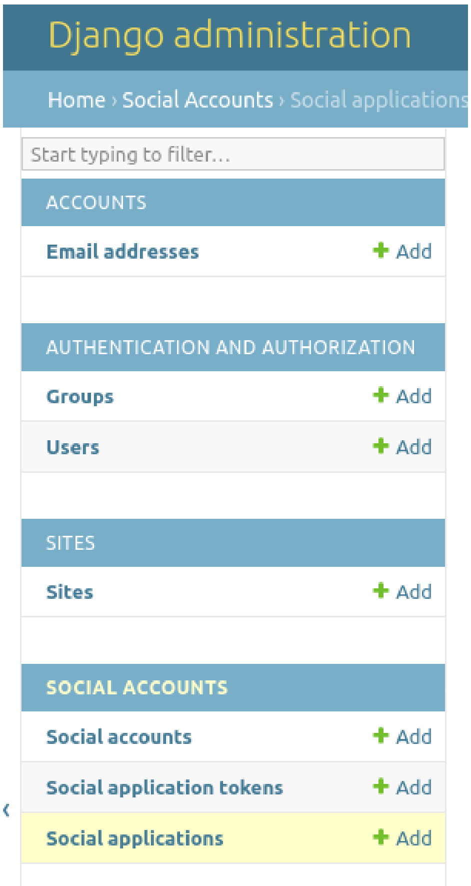
14) Use the credentials created in step 9 above.

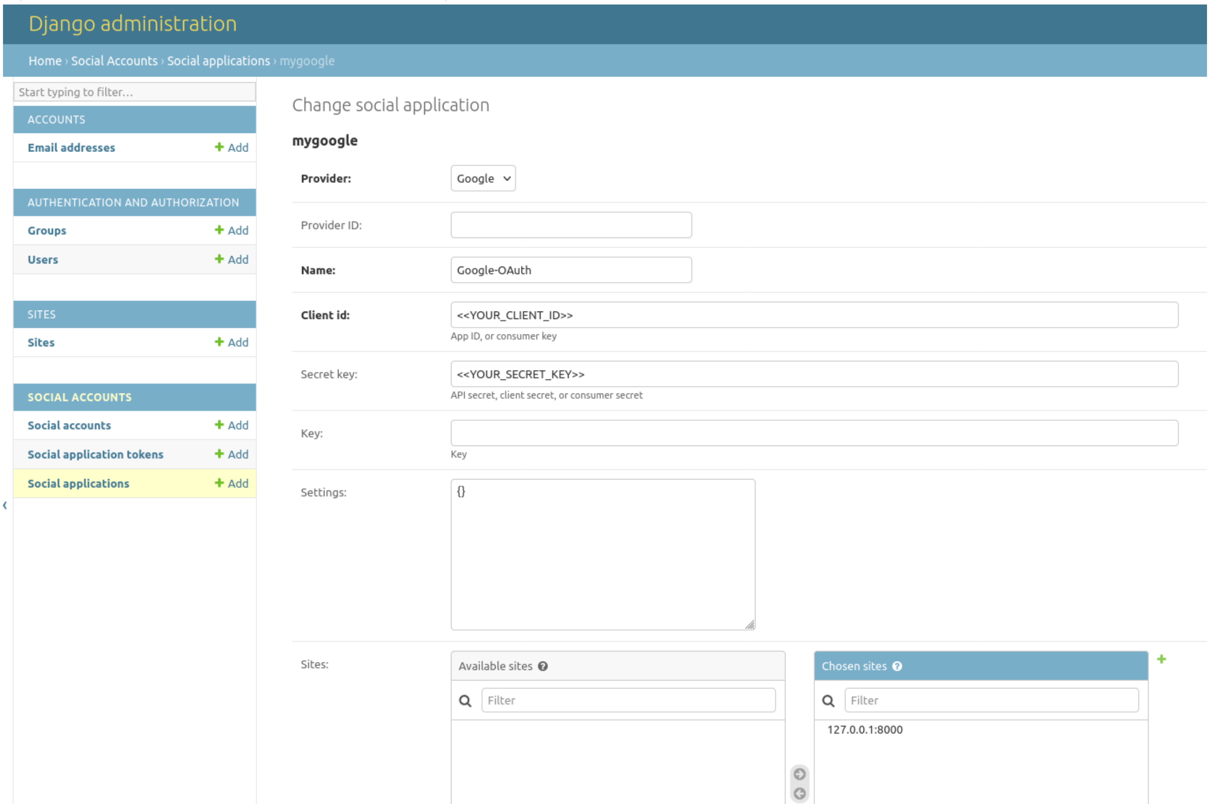


15) Go to sites tab and create a site (display name can be anything here and then click on save):



16) Go to the social applications tab and create a new social application and fill the details (Make sure to use the same client ID and client secret retrieved as part of step 10, choose the created site from list of sites and click on save):

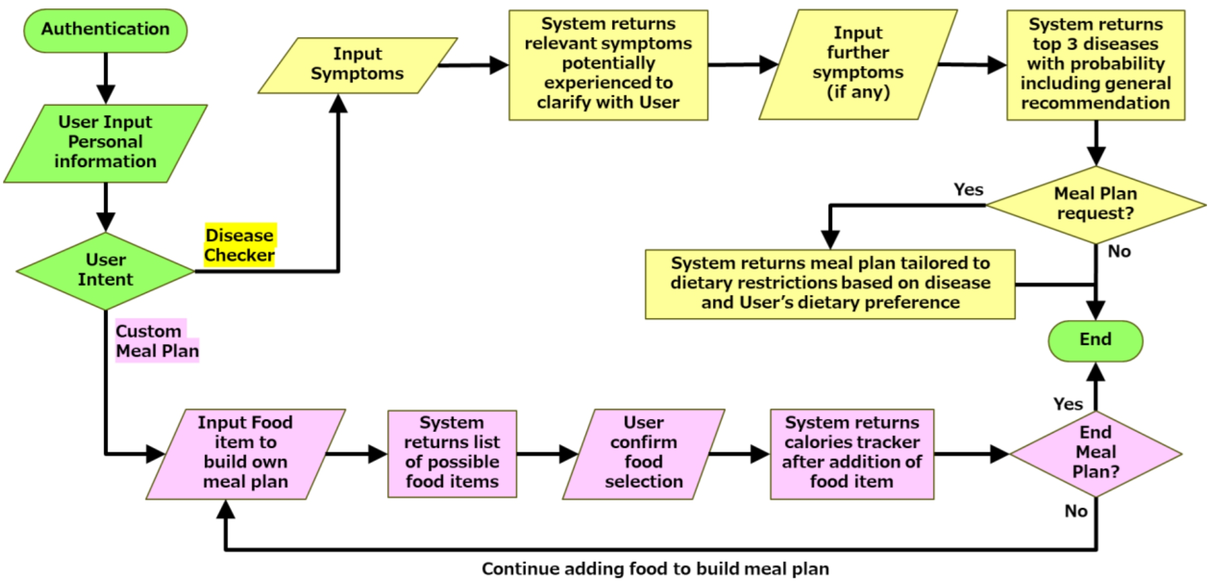




17) Logout from the django admin console, restart the server using command: "python manage.py runserver". The google authentication should work now.

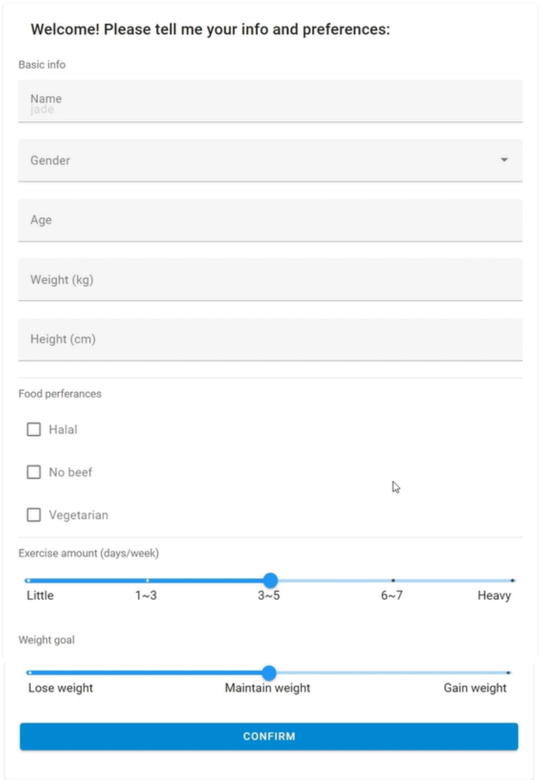
Note: Make sure the django server is currently running on the port 8000, else run it as "python manage.py runserver 8000". This must be the same port number added to redirection URIs in the google cloud API.

User Guide

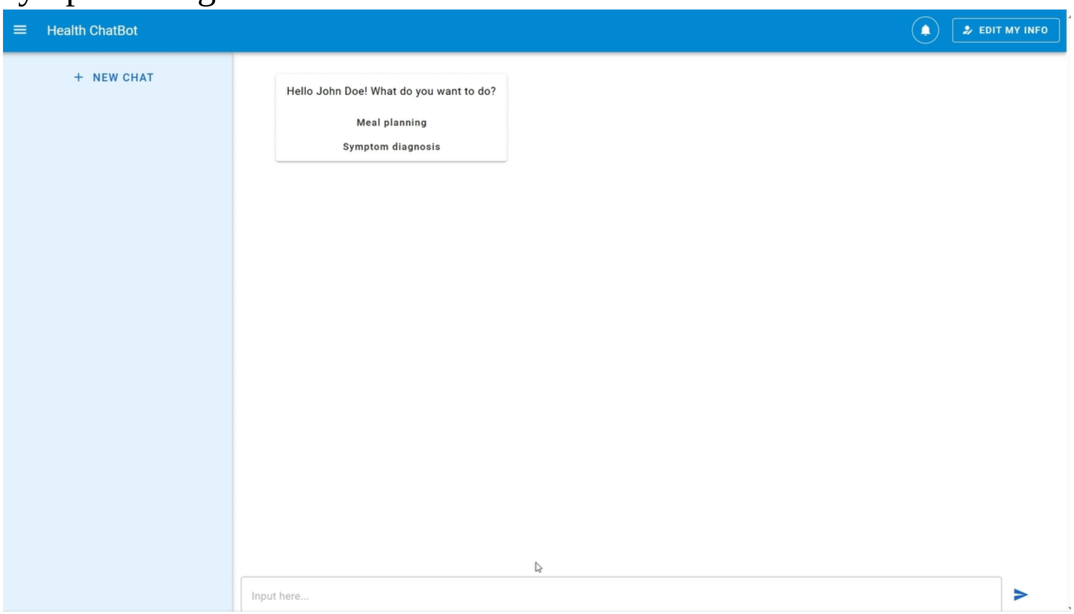


1) Log-in to chatbot using google account.

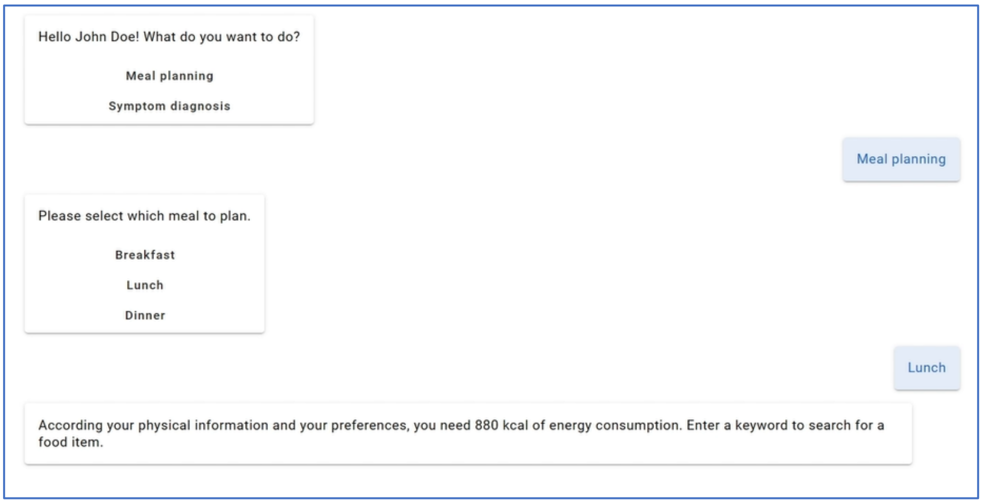
2) On first log-in, user will be directed to complete their personal information and preferences. These information will be used to guide and develop the meal plans. These information can be updated through the main page of the chatbot via the "Edit my Info" button on the top right of the screen.

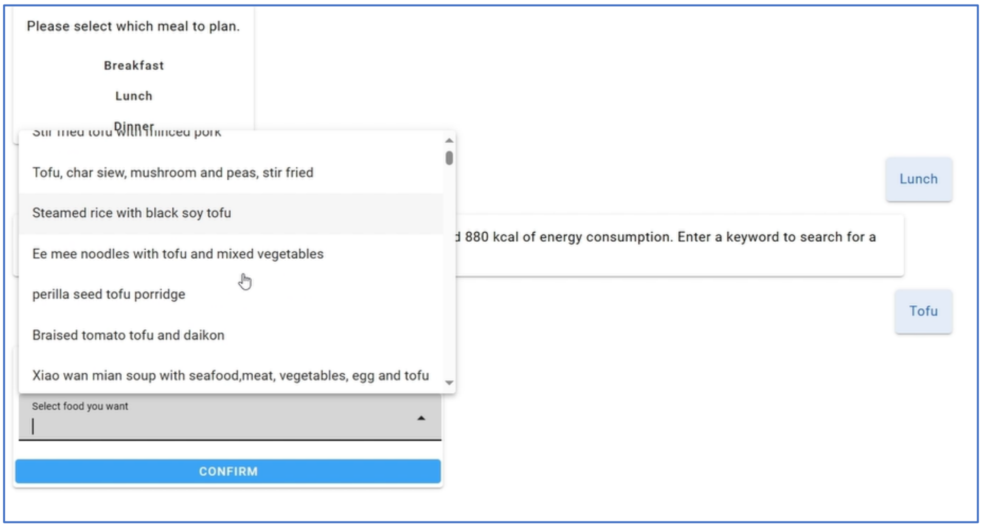


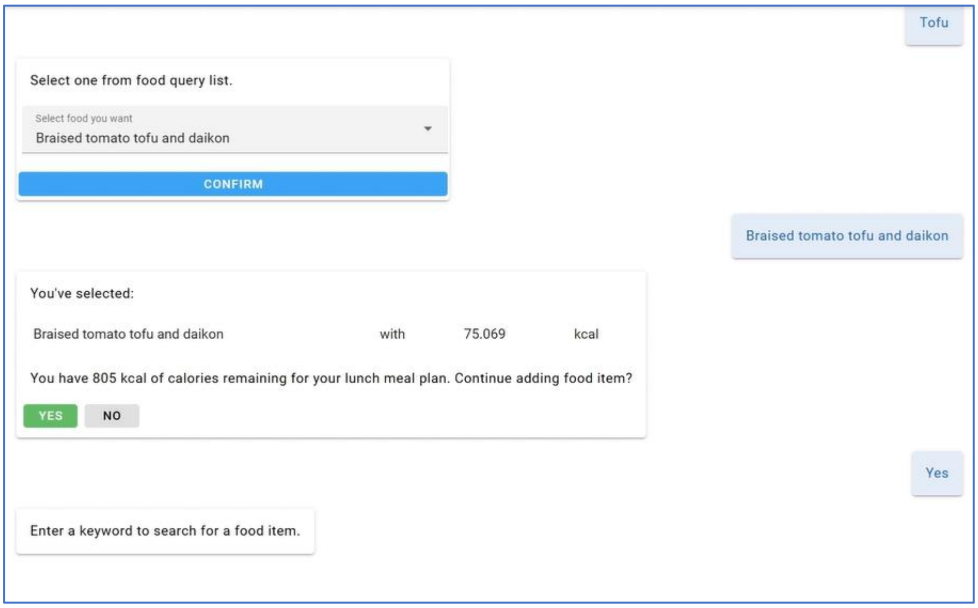
3) After confirming information and preferences, user will be directed to the main page of the chatbot where the 2 options for meal planning and symptom diagnosis will be available for selection.



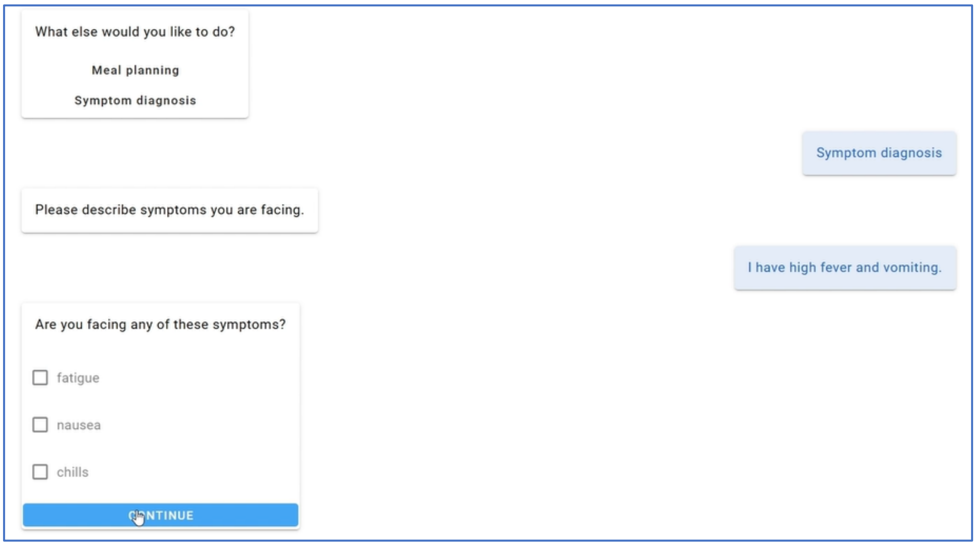
4) Upon selection of meal planning, the single custom meal plan can be generated following the on-screen prompts from the chatbot.

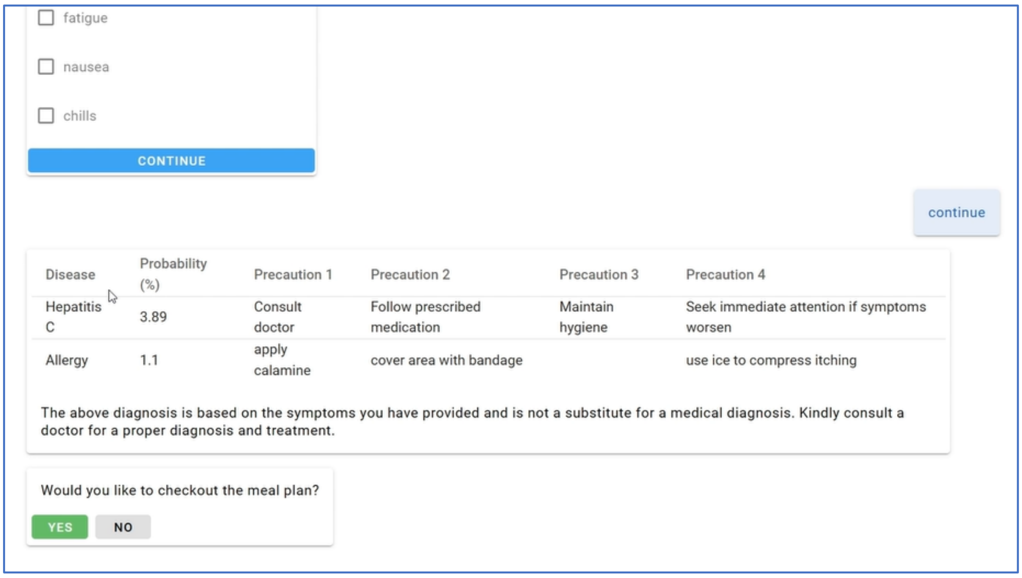

Hello John Doe! What do you want to do?
Meal planning
Symptom diagnosis
Meal planning
Please select which meal to plan.
Breakfast
Lunch
Dinner
Lunch
According your physical information and your preferences, you need 880 kcal of energy consumption. Enter a keyword to search for a food item.

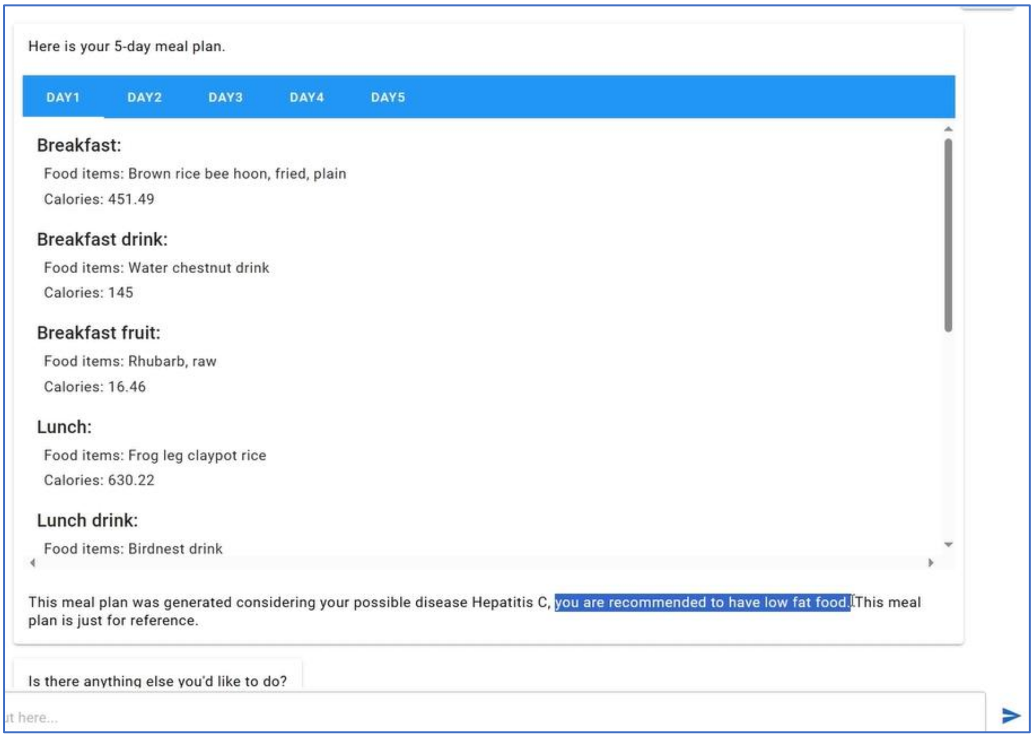

Please select which meal to plan.
Breakfast
Lunch
Tofu, char siew, mushroom and peas, stir fried
Steamed rice with black soy tofu
Ee mee noodles with tofu and mixed vegetables
perilla seed tofu porridge
Braised tomato tofu and daikon
Xiao wan mian soup with seafood,meat, vegetables, egg and tofu
Select food you want
CONFIRM
Lunch
880 kcal of energy consumption. Enter a keyword to search for a
Tofu


Tofu
Select one from food query list.
Select food you want
Braised tomato tofu and daikon
CONFIRM
Braised tomato tofu and daikon
You've selected:
Braised tomato tofu and daikon with 75.069 kcal
You have 805 kcal of calories remaining for your lunch meal plan. Continue adding food item?
YES
NO
Yes
Enter a keyword to search for a food item.

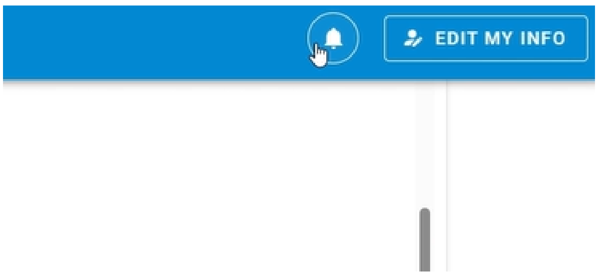
5) Upon selection of symptom diagnosis, on-screen prompts from the chatbot will guide the user accordingly to predict top 3 diseases based on user-input symptoms. Thereafter, user will have the option to request for a suitable meal plan based on personal preference and also dietary requirements based on potential disease contracted.

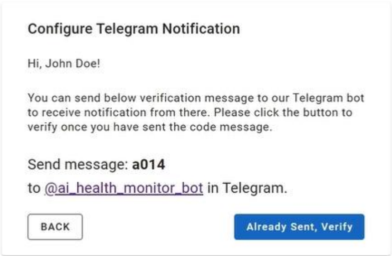


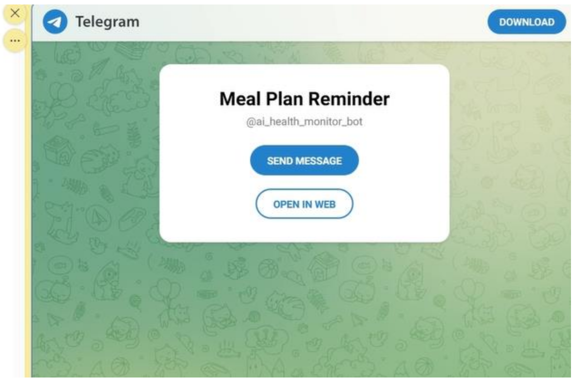




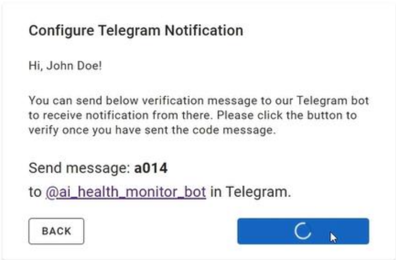
6) By clicking on the notification button (bell icon) on top right of the screen, a reminder on the meal plan will be sent to the user's telegram account.

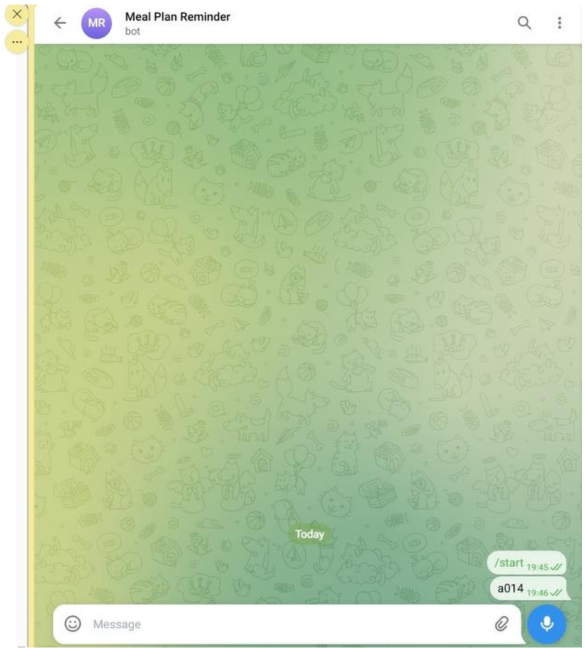




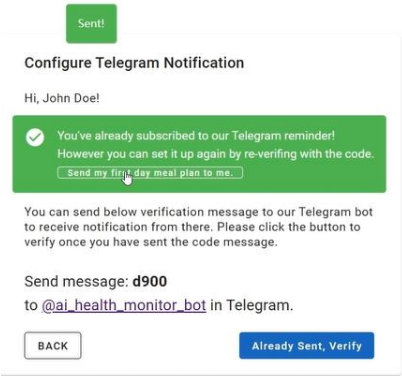


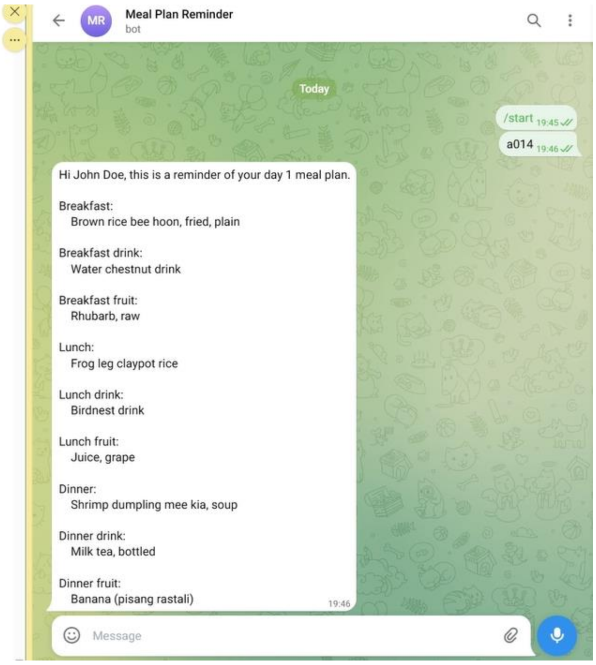
7) Configure the subscription to the meal plan reminder service by verifying with the Telegram bot by inputting the message shown. Click on "Already sent, Verify" thereafter".



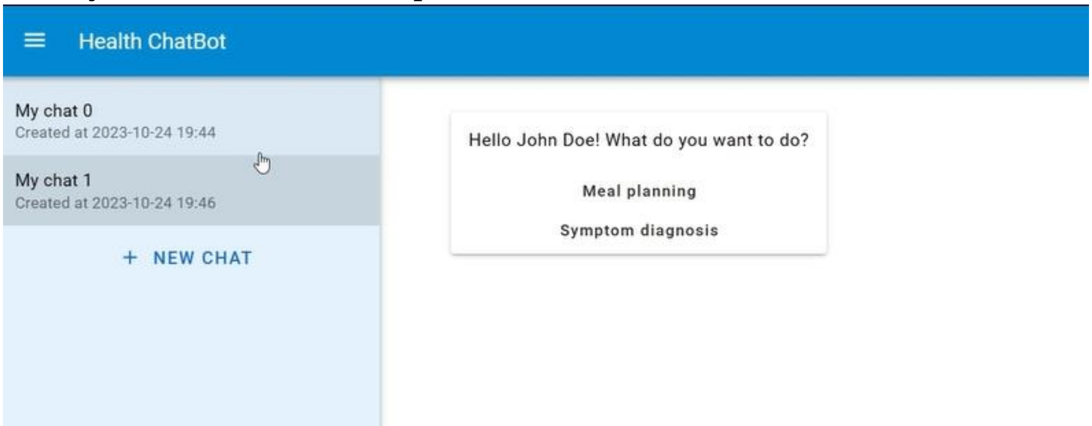


8) Once subscribed, the meal plan information can be sent to the Telegram account. Note that the sending of notification is currently a functional demonstration for the MVP. The system will ideally be sending reminders automatically every day after subscribing to the notification service.





9) For new usage, new chats can be created and past diagnosis or meal plan history can be assessed via panel on the left.



APPENDIX D – INDIVIDUAL PROJECT REPORT
YATHARTH MAHESH SANT (A0286001R)

Personal Contribution

Primarily involved in the development of disease diagnosis part of our project. Developed the multi label classification and tried out different models (namely: Decision Tree, Random Forest, SVM, Logistic Regression, Gaussian Naive Bayes). Tried two main different techniques for multi-label classification: OneVsRest and ClassifierChain Approach.

Also developed the NLP Chatbot using spacy and nltk. Gone through multiple revisions of the same and introduced features like suggesting relevant/likely symptoms to user based on current symptoms, introducing the additional fuzzy string matching (for approximate string matching) and the semantic similarity (cosine similarity).

Developed the backend for the diagnosis part using asynchronous web-socket approach in Django. Implemented a state-based approach for smooth transitions as and when the conversation between the bot and the user proceeds further and also integrated the Google Authentication portion. Developed UI components for the response returned by the bot primarily for the disease diagnosis part.

Learning Journey

Learned a lot about classification in general and got introduced to the new concept of multi label classification. Initially, tried out using a simple multi class approach and soon realized the mistake by having a look at the high accuracy of all models (even on test dataset), but non agreement of metrics like ROC AUC, log loss. Later on I realized that symptoms can be mapped to multiple diseases and hence need a multi label method here. Also learned a lot on how to handle high dimensional data and still try to maintain the interpretability.

Gained a lot of understanding in the cognitive systems part especially when it comes to NLP and chatbot development. Understood that even a simple chatbot implementation needs a lot of input pre-processing to understand the user intents and identify slots. Got to learn about how to handle textual data and how to focus on the named entities we are interested in. Due to some of the aspects involved in this chatbot, it also enhanced the mathematical foundations too, for instance, to suggest relevant symptoms the approach was to make use of conditional probabilities, so overall got a deeper understanding of mathematical concepts applied to real life.

Got a deeper understanding of the web development standards and was able to develop a truly scalable system using asynchronous programming and the web sockets standard. Learnt some design patterns too and was able to incorporate a loose version of the factory design pattern for the state transition process. Also got to explore on how to facilitate good interaction with the web sockets using javascript and client-side interaction.

Application of Knowledge and Skills

An inquisitive mindset to dig deeper into the classification part. Explore all possible models that I could in less time and given the nature of data. Was able to use lots of learnings from the course related to the classification models and added more information to my own knowledge base as well. Further, was able to also demonstrate some of the software engineering skills learned in the past for developing the interactive chatbot platform. Was able to manage well with the NLP part too, given the knowledge learnt from the cognitive systems course.

KRISTOFER ROOS (A0285949A)

<u>Personal Contribution</u>

Throughout the project, I supported a wide variety of efforts, ranging from data sourcing to competitive analyses, to market sizing calculations. Before starting to build the solution, I conducted extensive research and interviews with healthcare executives about the healthcare industry and current medical solutions, and the corresponding pockets of untapped value. This research and insight was critical in defining the solutions' unique selling proposition and value proposition, which personalizes a historically generic healthcare offering. Furthermore, the high-level industry trends I defined provide the context and backdrop for the solution's validity in the healthcare landscape. Once the solution space was identified and the demand was verified via 1 on 1 interviews, I supported in sourcing the data which is used to detect diseases and connect the outcomes to the meal plan generator. In order to connect the user outcome from the disease identification engine with the nutrition planner, there was a significant amount of data transformation, methodology creation, and data integration. Via the creation of a wide range of new variables and additional contextual data, I finally enabled the users' condition to be a driver in the development of a customized and balanced meal plan. Additionally, I performed a holistic risk analysis for the solution, exploring, predicting, and prioritizing risks that could stifle go-to-market efforts.

<u>Learning Journey</u>

During this project, I gained practical skills and knowledge that significantly broadened my understanding of intelligent reasoning systems in the context of digital healthcare. One critical learning area was data preprocessing, where I learned the importance of carefully preparing and cleaning data. This process, although time-consuming, turned out to be crucial for the quality of our final results. I had to think practically about what kind of data we needed, where to get it, and how to make it usable for our purposes. I also got hands-on experience in connecting stand-alone tech solutions. Specifically, I worked on integrating two systems: the meal planner and the disease identification tool. This task required me to understand each system's technical requirements and functionalities and find a practical way to make them work together seamlessly, and provide insightful results to the user.

From a higher level, I learned about the necessary steps involved in developing an AI-enabled minimum viable product, like defining the problem, selecting the right model, training it with data, and then deploying the solution. I also saw the challenges and complexities of bringing an AI product to the healthcare market, which has its own set of strict standards and data accessibility issues. Additionally, I really appreciate the experience of working with such smart and dedicated teammates which gave me insight into how a larger project can be broken down into assignable pieces, and later reintegrated together. This was particularly interesting when it came to connecting back and front-end components.

Furthermore, by seeing the progress and work of others in my team during the machine learning model development, I had exposure to practically learning how these systems are built, trained, and tested. Specifically, it was interesting to see the genetic algorithms in practice, which generated relevant, unique, and high-quality nutritional recommendations.

Overall, this project was a practical, hands-on learning experience that taught me a lot about the intersection of intelligent reasoning systems and healthcare, and the detailed work that goes into creating a successful, user-friendly intelligent reasoning system solution in the medical field.

Application of Knowledge and Skills

The technical skills honed during the project equip me for a broad spectrum of challenges across different industries. My ability to find quality sources and preprocess datasets, ensures the reliability of AI models, a critical factor in their success and applicability. The experience of integrating multiple tech systems not only stands crucial for ensuring seamless operational workflow but is also vital in roles that require the synthesis of multifaceted tech platforms. Furthermore, understanding genetic algorithms opens new horizons for innovative problem-solving, essential in environments where out-of-the-box thinking is key to progression.

The practical knowledge gained in AI product development is invaluable and widely applicable. Having navigated through all stages of AI product creation, I possess a well-rounded understanding that's crucial whether I'm contributing to a tech startup or driving innovation in established sectors. The specific market knowledge acquired, especially in a complex field like healthcare, prepares me for navigating other industries with their unique challenges and regulations. Also, mastering the intricacies of connecting sophisticated back-end processes with user-friendly front-end applications is a universal skill, critical for any role that aims to bridge the gap between complex technologies and end-user satisfaction.

My experience with team dynamics and planning is directly transferable to various workplace scenarios. Conducting a comprehensive risk analysis has instilled in me a strategic foresight that is critical for any project's success, regardless of the field. The skill of deconstructing large projects into manageable segments ensures efficiency and is adaptable to multiple professional settings, ensuring projects remain on schedule and within scope. Working with a diverse team has also refined my interpersonal skills, making me an effective collaborator in any team setting.

ZHANG YUSEN (A0285839H)

Personal Contribution

My primary contributions to the project includes developing the frontend, integrating the meal planner with backend and completing the front-back connection, together with teammates.

Front-end development mainly consists of the UI designing and program logic handling.

- For the designing part, the frameworks helped a lot. Most of the efforts were put on the chat message presentation. User experience was also in my consideration, according to which necessary feedback on interfaces were added.
- For the logic part, basic frontend functions are implemented such as the receiving, sending, rendering and save-and-loading of the chat messages, necessary redirections, web forms, etc.

The integration of meal planner was largely based on Yatharth's work on the chatbot backend. This involved adding additional states to handle more types of user input, according to the factory design pattern; and adding corresponding parts to the backend API and frontend interface.

Learning Journey

Through completing this project, I acquired useful knowledge mainly about web application and system designing and implementing.

- From the technology aspect, I gained experience on building web pages using a popular framework, and became more familiar with JavaScript programming through the process of solving a series of problems when coding. Gained practical knowledge about user interface and user experience designing, and developing a front-end separated web application. Learned useful techniques such as async programming and WebSocket.
- From the methodology aspect, I am now more aware that there is more to programming than simply coding, the importance of designing and algorithms cannot be overlooked.

Additionally, from working with team members, I gained a better understanding about machine reasoning and techniques by learning from their works, in particular the multi-label classification and genetic algorithm. Although not involved in data processing and model training tasks in detail, I went through their progressions, understood the ideas and did my own studies on relevant knowledge.

Application of Knowledge and Skills

From the exploration of knowledge and practical skills on web development and UI designing, I could delve deeper into UX, namely the user experience designing in relevant future works.

Further understanding acquired of software engineering and system designing would prompt me to think methodically and be organized when programming.

Would be able to work efficiently with people based on the realization of the importance of thorough communication with team members, the common goal and progress tracking.

HAO ZHENMAO (A0285960R)

Personal Contribution

In our project, my main areas of focus were as follows:

I actively collaborated with my teammate, Yusen, to design the front-end interface and establish the framework for program logic. This partnership was instrumental in creating a user-friendly and responsive interface for our system.

Additionally, I played a role in the development of the Telegram notification feature, considering both the Python backend and web frontend, aimed to enhance user engagement and real-time updates. My work in this aspect added a valuable component to our system.

Moreover, I also took part in structurally designing and thoroughly testing the system code. This phase was crucial to ensure the overall efficiency, organization, and reliability of the system.

Learning Journey

Throughout this project, I embarked on a journey of learning and skill acquisition, delving into several key areas:

- User-Centric Design and User Experience (UX): My collaboration with Yusen on the front-end interface deepened my understanding of user-centric design and UX principles. I grasped the importance of prioritizing user needs and crafting intuitive and visually appealing interfaces, knowledge that will guide my future projects in delivering superior user experiences.
- Real-Time Communication and Engagement: Developing the Telegram notification feature provided insights into real-time communication and user engagement strategies. This experience enhanced my ability to build interactive applications and foster user engagement, which will be invaluable for future projects.
- Structuring Code for Performance and Reliability: Working on the system code design and testing improved my proficiency in structuring code for optimal performance and reliability. I learned how to maintain a robust codebase, ensuring that our system operates seamlessly and efficiently.

These valuable skills and insights will undoubtedly benefit my future endeavours in the fields of technology and healthcare innovation, as I continue to explore intelligent reasoning systems and digital healthcare solutions.

Application of Knowledge and Skills

The knowledge and skills I acquired during this project have wide-ranging applications:

- My understanding of user-centric design will be applied to ensure that future projects prioritize user needs and deliver a satisfying user experience.
- Proficiency in front-end development and UX design will allow me to create visually appealing and intuitive interfaces in future projects.
- The experience in real-time communication will be valuable for developing engaging and interactive applications.
- My insights into machine learning, NLP, and advanced techniques like genetic algorithms have broadened my capabilities in tackling complex problems and finding innovative solutions, especially within the realm of healthcare innovation.

CHUA KIAN YONG KENNY (A0056377W)

Personal Contribution

In the development of this project, my primary contributions spans across data acquisition, research into relevant equations for deriving suitable measurements of meal plans, and algorithmic model development for the meal planner.

The initial phase involved meticulous curation and review of the dataset to categorize and include only sensible food items to be recommended.

The development of the meal planner model included the establishment of food choices filters to allow customizability in accordance with dietary preferences and requirements. Additionally, the formulation of fitness function was crucial for evaluating and optimizing the meal plans.

Learning Journey

The learning journey throughout this project was enriching. One key takeaway was the understanding of selecting appropriate resource optimization techniques based on the specific problem. Understanding the strengths and limitations of each algorithm played a pivotal role in crafting an efficient and effective meal planner.

Furthermore, the significance of data pre-processing is evident in influencing the success of the meal planner as could be observed from initial runs of the application where impractical food items were recommended. This realization emphasized the need for a meticulous pre-processing phase to ensure the dataset's integrity and, consequently, the practicality of the meal plans generated.

Another important lesson learned was that an envisaged idea might not be inherently user-centric. This recognition prompted a continuous loop of development to enhance the system. Specifically, the transition from a rigid meal planner to developing a more customizable system emerged as a key improvement. Acknowledging the practical challenges users face in strictly adhering to recommended meal plans led to the incorporation of this customizability. This shift aligns more closely with the realities of available meal choices to the user.

Application of Knowledge and Skills

An adaptive mindset to improve the system continuously and iteratively is important and could be applied to future projects. This would allow us to adopt a practical approach where a user-centric design could be achieved.

Additionally, the emphasis on meticulous data preparation underscores the importance of ensuring data quality in any data-driven project. A good understanding of the data is critical and thereby for future projects, the involvement of domain-experts to provide the necessary guidance and clarifications is of utmost importance in ensuring a successful project.

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