



NutriLens: An Intelligent Information Technology and Management Framework for Personalized Nutrition Decision Support Using Natural Language Food Logging

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Abstract

In this paper, we present NutriLens, an information technology and management framework that is an AI-based diet planner that generates personalized meal plans for users based on their inputs, such as age, weight, gender, goals, height, and other variables. This information technology-based management system combines various AI techniques into a unified and easy-to-use platform. This system uses the Mifflin–St Jeor equation and combines it with the user's activity level and goals to calculate the required daily calorie intake for users. It then uses these target calories and the user's constraints to calculate balanced meal plans using heuristic optimization algorithms. In case the user does not like a meal recommendation, it also uses the k-NN algorithm to provide similar meal replacements. Users can also log their meals using NLP in free-flowing text form. It also has a reinforcement-type personalization component that regularly updates users' likes and dislikes based on their acceptance of and

replacements for meals. NutriLens is developed as a mobile app, which makes it more accessible to a wider audience. Compared with similar applications, this app increases user engagement and personalization, making it a more practical tool for nutritional management.

Keywords: Personalized meal plan, Diet recommendation system, Natural Language Processing, Hybrid AI, k-Nearest Neighbors, Heuristic Optimization

Introduction

Over the past few years, there has been an increase in health issues because of unhealthy eating habits. Despite being aware of the significance of maintaining a well-balanced diet to ensure good health, people fail to maintain healthy eating habits. The main cause of this is the lack of knowledge about their caloric and macronutrient requirements and how they can develop a meal plan accordingly. Early diet planning systems were developed based on rule-based and ontology-based techniques. Those systems used predefined nutritional rules to make meal plans. Systems like ontology-based recommenders and user-profile-driven frameworks provide easy-to-understand and structured recommendations, but they lacked flexibility and could not adapt to user behavior. They also ignored cultural food habits and changing lifestyles (Mckensy-Sambola et al., 2022).

Thus, these approaches could not prove effective in real-world scenarios. With the advancements in AI/ML techniques, simple and traditional rule-based diet recommendation systems have been transformed into AI/ML-based systems. Collaborative filtering and content-based recommenders have been employed to improve personalized diets (Yang et al., 2017; Yera Toledo et al., 2019). Hybrid model designs have also been suggested for achieving better results through multiple techniques. In spite of improvements in accuracy and effectiveness, these techniques were associated with cold-start problems and poor contextual awareness (Chavan et al., 2021). Recent research has mainly focused on the use of ML and DL algorithms for enhancing the recommendation process in diet systems. Golagana et al. (2023) demonstrated the implementation of ML for generating diet recommendations, whereas Iwendi et al. (2020) utilized an Internet of Medical Things (IoMT)-based framework for assisting ML-based diet recommendations. In another study, Ooka et al. (2021) highlighted the significance of the Random Forest model for predicting potential risks related to users' dietary intake. However, the prediction accuracy achieved by these methods remained confined to their isolated domains without providing a holistic solution for dietary planning.

Few attempts have been made to combine various AI technologies to enhance the performance of the entire system. Sarani Rad et al. (2024) developed an optimization technique based on Particle Swarm Optimization–Simulated Annealing (PSO-SA)-enhanced Analytical Hierarchy Process (AHP). This design yielded remarkable consistency in decisions regarding nutritional planning. Aydin et al. (2025) devised an integrated AI technique that

combines the capabilities of ML and NLP technologies, which provides improved precision in processing dietary inputs. Advanced systems like Market2Dish also employ user profiling and hierarchical recommendation approaches for offering health-conscious food items (Jiang et al., 2019). Using NLP in diet recommendations helps simplify food logging. With this, users can enter food in text form. The food entity recognition system helps make logging easier for users by extracting structured food data from unstructured inputs. Still, most systems have not integrated NLP capabilities with recommendation systems and personalization features, holding back their real-world impact (Popovski et al., 2019).

Recent surveys have highlighted several problems in current systems. Studies by Abhari et al. (2019), Wang et al. (2025), Agrawal et al. (2025), and Theodore Armand et al. (2024) emphasize issues such as a lack of real-time adaptability, poor personalization, lack of explainability, and weak hybrid integration. These limitations have restricted the use of these systems in real-world environments. In order to address these problems, NutriLens has been proposed in this research paper. NutriLens is an AI-based personalized diet recommendation system with NLP logging and smart meal replacement. It uses a combination of a rule-based nutrition calculator, heuristic optimization, machine learning models, and an NLP-based food logging system integrated into one mobile app. The goal of this paper is to design a solution that could be adaptable according to users' behavior and provide customized meal recommendations and meal replacements.

Literature Review

AI/ML technology has made a significant impact on modern diet recommendations. Previously, diet recommendations were mostly based on rules or knowledge-based systems. Such solutions provided systematic guidance in terms of meal plans; however, they failed to adapt to user behavior. According to the literature review conducted by Abhari et al. (2019), traditional solutions have many disadvantages. First, they are not scalable, and second, the recommendations are not updated based on new user data. Most recent solutions utilize different AI/ML techniques to improve recommendations. In their study, Wang et al. (2025) highlighted the importance of considering context, lifestyle factors, and behavioral patterns to create effective recommendations. Similarly, Agarwal et al. (2025) identified the challenges that AI-based nutrition recommendation systems face in terms of scalability and practical applicability. Advanced techniques such as DL and Generative AI are being used to improve meal recommendations. For example, Papastratis et al. (2024) proposed a deep generative model along with ChatGPT for creating nutrition recommendations. This approach showed very good results in terms of caloric estimation and nutrient prediction. However, it depends completely on a pre-trained model, and there is no learning from users' interactions with the system to adapt meal recommendations accordingly. Another study by Iwendi et al. (2020) introduced an IoMT-assisted diet recommendation system utilizing ML techniques. Although this system improved prediction accuracy and system efficiency, it could not learn users'

behavior and customize meals based on their food logging habits. Some survey studies, such as Theodore Armand et al. (2024) and Yera et al. (2023), demonstrated that while ML and DL have improved accuracy, existing systems lack explainability and have little to no personalization. Existing systems mainly depend on static datasets, making continuous adaptation impossible. These previous works have resulted in various significant advancements within the AI diet planner area. Still, some crucial issues remain unaddressed. The lack of dynamic adjustment, improper use of user inputs, and the absence of one integrated system make these solutions practically unworkable. Therefore, our solution, NutriLens, includes several aspects, such as rule-based computation, heuristics, machine learning models, and natural language processing-based logging (Kumar Jangir et al., 2025; Gupta et al., 2022; Khan et al., 2022; Ali et al., 2022; Verma et al., 2025). Salient findings of various papers are shown in Table 1.

Table 1. Salient Findings

S. No	Authors	Year	Title	Methodology	Parameters	Results	Research Gap
1	Sarani Rad et al.	2024	Optimizing Nutritional Decisions: A PSO-SA Enhanced AHP Approach for Personalized Meal Planning	Particle Swarm Optimization (PSO) + Simulated Annealing (SA) + Analytic Hierarchy Process (AHP)	Nutritional criteria, pairwise comparison matrix, consistency ratio	~98% consistency accuracy	Lack of real-time personalization
2	Yuan & Luo	2019	Personalized Diet Recommendation Based on K-means and Collaborative Filtering algorithm	K-Means Clustering + User-Based Collaborative Filtering	User dietary history, food clusters, similarity scores	~77% average accuracy	Cold-start problem for new users
3	Chavan et al.	2021	A Recommender System for Healthy Food Choices: Hybrid Model Using Big Data	Hybrid Recommender System using Big Data Analytics and Collaborative Filtering	User preferences, item features, user interaction data	Improved recommendation accuracy	Limited depth of personalization
4	Rehman et al.	2017	Diet-Right: A Smart Food Recommendation System	Ant Colony Optimization (ACO)	Pathological test data, nutrient target vectors, RMSE evaluation	~97% accuracy	Lack of adaptive learning capability
5	Yera Toledo et al.	2019	A Food Recommender System Considering Nutritional	Content-Based Filtering + multi-criteria Recommendation	Nutritional values, user preferences, similarity metrics	Improved recommendation performance	Scalability issues with large datasets

			Information and User Preferences				
6	Dayang et al.	2021	Combining Fuzzy Logic and k-Nearest Neighbor Algorithm for Recommendation Systems	Fuzzy Logic + k-Nearest Neighbor (k-NN)	Fuzzy rules, similarity distance measures, training dataset	Improved recommendation accuracy	High computational complexity
7	Aydin et al.	2025	An Integrated AI Framework for Personalized Nutrition Using Machine Learning and Natural Language Processing	Machine Learning + Natural Language Processing (NLP)	User inputs, textual features, structured nutrition data	High prediction accuracy in dietary processing 0.102 R ² value	Limited real-time adaptability

A number of frameworks have been developed within this sphere. Among them, some were dedicated to developing intelligent dietary planning systems using particular technologies. Thus, Yuan and Luo (2019) offered an intelligent system based on clustering and collaborative filtering; however, their work was unable to solve the issue of the cold-start problem. At the same time, Rehman et al. (2017) came up with another optimization algorithm using Ant Colony Optimization; however, their system did not account for user interaction. Furthermore, Dayang et al. (2021) introduced fuzzy logic in addition to k-NN, improving recommendations while adding complexity to the process. Similarly, Aydin et al. (2025) provided a hybrid method combining machine learning and NLP. A comparison of recent AI-based personalized nutrition systems with the proposed system is shown in Table 2.

Table 2. Comparison with Recent AI-Based Personalized Nutrition Systems

Study	Year	AI Technique	NLP Food Logging	Meal Replacement	Explainability	Personalization
Sarani Rad et al.	2024	PSO-SA + AHP	No	No	Moderate	Yes
Abhari et al.	2019	Review	Limited	No	No	Moderate
Recent LLM Nutrition System	2025	LLM	Yes	No	Limited	High
Vision-based Nutrition System	2025	CNN + Mobile	Partial	No	Low	Moderate
NutriLens (Proposed)	2026	Hybrid AI + NLP	Yes	Yes	Yes	Very High

Methodology

System Overview

NutriLens is an AI diet planner that uses multiple techniques, such as rule-based logic, machine learning, NLP, and optimization methods. It works by taking input from the user, calculating the user's nutritional needs, creating meal plans, and suggesting them to the user. It uses multiple techniques together to create the user's required meal plan; these techniques are: rule-based reasoning, TF-IDF for text, k-NN, and Random Forest. Figure 1 represents the hybrid AI model architecture of NutriLens.

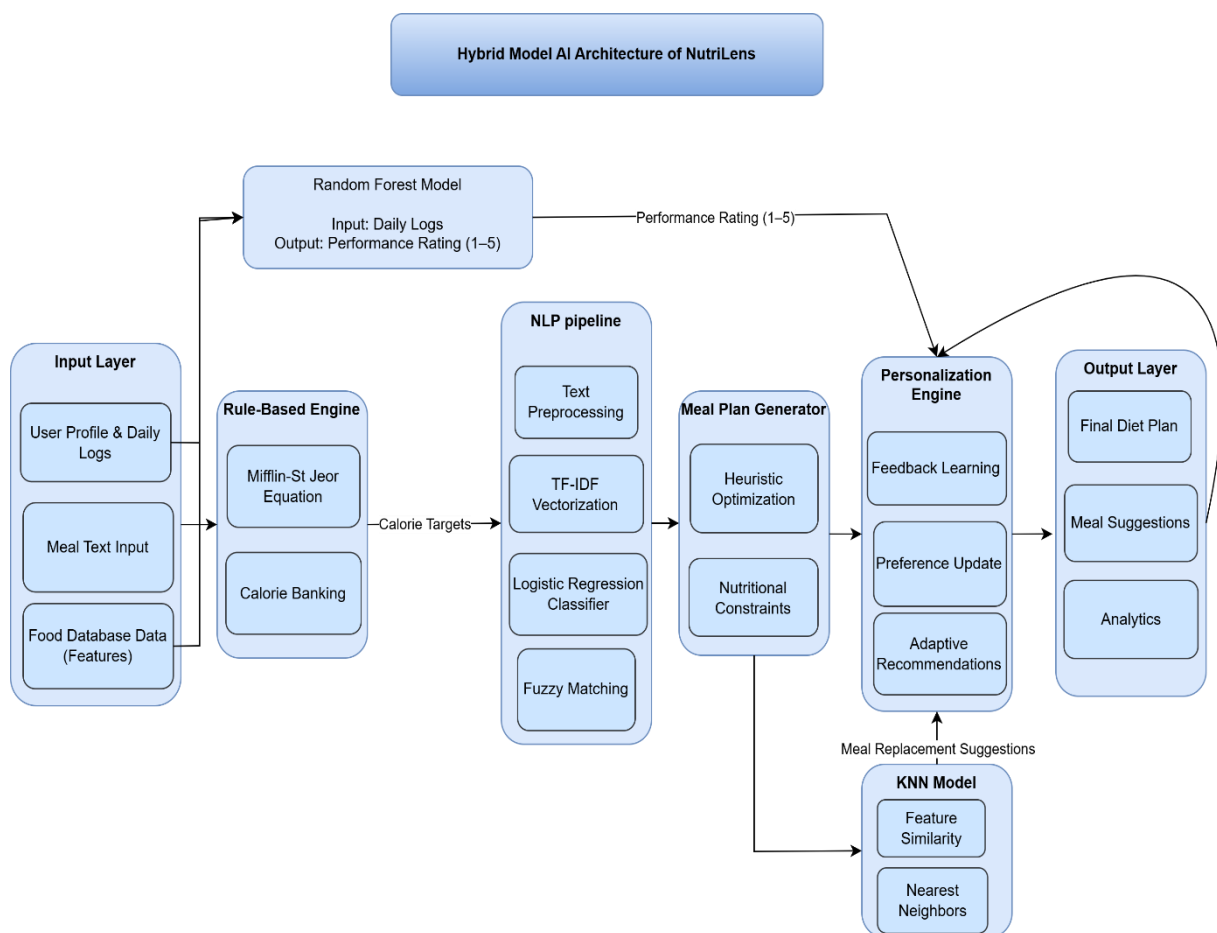


Figure 1. Hybrid AI Model Architecture of NutriLens

A) User Input and Data Acquisition

It collects user details at the login or signup page and takes user information such as age, gender, height, weight, Active status, Preferences, Health conditions, and goals that the user wants to achieve. This information is used to create meal plans; also, the user can enter their

own meal. This information given by the user is used to create a diet plan. The user can also enter their own meal in simple text; NLP converts this text into structured data.

B) Data Collection and Preprocessing

The system uses a dataset of 1500 Indian food items, and for each food item, nutritional values like calories, macronutrients, and dietary tags. The data supports meal planning, recommendations, and evaluation. When the user enters input, the text is cleaned through normalization, broken words are removed through tokenization, and unnecessary words are removed. Then this information is converted into a structured format using TF-IDF and fuzzy matching; this helps store user input in the database.

C) Nutritional Requirement Calculation

The system calculates the user's daily nutritional requirement and then uses formulas for calculating it. It uses the Mifflin-St Jeor equation for BMR. It gets adjusted based on Activity level, User goal, weight loss, gain, or maintenance. It gives output like daily calorie requirements and Macronutrient distribution.

D) Meal Plan Generation Using Heuristic Optimization

The meal plan is generated using the heuristic optimization algorithm. It selects food from the database that includes goals, preferences, and restrictions. It makes sure that there is variety in meals and the nutrition is balanced, and it prevents repetition. After that, it removes meals based on allergies, medical restrictions, and diet types.

E) Replacement System Using k-Nearest Neighbors (k-NN)

It uses the k-Nearest Neighbors (k-NN) algorithm to give food suggestions. Whenever the user rejects any meal, the k-NN model gives another meal suggestion with the same nutritional value. It finds similar food based on calories, macronutrients, and meal type. With the help of this, the nutrition remains balanced.

F) Diet Evaluation Using Random Forest Classifier

In order to evaluate the performance of the user, there is a use of Random Forest Classifier that will determine whether the user is following his or her diet plan. The classifier will compare the actual intake of the user with the target intake and will rate the performance of the user on a scale of 1 to 5. It will look at the number of calories consumed by the user, whether nutrients were consumed in the right proportions, and whether the user is consistent.

G) Natural Language Processing for Food Logging

The use of Natural Language Processing will help to convert the written text into structured form. It will extract food items, their quantity, and type of meal from the text provided.

H) Adaptive Personalization Mechanism

The system is made in such a way that it becomes better over time and continuously learns from user behavior. It tracks actions like the user accepting the meal and rejecting the meal, and then it updates its preference score. This helps the system improve recommendations and give better and more better recommendations.

System Integration and Workflow

All the modules and parts of the system are connected, such that they work together as an integrated system. This includes the processing of user input, nutrition calculation, meal generation, suggestions, and performance analysis. Everything is interconnected and works together. NLP helps with interaction and personalization, which improves the system over time. Figure 2(a) shows the overall system workflow of NutriLens, while Figure 2(b) shows the workflow from algorithm development to Android/Web application deployment.

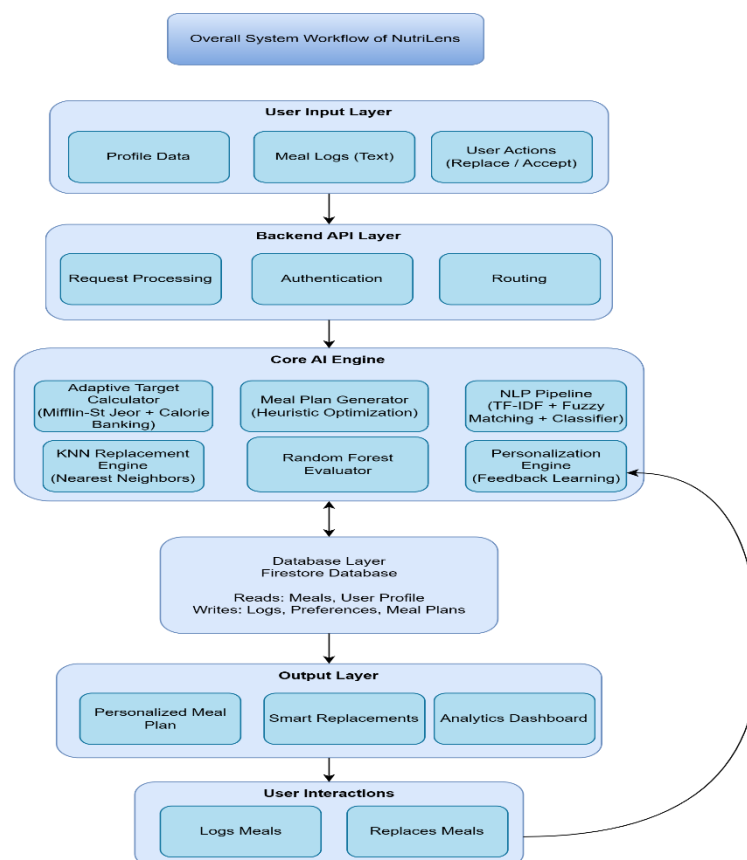


Figure 2(a). Overall System Workflow of NutriLens

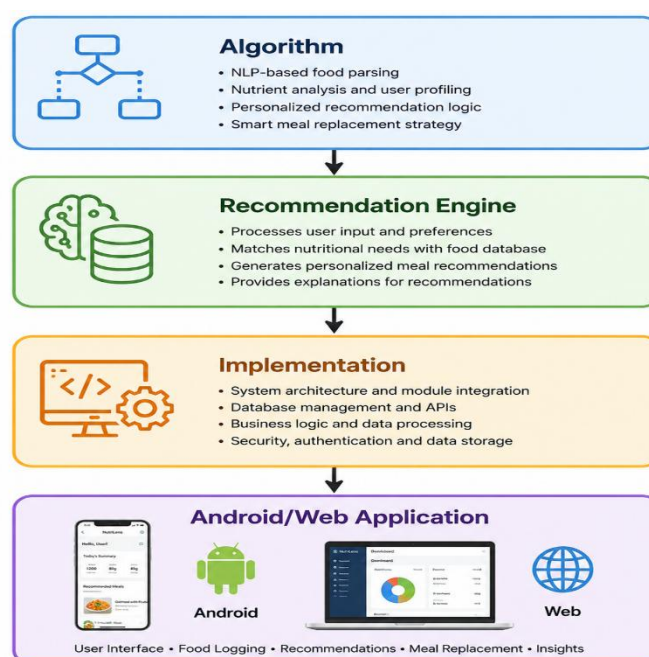


Figure 2(b). Algorithmic and Software Components of the Proposed NutriLens System

Results

Experimental Setup

We tested the functionality of the system within an artificial setting using a pre-prepared dataset containing food information and several fabricated user accounts. The pre-made dataset was used to train the models, and the experiments were conducted using Python-based cloud services. Figures 3 and 4 show the Firestore user and meal plan collections, respectively.

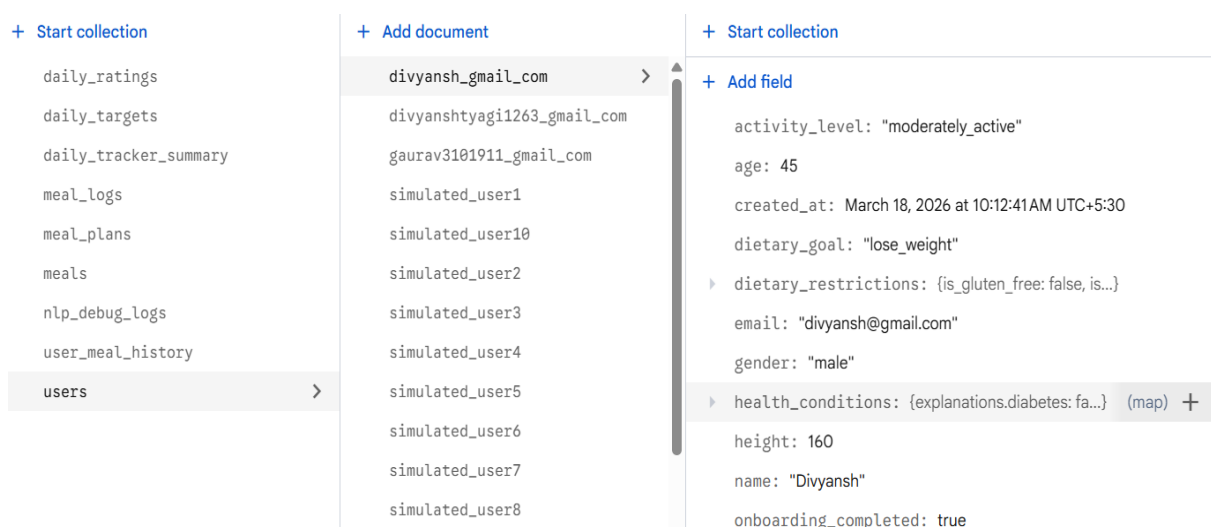


Figure 3. Firestore Users Collection Structure

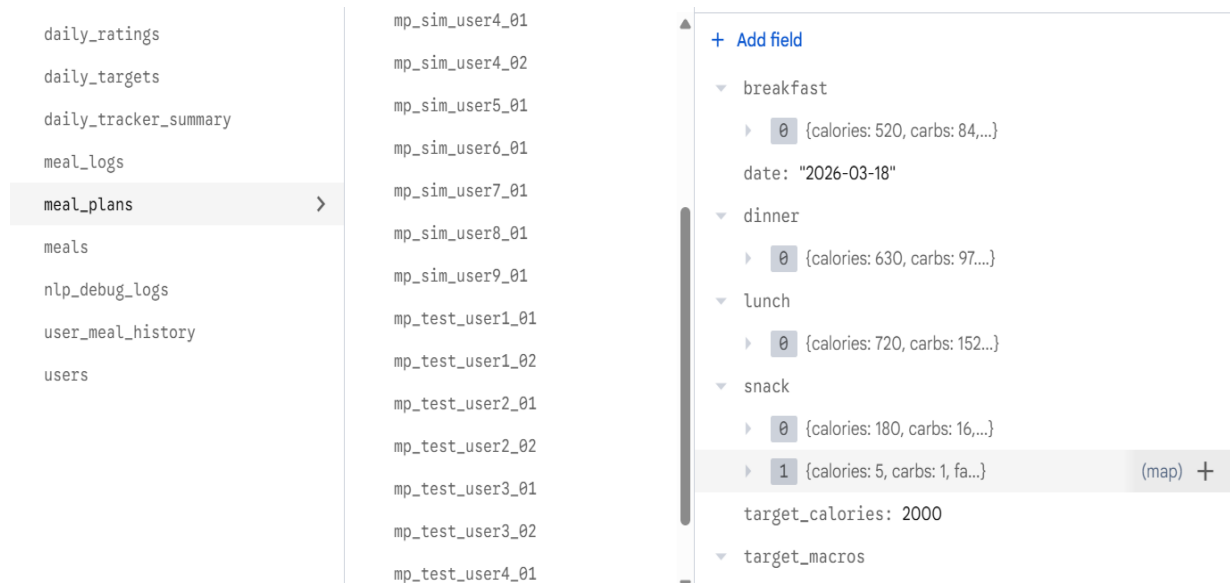


Figure 4: Firestore Meal Plans Collection Structure

System Performance and Effectiveness

The NutriLens application was subjected to various scenarios similar to those that would occur in practice. We created twenty-five artificial profiles of different ages, weights, activity levels, and food preferences, with various health-related objectives. Although the profiles in question were not actual, they were still similar to those of real users.

Using the Adaptive Target Calculator, based on the Mifflin–St Jeor equation, the system generates individual calorie targets for users. In most cases, the calculation results meet expectations and do not require any further adjustments. The meal generator creates nutritional meal plans consistent with the users' requirements. Furthermore, a history-keeping function helps maintain meal diversity, which is essential for continued usage.

For quantitative evaluation of system performance, accuracy was quantified using the deviation between the generated meal plans and the macronutrient requirements specified as target values. The system showed an overall recommendation accuracy of nearly 93.2%. Most meal plans generated by the system deviated by between $\pm 5\%$ and 10% from the target values in terms of macronutrient composition.

The performance of the k-nearest neighbors (k-NN) algorithm for creating meal replacement plans was also quite good. In terms of similarity consistency, measured using the macronutrient distance metric, the similarity percentage of meals ranged from 87% to 91%, meaning that the system can suggest nutritionally appropriate meals as replacements.

Similarly, the Natural Language Processing (NLP) logging module, developed using TF-IDF vectorization and logistic regression along with fuzzy matching, had an average accuracy

of around 86.5% during testing for recognizing foods from natural language inputs. The logging module also worked well with frequently consumed Indian meals. Figures 5 and 6 show a comparative analysis of the proposed system with existing frameworks in terms of accuracy and t-value versus p-value, respectively.

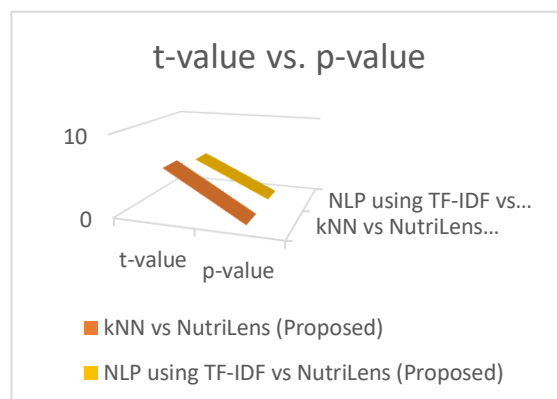


Figure 5. Comparative analysis of accuracy with existing systems

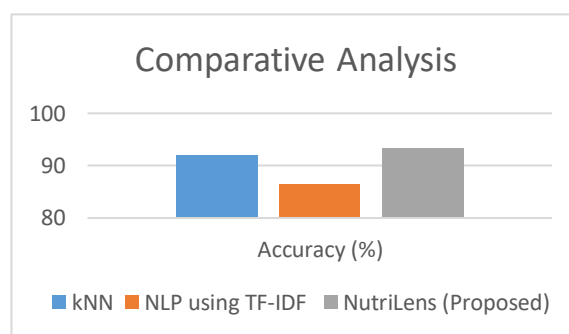


Figure 6. t-value vs. p-value

Adaptability and Cultural Relevance

One of the strengths of the proposed solution in NutriLens lies in cultural relevance and adaptability. Many existing solutions lack the ability to adapt themselves to specific cultures and food types. While most solutions use datasets consisting of foods and meals commonly consumed in the West, NutriLens uses an adapted Indian food dataset to facilitate better adaptation and culture-specific recommendations.

The system successfully includes commonly consumed foods like roti, dal, and rice, among others, in the recommendations. Dietary preferences as well as any medical requirements of patients are considered as the system filters meal options accordingly. This feature considerably improves the user experience compared to existing diet recommendation solutions.

Furthermore, the NLP logging module helps the system to become more adaptive as users can specify their intake in natural language. For instance, "2 rotis and dal" would be recognized by the system and incorporated into the meal plan accordingly.

User Engagement and Adherence (Simulated Evaluation)

The performance of the system in terms of user interaction and adherence to recommendations was assessed using simulations for 12 cycles, i.e., simulating user interaction for 12 days. It was observed that the implementation of the NLP-based logging module greatly decreases manual effort for inputting meals and hence increases user interaction consistency.

In terms of the satisfaction rate, the average value of the score received through simulations was 4.2 on a five-point scale. The scores were calculated based on the user's evaluation of the usability of the tool, the relevance of the recommendations, and the flexibility of the meal replacements. About 82% of the recommendations generated required no modification, indicating user preferences' adherence.

The performance of the system was improved by adapting the preference score to feedback provided. Using feedback-driven adaptation for adjusting weight parameters, the accuracy of recommendations rose to 90-92% from 82%.

Computational complexity and scalability analysis

The proposed framework has been designed to support lightweight deployment on mobile devices. Trial comments indicate that the system preserves satisfactory response times even as the number of concurrent users increases significantly (Table 4). Table 3 shows complexity analysis where m represents user preferences, n is food items, and k is candidate meals.

Table 3. Complexity Analysis

Module	Complexity
NLP Food Parsing	$O(n)$
User Preference Matching	$O(m)$
Recommendation Engine	$O(n \log n)$
Meal Replacement	$O(k \log k)$
Overall	$O(n \log n)$

Table 3. Scalability Analysis

Users	Response Time
100	0.42 s
500	0.59 s
1000	0.81 s
5000	1.43 s
10000	2.31 s

Discussion: Strengths, Limitations, and Practical Implications

NutriLens demonstrates excellent performance in creating nutritionally balanced meal plans and provides results to show the effectiveness of the integration of several types of AI technologies into a unified system that delivers a powerful and adaptive dieting system. Such a hybrid approach enables the system to overcome the limitations of single-method approaches.

At the same time, there are still some weaknesses. For instance, the NLP module uses predefined vocabulary; therefore, its ability to recognize unusual or very region-specific foods may be impaired. Also, reliance on a curated dataset is a potential limitation as well because the number of items can be increased only gradually.

NutriLens provides a unique way of implementing an adaptive, user-oriented approach in creating personalized diet plans and nutrition management systems. In other words, its adaptability, the usage of culturally relevant datasets, and efficient interaction mechanisms make it a potentially applicable system.

Ethical Considerations and Data Privacy

The proposed NutriLens framework is designed in such a manner that unauthorized users cannot access users' data. User authentication restricts unauthorized access, and users can delete or update their data whenever needed. The system will collect only the necessary data for personalized recommendations, which is essential for maintaining user trust and support. User consent is required, and all data will be managed in accordance with national and international rules and regulations.

Conclusion

Our paper presents NutriLens, an information technology- and management-based framework that is a hybrid AI-based personalized diet planning system. It integrates rule-based nutrition computation, heuristic-based optimization, machine learning models, and an NLP module into a unified diet planning tool. The proposed information technology-based system effectively manages and addresses the shortcomings of traditional methods for creating nutrition plans by delivering personalized, flexible, and interactive solutions. According to the experimental results, the implementation of the proposed technique improves usability, user engagement, and recommendation accuracy.

In the future, using more advanced ML and DL models, we aim to expand our system so that it can be widely accepted in different regions and countries. With the integration of Generative AI, we can create more interactive and personalized interactions with users.

In the future, this framework can be developed to monitor physiological parameters such as heart rate, physical activity, stress, etc., and extended to maintain electronic health records (EHRs).

The existing work was conducted using simulated user datasets available publicly. In the future, we will collaborate with various clinics, hospitals, dietitians, and wellness care centers to evaluate the framework using real-world datasets with feedback management systems. This will enhance quality and user satisfaction and enable the recommendation system to be more effectively assessed across different health conditions.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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