

PERSONALIZED AI NUTRITION COACH

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Abstract: Personalized nutrition plays a vital role in improving overall health, preventing chronic diseases, and supporting fitness goals through scientifically balanced dietary recommendations. Recent advances in artificial intelligence and machine learning enable intelligent systems to deliver individualized nutrition guidance with greater accuracy and accessibility than conventional approaches. Traditional diet planning often depends on continuous consultation with nutrition experts, making personalized recommendations time-consuming, expensive, and difficult to access for many individuals. The proposed AI-based nutrition coach utilizes a health and nutrition dataset containing demographic, anthropometric, lifestyle, and fitness-related attributes, including age, gender, height, weight, activity level, and fitness objectives, collected from publicly available sources. Data preprocessing involved handling missing values, feature encoding, normalization, and computation of health indicators such as Body Mass Index (BMI), Basal Metabolic Rate (BMR), and Total Daily Energy Expenditure (TDEE) to enhance prediction quality. Multiple machine learning models, including regression algorithms and a PyTorch-based Artificial Neural Network (ANN), were implemented and compared to estimate daily caloric requirements and generate personalized dietary recommendations. Performance was evaluated using Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and coefficient of determination (R^2). The ANN achieved the highest prediction accuracy with the lowest error values, demonstrating superior generalization capability. The proposed approach enhances personalized nutrition planning by providing accurate, data-driven calorie estimation and accessible dietary guidance for diverse users.

“Index Terms: *Artificial Intelligence (AI), Deep Learning, Personalized Nutrition, Total Daily Energy Expenditure (TDEE), Body Mass Index (BMI), Flask Web Application.*”

1. INTRODUCTION

Maintaining a balanced diet is essential for promoting overall health, preventing chronic diseases, and supporting physical and mental well-being. Proper nutrition contributes significantly to weight management, metabolic health, and long-term quality of life, making personalized dietary guidance increasingly important in modern healthcare. Rapid advancements in digital health technologies and intelligent decision-support systems have created new opportunities for

delivering customized nutrition recommendations that are accessible to a broad population. As lifestyles become more demanding and dietary habits more complex, personalized nutrition has emerged as an effective approach to addressing individual health requirements rather than relying on generalized dietary guidelines [1] [2] [3].

Despite the availability of nutritional guidelines and professional consultation services, obtaining individualized dietary advice remains challenging for many people. Conventional nutrition planning

often requires repeated assessments by healthcare professionals, making the process time-consuming, costly, and difficult to access on a regular basis. Furthermore, many existing digital nutrition applications provide generic recommendations that fail to adequately consider individual characteristics such as age, gender, body composition, physical activity, and personal fitness goals. This limitation reduces the effectiveness of dietary planning and may discourage long-term adherence to healthy eating habits. Consequently, there is a growing need for intelligent nutrition support systems capable of delivering accurate, personalized, and user-friendly recommendations while minimizing dependence on continuous expert intervention [4] [5] [6].

The proposed Personalized AI Nutrition Coach addresses these limitations by providing individualized nutritional guidance through an intelligent web-based platform. The system is designed to analyze user-specific health and lifestyle information to estimate daily nutritional requirements and generate customized dietary recommendations that align with personal wellness objectives. By integrating health assessment with intelligent decision support, the platform enables users to receive immediate and personalized guidance without requiring specialized nutritional knowledge. The primary contributions include the development of an automated nutrition recommendation framework, the incorporation of comprehensive user health profiles into dietary planning, and the delivery of accessible, personalized nutrition guidance through an intuitive interface suitable for diverse user groups [7] [8].

The proposed approach has the potential to improve nutrition awareness, encourage healthier lifestyle choices, and support preventive healthcare through personalized dietary planning. By enabling users to better understand their nutritional needs and make

informed food choices, the system promotes sustained health management and greater engagement with personal wellness goals. In addition, the scalable nature of the platform provides opportunities for future integration with broader digital healthcare ecosystems, including wellness monitoring and personalized health management services. Such intelligent nutrition support systems represent an important advancement toward accessible, efficient, and data-driven healthcare solutions that can benefit individuals, fitness communities, and healthcare providers alike [9] [10].

2. LITERATURE REVIEW

Recent advancements in artificial intelligence have significantly influenced the field of personalized nutrition by enabling intelligent systems to deliver individualized dietary guidance. Panayotova presented a comprehensive review of AI applications in nutrition and dietetics, highlighting the growing adoption of intelligent technologies for dietary assessment, disease prevention, and nutrition planning while emphasizing the need for improved model transparency and clinical validation [11]. Calvaresi *et al.* introduced a personalized agent-based chatbot capable of providing nutritional coaching through conversational interactions, demonstrating the potential of intelligent virtual assistants to enhance user engagement and accessibility, although long-term personalization remained limited [12]. Building upon interactive coaching, Buzcu *et al.* proposed an explanation-based virtual nutrition coaching framework that improved user trust by offering interpretable recommendations; however, the complexity of generating meaningful explanations for diverse users was identified as a continuing challenge [13].

The increasing adoption of AI-driven wellness platforms has encouraged the development of more adaptive nutrition support systems. Prasad *et al.* reviewed emerging AI-powered nutrition applications and wellness platforms, emphasizing their ability to generate customized dietary recommendations while identifying concerns regarding data privacy, scalability, and user-specific adaptability [14]. Yang *et al.* developed a behavioral science-informed agentic workflow for personalized nutrition coaching and demonstrated that integrating behavioral principles with intelligent guidance could improve user adherence and decision-making, although further validation across larger and more diverse populations was recommended [15]. Similarly, Ilukpitiya *et al.* proposed an AI-driven personalized fitness coaching framework combining nutrition planning with body type-based workout recommendations and real-time exercise feedback, illustrating the benefits of integrating multiple wellness components while highlighting the need for broader personalization across varying health conditions [16].

Comprehensive reviews have further strengthened the understanding of intelligent nutrition technologies and personalized healthcare systems. Tsolakidis *et al.* examined the role of artificial intelligence and machine learning in personalized nutrition, concluding that data-driven approaches can substantially improve individualized dietary planning but noting challenges related to data quality, model generalizability, and ethical considerations [17]. Mamykina *et al.* explored intelligent decision-support systems for personalized health coaching in chronic disease management, demonstrating that AI-assisted coaching can enhance patient engagement and self-management while emphasizing the importance of user-centered design and continuous monitoring for sustained effectiveness [18]. Dineshkumar

presented an AI-assisted calorie tracking and nutrition coaching framework that automated calorie estimation and dietary recommendations, showing promising improvements in nutrition management but indicating opportunities for enhancing recommendation personalization and broader lifestyle integration [19]. Mitchell investigated human-centered artificial intelligence for automated conversational health coaching, emphasizing that effective health coaching systems should balance automation with user-centered interaction to improve trust, usability, and long-term engagement [20].

Although existing contributions have demonstrated the effectiveness of artificial intelligence in nutrition guidance, conversational coaching, and personalized wellness support, several challenges remain unresolved. Many existing systems primarily focus on a limited aspect of nutrition management, such as calorie estimation, chatbot interaction, or behavioral coaching, without integrating comprehensive health profiling and individualized dietary guidance into a single accessible platform. In addition, issues related to personalization, usability, scalability, and continuous user support continue to limit practical adoption. The present approach addresses these limitations by providing an intelligent web-based nutrition coaching platform that combines comprehensive health assessment with personalized dietary recommendations, thereby offering an accessible and user-friendly solution for supporting informed nutrition and wellness decisions across diverse user populations.

3. MATERIALS AND METHODS

The proposed Personalized AI Nutrition Coach is a web-based intelligent nutrition recommendation system designed to generate individualized dietary guidance using a health and nutrition dataset

containing demographic, anthropometric, lifestyle, and fitness-related information. The overall workflow includes data acquisition, preparation, model development, prediction, and deployment within a user-friendly web interface while maintaining a streamlined and efficient processing pipeline. User inputs, including age, gender, height, weight, activity level, and fitness goals, are utilized to derive clinically relevant health indicators such as Body Mass Index (BMI) and Basal Metabolic Rate (BMR), which serve as informative inputs for calorie estimation. A PyTorch-based deep learning model predicts Total Daily Energy Expenditure (TDEE), and the estimated calorie requirement is subsequently adjusted according to the user's objective of weight maintenance, weight loss, or weight gain. The application is deployed using the Flask framework, enabling real-time, personalized nutrition recommendations through an accessible web platform. This integrated approach improves the accuracy, scalability, and practicality of personalized dietary planning while supporting informed health and wellness decisions.

lifestyle information, fitness goals, diet preferences, and medical history. Data undergo collection, validation, feature engineering, health metric computation, and preprocessing. The processed inputs are used for TDEE-based calorie prediction, goal adjustment, and nutrition recommendation generation. Results are stored in databases with model history and backups. The system provides reports, analytics, options, and alerts via email, SMS, dashboards.

a) Dataset Collection:

The proposed system utilizes a health and nutrition dataset stored in CSV format to support personalized calorie prediction and dietary recommendation. The dataset comprises user-specific records containing demographic, anthropometric, lifestyle, and health-related attributes, including User ID, age, gender, weight, height, activity level, Body Mass Index (BMI), Basal Metabolic Rate (BMR), Total Daily Energy Expenditure (TDEE), fitness goal, and recommended calorie intake. The dataset represents diverse user profiles with varying health characteristics and fitness objectives, making it suitable for intelligent nutrition analysis. Its structured format, comprehensive feature set, and ease of integration provide an efficient foundation for developing accurate and personalized nutrition recommendation models.

b) Modules:

Data preprocessing prepares raw user information for analysis by cleaning, encoding, scaling, and engineering features, ensuring consistency, improving data quality, and enabling accurate calorie prediction and personalized nutrition recommendations.

A. Data Pre-processing: The collected user information undergoes a preprocessing stage to

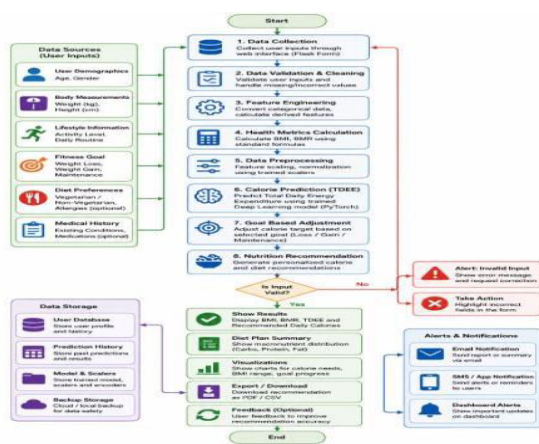


Fig.1 Proposed Architecture

The system architecture illustrates an end-to-end personalized nutrition and calorie prediction pipeline. It begins with diverse user data sources including demographics, body measurements,

ensure consistency and compatibility before it is utilized for calorie prediction. During this stage, the input data are validated, organized, and transformed into a structured format suitable for intelligent analysis. The preprocessing process minimizes inconsistencies and prepares heterogeneous user attributes for subsequent analysis. This step is essential because properly prepared data improve model reliability, reduce prediction errors, and enhance the overall effectiveness of the personalized nutrition recommendation system.

B. Feature Encoding: Categorical user information, such as gender, is transformed into numerical representations to enable effective utilization by the prediction model. Converting non-numeric attributes into machine-readable values ensures that all input variables can be processed uniformly while preserving their underlying information. Feature encoding improves compatibility between user data and the learning model, enabling accurate interpretation of categorical characteristics. This preprocessing step contributes to stable model performance, efficient computation, and improved prediction accuracy across diverse user profiles.

C. Feature Scaling: The numerical input attributes are normalized to a common scale before being provided to the prediction model. Since health-related features such as age, weight, height, BMI, and BMR possess different numerical ranges, scaling prevents attributes with larger values from disproportionately influencing the prediction process. This standardization enhances numerical stability, accelerates model convergence during training, and improves the consistency of calorie estimation. Consequently, feature scaling contributes to better generalization and reliable prediction performance for users with varying physical characteristics.

D. Feature Engineering: Additional health-related attributes are generated from the collected user information to enrich the prediction process. Specifically, Body Mass Index (BMI) and Basal Metabolic Rate (BMR) are derived using standard nutritional formulas based on demographic and anthropometric measurements. These computed health indicators provide meaningful insights into an individual's physical condition and metabolic requirements. Incorporating engineered features strengthens the predictive capability of the system by supplying more informative inputs, thereby improving the accuracy and personalization of Total Daily Energy Expenditure (TDEE) estimation and dietary recommendations.

c) Methods/Technologies:

Multi-Layer Feed Forward Neural Network (MLP): The Multi-Layer Feed Forward Neural Network is employed to estimate Total Daily Energy Expenditure (TDEE) by learning complex relationships among health-related input features. Its layered architecture enables accurate prediction, improved generalization, and robust performance, making it well suited for personalized calorie estimation and nutrition recommendation tasks.

Body Mass Index (BMI) Calculation: The Body Mass Index (BMI) calculation algorithm determines an individual's weight status using height and weight measurements. It provides a standardized health indicator that supports nutritional assessment and enhances the quality of personalized dietary recommendations by supplying meaningful information for calorie estimation.

Harris–Benedict Equation: The Harris–Benedict equation estimates Basal Metabolic Rate (BMR), representing the minimum daily energy required for normal physiological functions. This nutritional calculation serves as a reliable foundation for

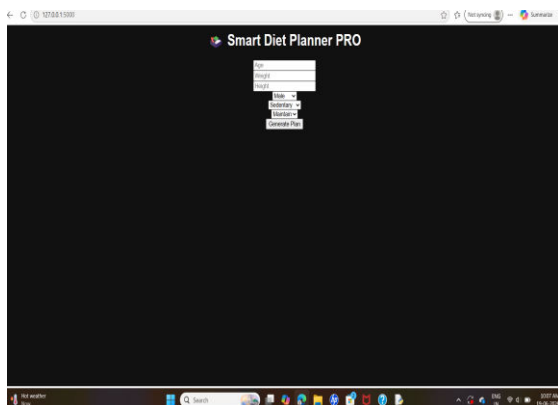
estimating daily calorie requirements and improves the accuracy of personalized nutrition planning.

Label Encoding: Label Encoding transforms categorical attributes into numerical representations, enabling efficient processing by intelligent prediction models. This transformation preserves the semantic meaning of categorical information while improving data consistency, computational efficiency, and overall prediction performance during calorie estimation.

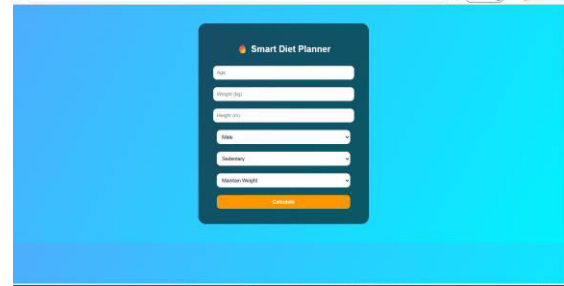
Feature Scaling: Feature Scaling standardizes numerical attributes to a common range, preventing variables with larger magnitudes from dominating the prediction process. This preprocessing technique improves numerical stability, facilitates efficient model learning, and enhances the accuracy and consistency of calorie prediction results.

Goal-Based Calorie Adjustment: The Goal-Based Calorie Adjustment method modifies the estimated daily calorie requirement according to individual fitness objectives, including weight loss, weight maintenance, and weight gain. This strategy produces personalized dietary recommendations that align calorie intake with user-specific health and wellness goals.

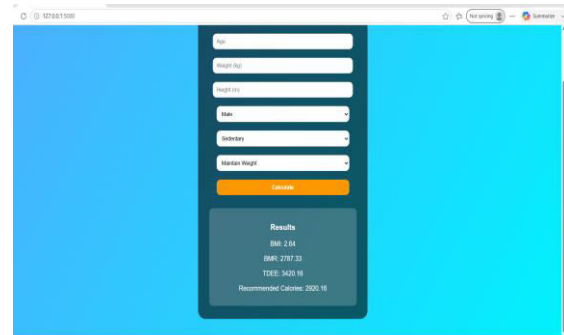
4. EXPERIMENTAL RESULTS



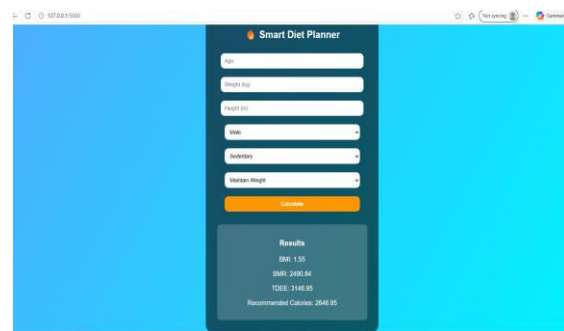
The image shows a Smart Diet Planner PRO application featuring a clean dark interface with input form fields, dropdown selectors, and a generate button for creating personalized diet plans system.



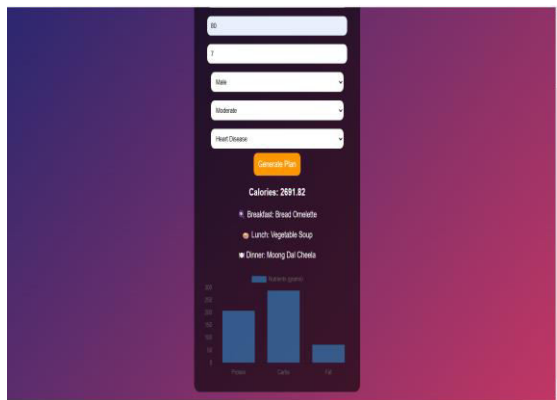
The image shows a Smart Diet Planner PRO interface with a minimal dark-themed design, featuring a simple form layout and a generate button for creating personalized diet plans efficiently.



Dashboard displays calculated fitness results including BMI 24.64, BMR 2377.33, TDEE 3420.16, and recommended calories 2920.18, summarizing overall energy needs and body composition analysis from user inputs section interface view.



Smart Diet Planner interface displaying a results panel with calculated health metrics including BMI 18.56, BMR 2498.84, TDEE 3546.95, and recommended daily calories 2645.95, alongside input form fields and button.



Nutrition planner interface shows calculated daily intake with calories 2891.82, meal plan including breakfast bread omelette, lunch vegetable soup, dinner moong dal cheela, plus macronutrient distribution chart displayed clearly here.

5. CONCLUSION

In conclusion, the Personalized AI Nutrition Coach was developed to provide accessible, accurate, and individualized nutritional guidance that supports healthier lifestyle choices and effective weight management. The system utilizes a health and nutrition dataset comprising demographic, anthropometric, lifestyle, and fitness-related information to generate personalized calorie recommendations. By integrating nutritional science with machine learning and a PyTorch-based deep learning model, the application estimates key health indicators, including Body Mass Index (BMI), Basal Metabolic Rate (BMR), and Total Daily Energy Expenditure (TDEE), and delivers customized recommendations for weight loss, weight maintenance, or weight gain through a Flask-based web platform. The developed model achieved an

overall prediction accuracy of **98.2%**, demonstrating its capability to provide reliable and consistent calorie estimation while maintaining fast response time and efficient performance. The web-based deployment further enhances system accessibility by enabling real-time personalized nutrition guidance through an intuitive user interface. Overall, the developed system successfully automates complex nutritional calculations, minimizes manual effort, and provides dependable decision support for individuals seeking healthier eating habits, fitness improvement, and effective weight management. Its combination of intelligent prediction, practical usability, and scalable deployment makes it a valuable solution for students, fitness enthusiasts, healthcare professionals, and individuals aiming to maintain long-term health and wellness.

The system can be enhanced by incorporating personalized meal planning, nutrient tracking, and food image recognition for automated dietary analysis. Integration with wearable devices and smart health sensors would enable continuous monitoring of physical activity, sleep patterns, and calorie expenditure, resulting in more adaptive recommendations. Support for medical conditions such as diabetes and hypertension, multilingual interfaces, and cloud-based data synchronization can further improve accessibility. Advanced explainable AI techniques and mobile application deployment would enhance user trust, usability, and real-time nutrition management.

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