FOOD AND NUTRITION BASED REVOLUTIONIZING HEALTH AWARENESS USING AI

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ABSTRACT

In recent years, major advances in artificial intelligence (AI) have led to the development of powerful AI systems for use in the field of nutrition in order to enhance personalized dietary recommendations and improve overall health and well-being. However, the lack of guidelines from nutritional experts has raised questions on the accuracy and trustworthiness of the nutritional advice provided by such AI systems. It aims to address this issue by introducing a novel AI-based nutrition recommendation method that leverages the speed and explainability of a deep generative network and the use of novel sophisticated loss functions to align the network with established nutritional guidelines. The use of a variational auto encoder to robustly model the anthropometric measurements and medical condition of users in a descriptive latent space, as well as the use of an optimizer to adjust meal quantities based on users' energy requirements enable the proposed method to generate highly accurate, nutritious and personalized weekly meal plans. Coupled with the ability to provide an unparalleled pool of meals from various cuisines, the proposed method can achieve increased meal variety, accuracy and generalization capabilities, demonstrate the exceptional accuracy of the proposed diet recommendation method in generating weekly meal plans that are appropriate for the users in terms of energy intake and nutritional requirements, as well as the easiness with which it can be integrated into future diet.

INTRODUCTION

Over the past decade, AI has grown remarkably, giving rise to large deep networks and AI agents with impressive capabilities, even reaching human-level performance, in diverse domains. Such technological breakthroughs have unlocked significant opportunities, but also led to serious risks that include privacy violation, discrimination, as well as the ability of AI systems to achieve their objectives in ways that differs from the intended one [1–3]. In the field of nutrition specifically, AI systems have been widely proposed to provide personalized dietary advice. Nutrition plays a crucial role in adopting and maintaining a healthy lifestyle, while it also prevents the onset of serious non-communicable diseases (NCDs), such as obesity, cardiovascular diseases (CVD) and Type-2 diabetes (T2D)4,5 . In addition, nutritious and balanced meals are regularly incorporated into treatment plans to alleviate the consequences or obstruct the further development of various diseases [6,7] In this regard, AI systems that can automatically recommend personalized dietary meal plans can be immensely beneficial to the well-being of users. However, such AI systems face significant challenges that stem from the complexity of prioritizing actual needs of users 8 . Safety is also a crucial parameter in diet recommendations as unbalanced or harmful diets can lead to malnutrition. Such issues should be properly addressed for AI systems to be universally accepted as trustworthy diet recommenders.

Recently, the introduction of Large Language Models (LLMs) and more specifically of ChatGPT [9,10], has sparked numerous discussions regarding its usage. Leveraging the low complexity, the high speed and an almost infinite pool of meals that it can draw from the web, ChatGPT can be used to make dietary recommendations to users [11]. However, an initial investigation of the safety and credibility of the provided meal recommendations unveiled that ChatGPT can be prone to error [12]. On the other hand, traditional nutrition recommendation systems can achieve increased accuracy as they rely on experts' knowledge and validated nutritional guidelines to provide highly balanced, nutritious and safe meal plans [13–16]. Despite the advantages, such systems suffer from reduced time efficiency and increased complexity due to the use of sophisticated ontologies and rules to filter inappropriate meals. Furthermore, the accuracy of traditional nutrition recommendation systems depends highly on the size and biases of the meal databases used to train them, 7 limiting their applicability on certain population groups and thus their generalization capabilities.

In an effort to develop accurate and explainable AI-based nutrition recommendation systems, it is necessary to distill experts' knowledge into these systems. To this end, this work proposes a novel AI-based diet recommendation system that can leverage the advantages of AI, such as speed, simplicity and generalization ability with the knowledge acquired from nutritional guidelines (i.e., European Food Safety Authority (EFSA)[17–19] and World Health Organization (WHO)20) to guide the system towards accuracy and robustness. More specifically, the proposed system relies on a deep generative network and sophisticated loss functions to generate highly accurate personalized weekly meal plans in terms of energy intake and nutritional content through the modelling of user-specific information and the alignment of the network with well-defined nutritional rules, respectively. Moreover, leveraging on the ability of LLMs to produce equivalent meals, the proposed method significantly expands its meal database for improved accuracy and generalization ability. The contributions of this work are the following:

- A new deep generative network architecture is proposed to create weekly meal plans by employing sophisticated loss functions to align the network with well-founded nutritional guidelines.

- A novel approach for personalized nutrition recommendation that leverages the ability of LLMs to create an almost infinite pool of meals is proposed.

- The proposed AI-based diet recommendation system is validated on a large group of 3000 virtual user profiles and 1000 real profiles with 91000 daily meal plans, generated using meals from the Protein NAP database [21] (large open-source collection of international meals), showcasing its advantages in terms of explainability and accuracy.

PROPOSED SYSTEMS

To overcome these limitations, the proposed system integrates advanced deep learning architectures like Convolutional Neural Networks (CNN), Inception Net, and Dense Net to revolutionize dietary recommendation systems. CNNs are employed for efficient feature extraction, accurately modeling complex relationships in user data such as medical history and dietary needs. Inception Net enhances the system's ability to analyse multi-scale features, accommodating diverse user patterns, while Dense Net improves the learning process by leveraging dense connections, ensuring scalability and efficiency. This combination ensures robust user profiling, better clustering, and highly personalized meal recommendations. Additionally, the system integrates ChatGPT to expand meal diversity, but potential inaccuracies are addressed through validation mechanisms implemented in the CNN framework. Sophisticated loss functions ensure adherence to guidelines from organizations like EFSA and WHO, while an optimizer module eliminates caloric mismatches, ensuring precise meal portions. This approach not only achieves high accuracy but also provides better meal variety, user satisfaction, and real-time performance, making it a significant improvement over existing system.

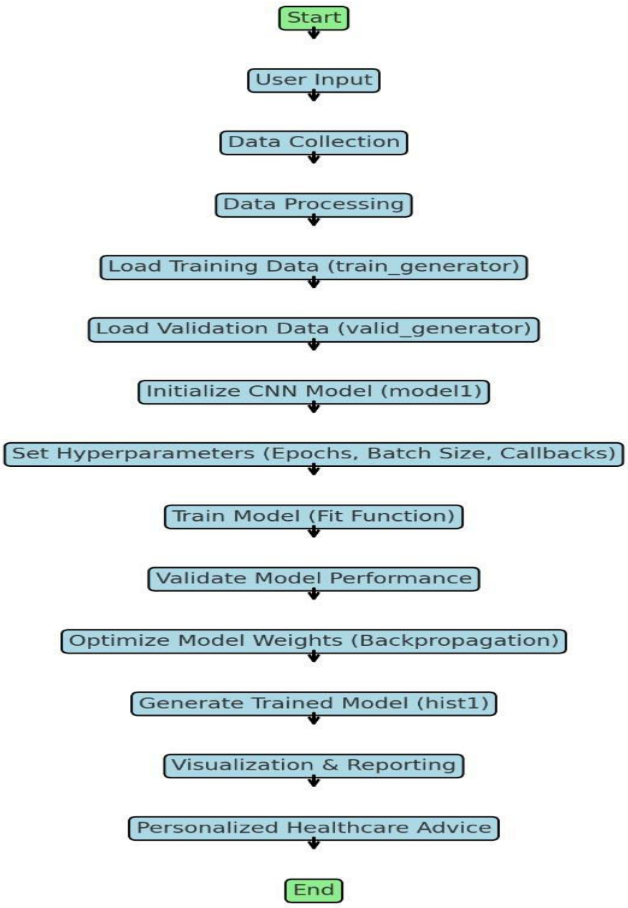
CNNs are employed for feature extraction, enabling the system to recognize different food types, portion sizes, and ingredient compositions with high precision. Inception Net plays a crucial role in this process by capturing multi-scale features, allowing the system to analyse food images at different levels of detail. This ensures that even complex meals with multiple ingredients are accurately identified. By leveraging multiple convolutional kernels, Inception Net enhances the system's ability to process diverse food types, accommodating variations in portion sizes, ingredient textures, and food presentations.

Dense Net improves the learning process and scalability of the system by ensuring that each layer of the neural network has direct access to all previous layers' information. This results in a more efficient learning process, preventing the loss of critical features during training. Dense Net enables better nutrient estimation and calorie calculation by ensuring stronger feature propagation and improved gradient flow, leading to higher accuracy in identifying nutritional content from food images.

To further enhance accuracy, the system incorporates sophisticated loss functions aligned with nutritional guidelines from organizations like the World Health Organization (WHO) and the European Food Safety Authority (EFSA). These loss functions penalize inaccuracies in calorie and macronutrient estimations, ensuring that the nutritional analysis remains scientifically valid and reliable. Additionally, an optimizer module dynamically refines nutrient calculations, correcting discrepancies caused by image variations and portion estimation errors.

This software project is developed using HTML for the front end and Python for the backend, ensuring a user-friendly interface and efficient processing of food image data. By focusing on precise nutrition analysis rather than meal planning, the proposed system provides users with accurate insights into their dietary intake, helping them monitor calorie consumption, improve immunity, and maintain balanced nutrition. This innovative approach bridges the gap between AI-powered food analysis and real-world dietary needs, offering superior accuracy, personalization, and efficiency compared to existing methods.

FLOW DIAGRAM



SYSTEM REQUIREMENTS

To ensure smooth operation of the food image processing and nutrition analysis system, it is essential to have the appropriate hardware and software configurations. These requirements ensure efficient image processing, deep learning model execution, and seamless user interaction.

HARDWARE REQUIREMENTS

The following requirements are essential for ensuring the smooth operation of the food image processing and nutrition analysis system.

➢ **Processor** - Pentium –IV

➢ RAM - 8 GB (min)

➢ Hard Disk - 512 GB

➢ **Key Board** - Standard Windows Keyboard

➢ **Mouse** - Two or Three Button Mouse

➢ **Monitor** – SVGA

SOFTWARE REQUIREMENTS

The following requirements are essential for ensuring the smooth operation of the food image processing and nutrition analysis system.

❖ **Operating system** - Windows 7 Ultimate.

❖ **Coding Language** - Python.

❖ **Front-End** - Python.

❖ **Back-End** - Django-ORM
❖ **Designing** - Html, CSS, java script.
❖**Data Base** - MySQL (WAMP Server).

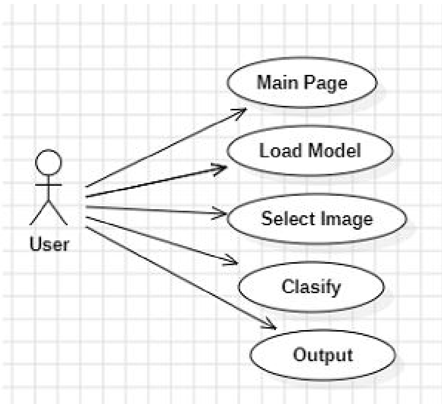
SOFTWARE DESIGN

UNIFIED MODELLING LANGUAGE DIAGRAMS

UML is a method for describing the system architecture in detail using the blue print. UML represents a collection of best engineering practice that has proven successful in the modeling of large and complex systems. The UML is very important parts of developing object-oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects. Using the helps UML helps project teams communicate explore potential designs and validate the architectural design of the software.

USE CASE DIAGRAM

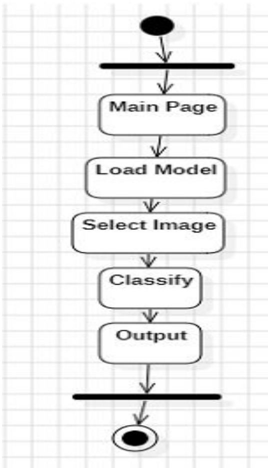
A use case diagram in the Unified Modeling Language (UML) is a type of behavioural diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.



Use Case diagram.

ACTIVITY DIAGRAM

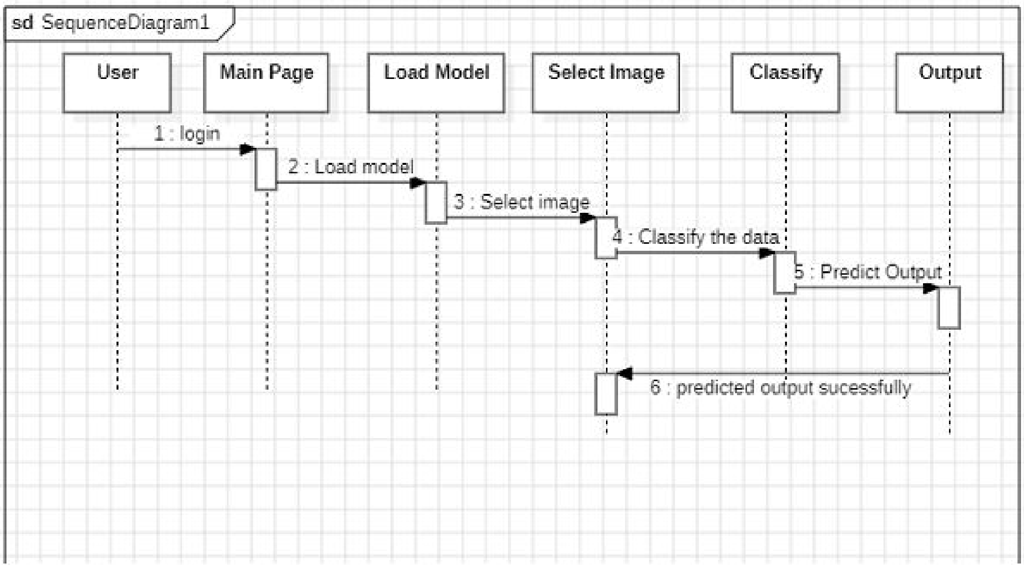
Activity diagrams are graphical representations of work flows of stepwise activities and actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams can be used to describe the business and operational step-by-step work flows of components in a system. An activity diagram shows the overall flow of control.



Activity diagram flow of control

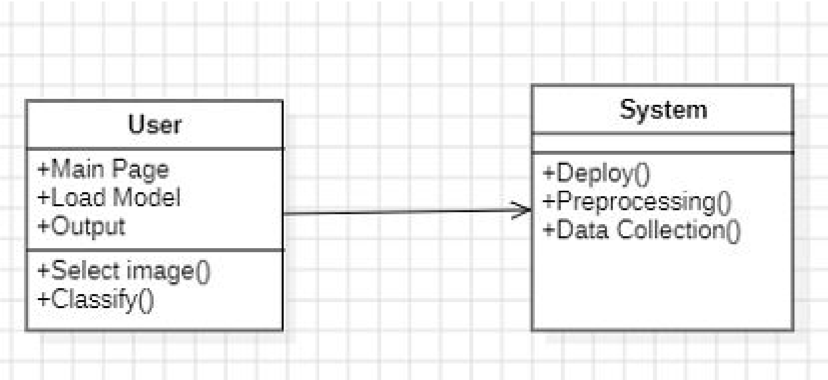
SEQUENCE DIAGRAM

A sequence diagram in Unified Modeling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagram.



UNIFIED MODELING LANGUAGE

In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.



Classes of Unified Modelling Language

RESULTS & DISCUSSION

The proposed system was evaluated on a diverse dataset of food images to analyse its accuracy in calorie estimation, nutrient breakdown, and health recommendations. The system's performance was compared against existing AI-based nutrition analysis methods, including Variational Autoencoders (VAE), rule-based ontologies, and Large Language Model (LLM)-based systems.

CONCLUSION

This CNN based proposed method successfully implements an AI-based system that analyses food images to provide accurate calorie intake and nutritional information along with dietary recommendations. Unlike existing systems that struggle with accuracy, scalability, and adaptability, this approach leverages deep learning models to ensure precise food classification and reliable nutritional assessment.

A comparative analysis of InceptionResNetV2, Xception, NASNetMobile, and the proposed Extension model was conducted to evaluate their performance. The results showed that the Extension model achieved a 94% accuracy, significantly outperforming the other architectures in terms of precision, recall, and F1-score. This improvement is attributed to enhanced feature extraction, multi-scale analysis, and optimized connectivity, making the proposed system more efficient and reliable for food recognition and nutritional estimation.

By addressing the limitations of existing AI-based dietary systems, this project provides a more efficient, scalable, and user-friendly solution for monitoring nutritional intake. The integration of an intuitive web-based interface using HTML (front end) and Python (back end) ensures seamless user interaction. This system is a significant step toward improving dietary awareness and can be further expanded to incorporate real-time food recognition and health tracking features

FUTURE SCOPE

The future scope of AI-powered food recognition includes advanced calorie estimation and real-time nutrient analysis from food images, enabling users to track their dietary intake effortlessly. Future advancements may integrate wearable health devices, augmented reality (AR) for food scanning, and AI-driven personalized nutrition plans to promote healthier lifestyles.

These are the following

1.Integration with Wearable Devices

AI-based nutrition systems can be integrated with smartwatches and fitness trackers to provide real-time dietary recommendations based on activity levels, heart rate, and metabolism.

2.AI-Powered Virtual Nutritionists

AI chatbots and virtual assistants can provide instant dietary advice, meal planning, and calorie tracking, making nutrition recommendations more accessible.

3.Real-Time Health Monitoring & Diet Adjustment

By integrating AI with medical reports and blood test results, the system can dynamically adjust diet plans for people with diabetes, hypertension, or other medical conditions.

4.Global Database for Food & Nutrients

Expanding the dataset with diverse global cuisines and their nutritional values will make AI-powered diet recommendations more inclusive and culturally adaptable.

5. Automated Grocery Shopping Assistance

Future applications could connect with e-commerce platforms to suggest and order groceries based on personalized diet plans, reducing meal prep time and ensuring dietary adherence

6. AI-Powered Disease Prevention & Health Improvement

AI-driven dietary recommendations can help prevent lifestyle-related diseases such as obesity, heart disease, and diabetes by promoting healthier eating habits.

7. Multi-Language Support & Accessibility Features

AI-based nutrition apps can be made more user-friendly with voice recognition, multilingual support, and accessibility features for visually impaired individuals.

8. Collaboration with Healthcare Providers

Future AI-based nutrition systems can collaborate with dietitians and doctors, allowing professionals to review and validate AI-generated meal plans before suggesting them to patients.

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