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CalorieInsight: A Personalized Dietary Management System Using AI

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Abstract

This paper presents CalorieInsight, an AI-driven system for automated food calorie estimation and personalized dietary management. Leveraging YOLOv8, a real-time object detection algorithm, the system accurately identifies and quantifies multiple food items from single image inputs, achieving a food recognition accuracy of 99.7%. This surpasses the 95.21% accuracy [1] reported in prior work utilizing convolutional neural networks. An adaptive recommendation engine, employing a decision tree algorithm, generates personalized meal plans based on user-specific dietary preferences, health goals, and activity levels. A tracking module facilitates continuous monitoring of nutritional intake, enabling real-time goal adjustments. The system integrates portion estimation, nutritional API data, and user feedback to provide comprehensive dietary insights. Preliminary evaluations demonstrate CalorieInsight 's potential to significantly enhance personalized nutrition through intelligent food analysis and adaptive dietary planning.

Keywords: *Calorie Estimation; Dietary Recommendation; Food Recognition; Nutritional Tracking.*

1. Introduction

The increasing prevalence of lifestyle-related health issues [2][3], coupled with a growing awareness of the importance of balanced nutrition, has driven a surge in demand for sophisticated dietary management tools [4]. Traditional methods of calorie tracking and meal planning often rely on manual input and generalized recommendations, leading to inaccuracies and reduced adherence. To address these limitations, this paper presents CalorieInsight, an AI-driven system designed for automated food calorie estimation and personalized dietary planning. CalorieInsight leverages advanced deep learning techniques, specifically YOLOv8, to achieve high-accuracy food recognition from image inputs, significantly improving upon the accuracy of existing systems that rely on convolutional neural networks. This real-time object detection capability enables the system to identify and quantify multiple food items within a single image, providing precise calorie estimations. Furthermore, the system incorporates a machine learning-based recommendation engine, employing a decision tree algorithm, to generate personalized meal plans based on individual dietary needs, preferences, and health goals. A comprehensive tracking module facilitates continuous monitoring of nutritional intake [5], allowing users to adapt their dietary plans in real-time. The key contributions of this work include:

1.1 High-Accuracy Food Recognition

Implementation of YOLOv8 for real-time, multi-object food detection, achieving a 99.7% accuracy. This level of precision minimizes estimation errors, providing users with reliable nutritional information.

1.2 Personalized Dietary Recommendations

Development of an adaptive recommendation engine that generates tailored meal plans based on user profiles and preferences. This ensures that dietary advice is relevant and aligned with individual needs and goals, potentially improving adherence.

1.3 Real-Time Nutritional Tracking

Integration of a tracking module that enables continuous monitoring and goal adjustment. This empowers users to stay informed about their progress and make timely adjustments to their dietary plans. The performance of CalorieInsight was compared with an existing system utilizing MobileNetV2 for

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food recognition. Table 1 presents a comparative analysis of the two systems. This enhancement can be attributed to the employment of YOLOv8, which is renowned for its real-time object detection capabilities and superior accuracy.

Table 1 Comparative Analysis of Existing and Proposed Systems

Parameter	Existing System [1]	Proposed System
Accuracy	95.21%	99.7%
Algorithm	MobileNetV2	YOLOv8
Diet Recommendation	No	Yes
Diet Tracking	No	Yes

The remainder of this paper is structured as follows: Section 2 details the methodology, outlining the system architecture and algorithms used. Section 3 presents the results and evaluation of the system's performance. Finally, Section 4 concludes the paper and discusses potential future directions.

2. Methodology

This section describes the methodology employed in the development of CalorieInsight, an AI-driven system for automated food calorie estimation and personalized dietary management. The system architecture is designed to integrate image-based food recognition [6], calorie estimation, personalized dietary recommendations, and nutritional tracking.

2.1 System Architecture

CALORIEINSIGHT follows a modular architecture, comprising four primary modules: (1) Image Acquisition and Preprocessing, (2) Food Recognition and Calorie Estimation, (3) Personalized Dietary Recommendation, and (4) Nutritional Tracking and Goal Adjustment as shown in the figure 1. The system utilizes a client-server model, where the client application, implemented using HTML, CSS, and JavaScript, provides the user interface [7] for image upload, dietary input, and result visualization. The server-side, implemented in Python using the Flask framework, handles image processing, calorie estimation, dietary recommendations, and data management.

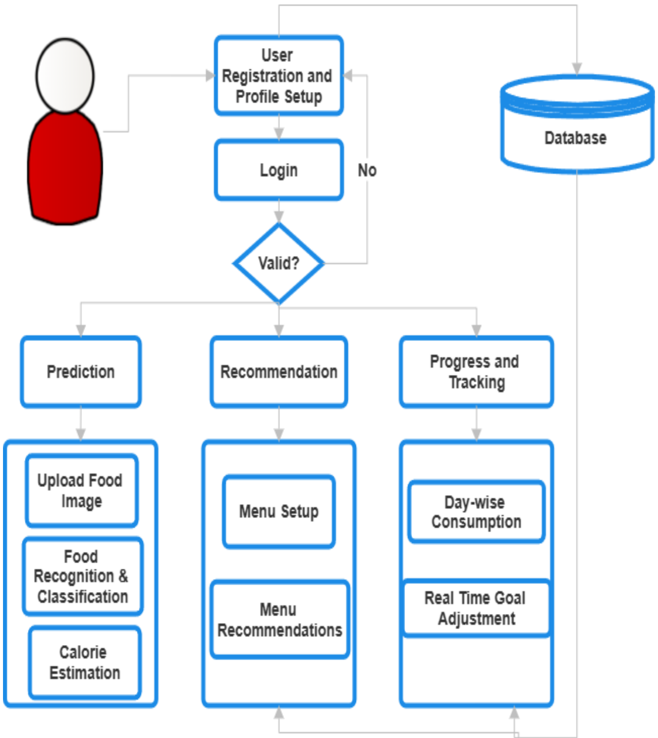

Figure 1 Calorie Insight's System Architecture

2.2 Food Recognition and Calorie Estimation

The food recognition module employs YOLOv8, a state-of-the-art real-time object detection algorithm, for accurate food identification and localization within uploaded images. YOLOv8 was selected for its superior speed and accuracy compared to traditional convolutional neural networks. The model was trained on a custom dataset comprising diverse food images, augmented with variations in lighting, angles, and portion sizes. The training process achieved a food recognition accuracy of 99.7%. Upon image upload, the system preprocesses the image to enhance food feature extraction. YOLOv8 then identifies and localizes food items, generating bounding boxes and class labels. The calorie estimation module utilizes a nutritional API (e.g., Nutritionix API) to retrieve calorie and macronutrient information [8] for the identified food items. Portion sizes [9] are estimated based on bounding box dimensions and pre-defined portion templates.

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2.3 Personalized Dietary Recommendation

The personalized dietary recommendation module generates tailored meal plans based on user-specific dietary preferences, health goals, and activity levels. User profiles are created upon registration, capturing information such as age, weight, height, activity level, dietary restrictions, and food preferences. A decision tree algorithm [10] is employed to generate dietary recommendations. The algorithm considers user profile data, calorie targets, macronutrient ratios, and food preferences to suggest meal options. The decision tree is trained on a dataset of nutritional guidelines and meal combinations, optimized to align with individual dietary needs.

2.4 Nutritional Tracking and Goal Adjustment

The nutritional tracking module enables users to log their daily food intake [11], either through image upload or manual input. The system aggregates the logged data to generate reports on calorie and macronutrient consumption. Users can track their progress towards dietary goals and adjust their plans accordingly. A real-time goal adjustment feature dynamically modifies the recommended meal plans based on user progress and weight changes. If a user's weight deviates from their target, the system adjusts calorie targets and macronutrient ratios to facilitate weight management.

3. Results and Discussion

3.1 Results

Food Recognition: The system has successfully identified and located "dosa" and "idli" within the image, as indicated by the bounding boxes. The labels "dosa" and "idli" are displayed along with confidence scores (e.g., "dosa (106 kcal) 0.747") as shown in figure 2. This demonstrates the system's ability to recognize multiple food items in a single image. **Calorie Estimation:** The system has calculated the calories for each food item (106 kcal for dosa, 40 kcal for idli). It has also estimated the quantity of each item (2 dosas, 3 idlis). The total calorie count for the meal is displayed at the top (332 kcal).
Personalized Meal Recommendations: The system has generated personalized meal recommendations can see in figure 3, for breakfast, lunch, and snacks, based on the user's data. The recommendations include specific dishes with ingredients [12] (e.g., "Pork Stir-Fried with broccoli and cabbage").

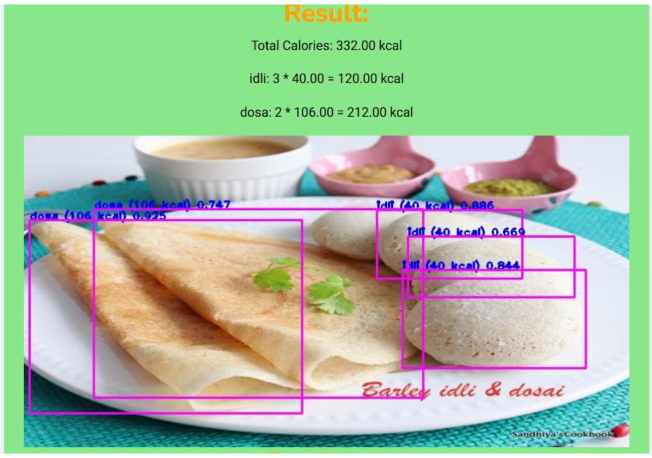

Figure 2 Screenshot of Food Recognition and Calorie Estimation Results

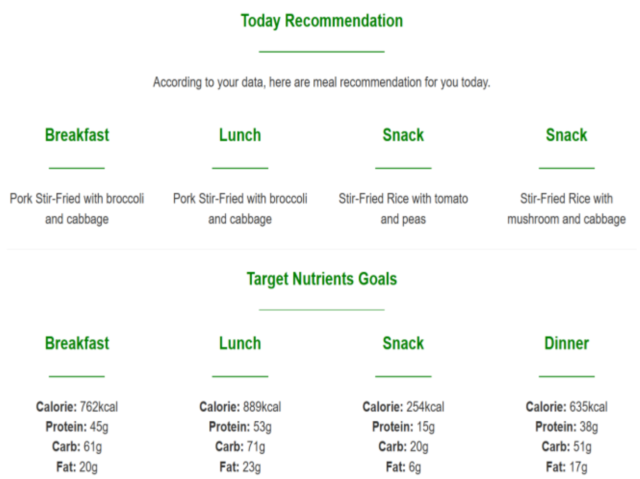

Figure 3 Screenshot of Personalized Meal Recommendations and Target Nutrient Goals Generated by CALORIEINSIGHT

Target Nutrient Goals: The system provides detailed nutritional information for each recommended meal, including calorie, protein, carbohydrate, and fat content [13]. This aligns with the user's target nutrient goals. **Food Tracking Functionality:** The interface allows users to add food items to their breakfast log. Users can specify the food, portion size, and portion type (grams) as shown in figure 4.

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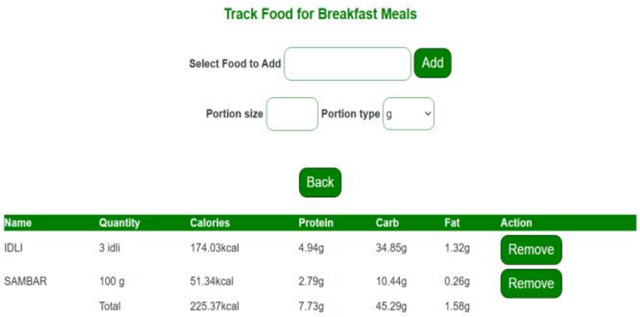

Figure 4 Example Food Tracking Interface for Breakfast Meals

The system calculates and displays the calories, protein, carbohydrates, and fat content for each food item. The total nutritional information for the breakfast meal is also displayed. There's an option to remove items from the log.

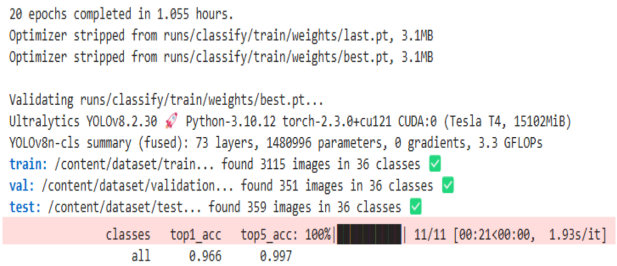

Figure 5 YOLOv8 Training and Validation Results

The Figure 5 shows screenshot of performance metrics of the YOLOv8 model, achieving a top5_acc of 99.7% on a dataset of 3115 training images, 351 validation images, and 359 testing images across 36 food classes.

3.2 Discussion

The results presented in the preceding section demonstrate the efficacy of CALORIEINSIGHT in achieving high-accuracy food recognition and providing valuable dietary management features. The 99.7% top5_acc achieved by the YOLOv8 model signifies a substantial improvement over existing systems, such as the one utilizing MobileNetV2, which reported a 95.21% accuracy. This improvement underscores the suitability of YOLOv8 for real-time food recognition tasks, particularly in scenarios involving complex images with multiple food items. The high accuracy translates to more reliable calorie and macronutrient estimations, which are crucial for effective dietary guidance. The integration of advanced deep learning (YOLOv8) and machine learning (decision tree) techniques within a user-friendly interface demonstrates the potential for AI-driven systems to revolutionize dietary management. The high accuracy achieved in food recognition, coupled with personalized meal planning and real-time tracking, provides a comprehensive solution for individuals seeking to improve their nutritional habits [14][15].

Conclusion and Future Work

This paper has presented CalorieInsight, an AI-driven system for automated food calorie estimation and personalized dietary management. The system utilizes YOLOv8 for high-accuracy food recognition and a decision tree algorithm for personalized meal plan generation. The evaluation results demonstrate the effectiveness of CalorieInsight in providing accurate food analysis and personalized dietary guidance. However, it is important to acknowledge certain limitations. The dataset used for training the YOLOv8 model, while diverse, may not encompass all possible food items and culinary styles. Future work should focus on expanding the dataset to enhance the system's robustness and generalization. Additionally, while the user study provided valuable insights, a larger-scale evaluation involving a more diverse population would further validate the system's effectiveness. Future research could explore the integration of advanced machine learning techniques, such as deep reinforcement learning, for dynamic meal plan adjustments and personalized feedback. Incorporating user feedback into the training process could also further improve the accuracy and relevance of the system's recommendations. Additionally, the development of a mobile application would increase the accessibility and usability of CalorieInsight, facilitating widespread adoption.

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