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Generative AI-Based Recommendation system for Healthier Food Alternatives.

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ABSTRACT

Addressing the growing health concerns around the world, we need to introspect on our food choices and eating habits to enhance the need for healthier dietary choices and food safety. Our research project introduces a platform that empowers individuals to make informed food decisions.

System provides personalized dietary recommendations and detects food adulteration using generative AI technologies. The methodology involves generative AI techniques, like Llama and Langchain, to build an advanced platform for food recognition and personalized diet recommendations. The platform analyses user inputs, such as ingredient lists and food images, to deliver important nutritional information and health-focused alternatives. Generative Adversarial Networks (GANs) are utilized to analyze food images, ensuring precise detection of adulteration in real-time. This approach enhances our ability to verify food safety. Users can also upload a food image or ingredient list, and the system processes the input using a combination of LLMs and GANs to give an ingredient analysis of a food product and provide healthy alternatives for users. This is crucial for providing nutritional insights and safety alerts against adulteration. It helps users stay healthy by providing clear nutrition information, warning them about unsafe food, and empowering them to make smarter, safer food choices.

KEYWORDS: Food Adulteration, GAN (Generative Adversarial Network), Generative Artificial Intelligence, LLMs (Large Language Models), Recommendation System.

1. INTRODUCTION

In today's fast-growing global order, we often neglect our health and food habits. Because of this, various global health concerns are rising at a high pace. According to WHO, obesity is the new global epidemic spreading across the globe (2024). One of the main causes of obesity is our daily food choices, which are responsible for the overall health of any human being [1]. The lack of proper nutrition causes many chronic diseases other than obesity, such as cardiovascular diseases, endocrinal disorders, diabetes, kidney stones, and many more [6]. As these concerns rise, it's everyone's duty to realize the importance of nutritional value and food habits [5]. Many good health alternatives can increase the nutritional value of our food and can prevent many disorders; often, we are unaware of them [9]. Many processed food products contain adulterants, additives, artificial flavours, and colours which are really dangerous for our body [4]. Now, it's high time that we should realize the importance of food safety and change our food habits accordingly, so that it prevents us from any disease.

Recent advancements in Generative-AI have paved the way for innovative solutions to address these issues. These technologies offer an approach to analyse food nutrition, estimate caloric values, and provide precise health alternatives [8]. In recent years, Machine Learning models, especially Convolutional Neural Networks (CNN), emerged as highly effective in tackling the problems of various fields, including food nutritional analysis, calorie estimation, food ingredient, and adulteration detection, etc. [2][3]. However, all these models highly rely on large input image handling and strict feature extraction rules [9]. Also, the conventional CNN methods have high memory complexity, which is one of the main drawbacks of Machine Learning models [3]. These ML algorithms are also not flexible enough to integrate with other algorithms to give an efficient experience to the user [7].

To address these drawbacks of the existing system, we are using Generative-AI technologies. Our system leverages Generative-AI to enhance the efficiency and flexibility of food recognition, nutritional analysis, and adulteration detection [6,8]. Unlike conventional systems, Generative-AI models, such as Generative Adversarial Networks (GAN) and Language Models (LLM), are capable of generating realistic representations of food data and creating synthetic data [7]. These features allow greater adaptability with higher amounts of data and variable data. We can also augment existing datasets to increase robustness in ingredient analysis and adulteration detection [4].

2. LITERATURE SURVEY

To give accurate nutritional analysis to the user, the first step would be to estimate the amount of calories present in the food we are consuming. The calorie-specific food choices can improve the health of users [1]. Various methods are used for calorie estimation in existing systems. Most of them uses neural network algorithms and object detection algorithms [8]. The existing system follows some basic set of steps, such as collecting input images and forming a dataset and then training that image data on models based on CNN (Convolutional Neural Networks) and object detection algorithms to get output of nutritional analysis.

Sarode et al. [1] uses PostgreSQL as the backend part to store annotated input images, which are trained on Deep CNN algorithm-based models to provide caloric values. Nivedhitha P et al. [2] uses Food101 and EDA food datasets as input and creates a system that recognizes foods using the YOLOv4 (You Only Look Once version 4) algorithm [2]. The YOLO algorithm provides faster results than other CNN algorithms [2]. Sombutkaew R. et al. [3] uses the Mask-RCNN (Mask Region-based Convolutional Neural Network) algorithm for accurate Thai food detection. The Mask-RCNN algorithm provides more insights, such as food area estimation and depth analysis, to increase food calorie and nutrient estimation [3]. Understanding similarities and differences between various CNN models enhances our knowledge of various methods and their evaluation metrics [9]. Gözde ÖZSERT YİĞİT et al. [9] provides a comparison of various CNN models, such as Alexnet and Caffenet, which gives us an idea about the development of application-specific convolutional neural network models [9].

The next feature which our system aiming for is to integrate ingredient analysis and adulteration detection with nutritional analysis. The ingredient analysis increases knowledge about nutritional contents, allergens, and additives present in our food, which we are consuming regularly [6]. Ingredients play an important role in the metabolism of our body [7]. Giulia Menichetti et al. [6] provide the degree of food processing using the "FoodProX" algorithm. The FoodProX algorithm uses Fpro-scores and a Multi-Class Random Forest classifier to offer output. Meanwhile, Erban Alexander et al. [7] use metabolomic annotated food data and a Random Forest classifier to give genetic analysis. Adulteration detection using CNN is analyzed by Saranya P. et al. [5], who uses various image processing techniques such as Digital Image Processing (DIP) etc., and compares the results of various CNN-based models. Agrawal U. et al. [4] creates a model specifically for spice adulteration detection using Histogram Oriented Gradient (HOG) and Local Binary Patterns (LBP) feature extraction methods [4]. These provide important insights into adulteration detection.

Sudharson K. et al. [8] provide insights into a personalized nutritional system using cutting-edge AI and a comparison of the performances of various AI-based models and feature insights used in nutritional analysis. M. Kuzlu et al. [11] propose a Streamlit-based AI platform for NextG applications. However, the AI model used in this application provides crucial insights in the field of Artificial Intelligence. Xu Guo et al. [10] explore recent research in LLM (Large Language Models) and synthetic data generation, which is the base of our proposed system.

Table 1: Major Literature Summary

Authors & Year of Publication	**Methodology Adapted**
Ketaki Sarode et. al. (2023)	PostgreSQL database system, React Native, Deep CNN algorithm, and Roboflow for calorie estimation [1].
Meenashree S. S. et. al. (2022)	Food 101 dataset, Vector formation, YOLO V4 CNN algorithm for food recognition and calorie estimation [2].
Xu Guo et. al. (2024)	Real-time synthetic data generation using LLM (Large Language Model), Prompt engineering, and Verbalizer [10].
Urvashi Agrawal et. al. (2024)	Neural Networks with Histogram Oriented Gradients (HOG) and Local Binary Patterns (LBP) for spice adulteration detection [4].
Nivedhitha P. et. al. (2022)	Food101 and EDA food datasets, YOLOv4 for food recognition [2].
Sombutkaew R. et. al. (2023)	Mask-RCNN algorithm for Thai food detection, food area estimation, and depth analysis to enhance calorie and nutrient estimation [3].
Giulia Menichetti et. al. (2024)	"FoodProX" algorithm, Fpro-scores, and Multi-Class Random Forest classifier for food ingredient analysis [6].
Saranya P. et. al. (2024)	Digital Image Processing (DIP) techniques and comparison of CNN-based models for adulteration detection [5].

3. METHODOLOGY

The proposed system uses Generative AI techniques, including Large Language Models (LLMs) such as Llama and tools like LangChain, to develop an advanced platform for food adulteration detection, personalized dietary recommendations, and food recognition. Using Generative Adversarial Networks (GANs), the system can study food images, accurately classify food items, and provide detailed calorie estimates. Furthermore, GANs are used to detect food adulteration.

With the help of Transformer Google Gemini Pro API, the system analyzes both text and images provided by the user. This helps the system gather nutritional information and ingredients, making food identification and detecting adulteration more accurate

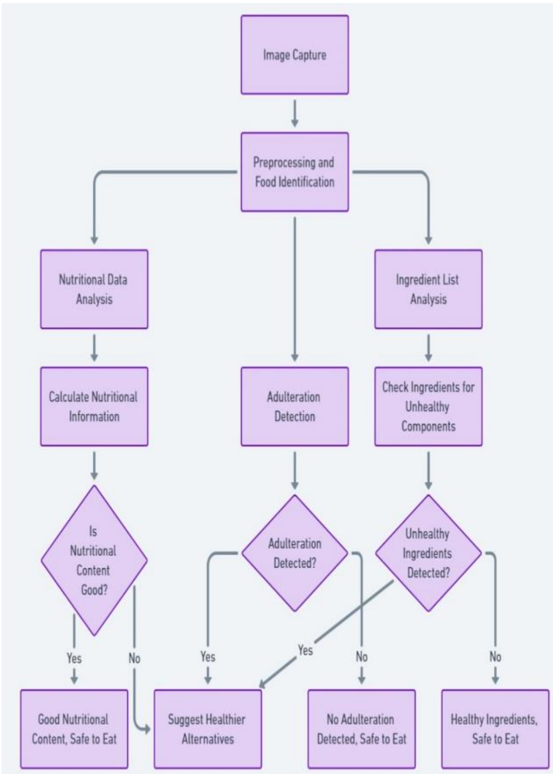

Fig. 1: Methodology

The system uses OpenCV for image processing tasks like contrast enhancement, edge detection, and noise reduction. There are several steps to improve image analysis. Gaussian Blur is applied to reduce image noise and improve feature extraction for both text recognition and food identification. CLAHE (Contrast Limited Adaptive Histogram Equalization) is applied to make details clearer, especially in low-quality images. The system makes use of (Employs) Content Based Filtering Algorithm to Provide Healthier Alternatives.

For the user interface, Streamlit, an open-source framework, enables users to interact with the system by uploading food images and receiving the output. Text identification is handled using Vanilla GAN, which converts text from ingredient lists on packaged foods into machine-readable data. The system provides a highly accurate, real-time platform for estimating both the nutritional value and safety of food, leading to healthier and safer daily eating choices.

Table 2: Technologies and Algorithms

Technology	**Used in the Project**	**Advantages in the Project**
Food Identification	Google Gemini Pro Vision.	High accuracy in identifying food, even in challenging scenarios like poor lighting.
Semantic Segmentation	Custom-trained model for food portion segmentation.	More precise segmentation and accurate portion size estimation.
Monocular Depth Networks	Monocular depth estimation for portion size accuracy.	Improved practicality and accurate 3D size estimation from a single image.
GAN for Packaged Food	Vanilla GAN for text extraction from images.	Cost-effective while maintaining reasonable accuracy for images.
Text Processing	BERT for ingredient list analysis.	High accuracy in understanding and classifying ingredients.
Adulteration Detection	LSTM networks for detecting patterns of adulteration.	Robust detection of adulterants through complex pattern analysis.
GANs for Recommendations	GANs for generating healthier food alternatives.	Creates healthier alternatives even with limited database options.

3.1 Expected Results

• Image Capture: The process starts with capturing an image of the food product.
• Preprocessing and Food Identification: The system performs preprocessing to clean the data and identify the food.

• Nutritional Data Analysis Service: The system fetches the necessary nutritional information related to the food item from a database. It calculates key nutritional metrics, such as calories, fats, carbohydrates, and proteins. A decision point evaluates whether the nutritional content is good (healthy).

• Adulteration Detection Service: The system runs tests or models (such as machine learning or GANs) to detect possible adulteration in the food. A decision point evaluates whether adulteration was found.
• Ingredient List Analysis Service: This branch focuses on analyzing the ingredients list of the food. A decision point checks if the system needs to compare multiple ingredient lists (this might apply to comparing different versions or brands of the same product).
• Healthier Alternatives Recommendation: Any time the system finds that the food is not ideal, either due to poor nutritional content, adulteration, or unhealthy ingredients, it directs the flow to Healthier Alternatives Recommendation, where the user is provided with alternative food options that are healthier and safer.

4.CONCLUSION

Human beings possess 3 fundamental necessities for survival. One of them is food. In today's era, making healthy food choices, avoiding junk and adulterated foods, and finding nutritious alternatives can be challenging due to a lack of knowledge. This makes it hard for us to stick to a healthy and balanced diet every day. To address these challenges, we are developing a comprehensive system with key objectives: providing healthy food alternatives, delivering personalized diet plans, detecting food adulteration, and identifying the nutritional composition and caloric value of foods. The proposed methodology employs the advanced Generative AI technologies such as Generative Adversarial Networks (GAN) , Large Language Model (LLM) ,LangChain and other generative AI models for accurate calorie estimation, adulteration detection and recommendation . We enhance the system’s accuracy and efficiency by integrating a user-friendly API. By combining advanced technologies, our system improves the customer experience compared to existing systems that rely on traditional neural networks. This system provides healthier food recommendation, personalized dietary plan , detection of adulteration for healthy life. OR Our system helps society by offering healthier food recommendations, creating personalized dietary plans, and detecting food adulteration, promoting a healthier lifestyle and empowering individuals to make informed, nutritious choices for their well-being.

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