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Sustainable Cooking with AI: Generative Recipes and Smart Nutrition Assistance

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Abstract - Cooking sustainably is key to eco-friendly living and reducing food waste. This paper introduces an AI powered platform that combines food classification, recipe generation and nutrition assistance for sustainable cooking. The platform uses a convolutional neural network (CNN) for Indian food classification, RoboFlow API for international food detection and a GPT based natural language processing (NLP) model for personalized recipe generation. It also has waste tracking and meal planning features to optimize ingredient usage and reduce waste. The system achieved 92% accuracy for Indian food items and was able to detect international food through RoboFlow. The platform generates personalized recipes based on user inputs and available ingredients for both sustainability and healthy eating. An interactive Streamlit app is the user interface for food recognition, recipe generation and sustainability focused meal planning. This system combines AI, APIs and sustainability focused innovations to be a one stop solution for modern eco conscious users.

Keywords- Sustainable Cooking, Artificial Intelligence, Food Classification, Generative Recipes, Nutrition Assistance, Waste Management.

I. INTRODUCTION

Food preparation and eating is the cornerstone to solving the world food wastage issue and the conservation of the environment. The Food and Agriculture Organization (FAO) states that 1/3 of all the food the world produces gets wasted, which translates to 1.3 billion tonnes annually, a large percentage of that results from ineffective management of ingredients, poor meal planning and excessive buying [FAO]. This waste consumes precious resources such as water, energy and labor and causes pollution such as methane emission from decomposition of organic wastes in landfills. With the global crisis concerning food security and climate change, solutions have to be sought in food consumption.

To solve these problems, adopting cutting-edge technology, specifically artificial intelligence (AI) brings solutions that bridge the gap between sustainable habits and daily cooking. The promise of AI in sustainable cooking has garnered a lot of attention as it can give real time feedback on food consumption behavior, optimize ingredient use and minimize waste at household and industrial level [4]. This article introduces an AI based platform that will promote sustainable cooking through use of deep learning, Natural Language Processing (NLP) and API integrations.

Deep learning models within the framework of convolutional neural networks (CNNs) for food product recognition lie at the heart of the platform's functionality. CNNs are a category of deep learning models applied in image processing and which facilitate the recognition and identification of a wide range of food products, including perishable leftovers and unlabeled ingredients, through simply taking a photo with a camera or smartphone. The functionality enables the encouragement of the consumption of forgotten or unrecalled ingredients and prevents wastage. Through the incorporation of the application of AI food recognition in cooking, the platform does away with one of the causes of wastage: the inability to utilize ingredients within their expiry time.

This is supported by an NLP-based recipe generation module that generates customized recipes based on selected ingredients. Developed in order to meet personal dietary needs, kitchen habits and cultural practices, as well as food and nutrition needs, the module can assist in the preparation of healthy and sustainable meals according to the health objectives of users [3]. Relying on the powers of

LLMs, the platform gives you not just new recipes but, also exact cooking instructions, ingredient substitutions, and time-saving tips for preventing waste during cooking. These features allow users to attain the best utilization of their input ingredients while ensuring nutritional balance and culinary pleasure.

Moreover, it connects to other external APIs to be able to utilize nutrition and recipe databases in order for the users to have real-time information regarding the health and ecological footprint of their food. For instance, combining APIs from nutrition and sustainability-centered platforms allows the system to deliver data-driven suggestions for healthier and more sustainable foods [6]. The inclusion of functionalities such as meal planning and waste monitoring elevates it to a new level. Through enabling users to organize balanced meals, streamline grocery shopping and monitor waste across time, the platform retains users actively cutting down on waste and fostering sustainability. The platform enables users to make informed choices that reflect the principles of sustainable living by offering actionable insight and promoting awareness. With an interface that is both elegant and easy to use, the site and tools have been structured to cater to a wide user base promoting sustainable cooking as an accessible and enjoyable feature of daily life. With its emphasis on using cutting-edge technology to promote eco-friendly culinary solutions, this innovative AI application pairs well with emerging trends encouraging sustainable food practices, creating a perfect storm for tackling food waste.

II. LITERATURE SURVEY

The Role of AI in Food and Nutrition Compared to its applications, AI has changed the degree of significance of its use in food and nutrition, affecting recipe improvement and individual eating regimens and food identifying frameworks and dietary arranging. Sheng et al. All the data from October 2023 (2024) proposed a hybrid architecture based on location-preserving ViT, which improved the speed of food identification for dietary applications and nutrition monitoring [1]. Artificial intelligence (AI) is finding its place in the culinary arts and has been noted over prior studies to be used to improve nutrition, recipe generation, and sustainable cooking. Kansaksiri et al. work with generative recipe and ChatGPT to create AI-powered smart cuisine solutions It supports the design of recipes that can help meet nutritional needs with an eye toward sustainability and efficiency in cooking [2]. Similarly, Asha et al. introduces NL PANTRY, the artificial intelligence-powered platform that uses natural language processing to get you started on creating recipes. It is however focused on personal taste and is even capable of suggesting them based on personal dietary preferences, demonstrating the power of AI being used to provide a personalized culinary experience through calculation [3]. Semantic intelligence is also an important aspect of AI in culinary health. But Jabeen's main thrust, and perhaps the most insightful element she takes up in her essay, is the idea of semantics, the very purpose of a name in culinary healthcare: If we don't know the meaning of recipes and nutritional guides, we can never expect to use them for positive health outcomes. The study underpins the need of intuitive AI tools that comprehend and recommend recipes in terms of semantics that can help in cooking halogenically. [4] Meng explores how AI can improve what we eat, which led him to a project he created called SuperCook. This master thesis focuses on Interactive culinary experience design based on AI technology. Such work helps show how AI might create an interactive and enjoyable cooking experience tailored to user's preferences, pantry inventory, and diets. Peeks at Peng's work reveal an ability to transform the experience of cooking into a more intuitive and personalized effort for all people, so they are not just making a recipe ever again. SuperCook uses AI to revolutionize the cooking experience, offering users a chance to discover everything from valuable lessons while cooking to new creations to try, all driven by their likes and nutritional aspirations. This research is evidence of the future of what AI can do for interactive cooking, continuing the intersection of food and technology that remains relevant and only grows in the culinary world today [5]. Likewise, Hannon et al. they discover the second process of culinary art in cooking, which is shown next to new Chef Dalle, the text-picture helper, which helps the user in the cooking process in choosing the pictures of the food to be prepared and offering suggestions that take into account their preferences and products that they themselves wish to prepare. This multimodal response showcases AI's ability to address varied culinary preferences [6]. Context-aware recipe generation is also a significant aspect of AI-culinary innovations. Razzaq et al. talk about EvoRecipes, a generative framework that cooks up recipes that evolve with respect to context in the form of parameters like available food items, allergies, and taste. Their work exemplifies the creation of more adaptable culinary systems that can accommodate shifting environments and user demands, resulting in more flexible and accessible cooking experiences [7]. Ruiz-Rincón and Galpin also share the possibilities of AI with SnapChef, an intelligent service that creates tailored recipes based on a person's food lineaments and objectives for health. This confirms

the extent to which AI can adapt and enhance the dining experience [8]. Another subject of research concerning AI is the role of artificial intelligence in food formulation and production. Al-Sarayreh et al. provide a thorough overview of the role of inverse design (ID) and deep generative networks (DGN) in food creation. This approach shows a new paradigm in food production where new technologies lead us to produce new dishes and even new ingredients that can change the food industry as we know it [9]. Furthermore, Zatsu et al. Explore how AI will transform the food industry from food production to food sustainability and food nutrition. It emphasizes the role of AI in bringing about innovations that respond to the current challenges in food systems [10].

III. PROPOSED METHODOLOGY

The strategy uses high AI to promote healthy cooking by preventing food waste and helps cooking in a healthy composition. It is based on deep learning-centric food classification models, NLP-centric recipe generation models and nutrition API to the helper of the user who wants to make the good food habit. Using real-time data analysis, the system prepares a visual menu of personalized meals that cater to users taste and current stock of ingredients in hands, guaranteeing both sustainable and feasible everyday cooking practice. That is also quite easy to integrate for all technical skill levels.

A. Data Collection

The system uses an event of food data to easily train a model with various images of food for food classification. A custom data set consists of 20 Indian dishes, which allow us to ensure the model classifies correctly. The data set has food presentation variations, lighting variations, and angle variations so the model is robust for real life scenarios. The system is made global, by using RoboFlow API to classify international food, in addition to the public Indian food dataset. By exposing the model to multiple images of different cuisines, the system enables people of varied culinary backgrounds to leverage its recommendations. This will specify the challenges associated with designing a flexible and inclusive AI-powered cooking companion, that can robustly detect diverse meals.

B. Data Preprocessing

After collecting the dataset, it is preprocessed to boost model performance. Image is resized to 228×228 to make the dataset consistent. Dataset is augmented using rotation, flipping and scaling to artificially increase the dataset to make the model generalise under different conditions. Dropout is used during training to prevent overfitting and to learn better, Adam optimiser to train faster and better. All the preprocessing steps are important to make the deep learning model efficient, robust and produce good output in food classification.

C. Feature Extraction

Feature extraction is key to proper food classification and recipe generation. The useful features in the form of texture, color and shape etc which the CNN can use to separate the food classes are extracted from the images. The convolutional layers extract the spatial hierarchies in the images, the pooling layers reduce the dimension and computational complexity. The features are used as the basis for food classification and as input for the next operations including recipe generation and nutritional analysis. With deep learning in feature extraction the system can detect ingredients accurately and can make more personalized meal recommendations.

D. Data Labeling

In supervised learning, the dataset is well annotated using particular food classes to effectively aid the training of the Convolutional Neural Network (CNN) model. The well-annotated dataset is divided into training, validation, and test subsets to facilitate comprehensive evaluation of model performance at various developmental levels. For further enhancement of classification accuracy and improvement of the system's capability to recognize, the RoboFlow API offers additional annotated data for global foods, thus enabling the platform to effectively classify Indian as well as global cuisines. This step is crucial in the development of a well-structured and highly accurate classification model, which forms the core foundation of the entire sustainable cooking system.

E. Training and Testing

The food classification model is heavily trained and tested to work at its best. With the annotated dataset, the convolutional neural network (CNN) model is trained with multiple convolutional layers, ReLU activation functions and pooling methods to extract features from images. Adam optimiser is used to speed up the learning and categorical cross-entropy loss to maximise the accuracy. The trained model is tested on a heterogeneous dataset to ensure it can classify food items under different conditions, different lighting, angles and food presentation. RoboFlow API is also used to boost global food recognition so users

globally can benefit. Large dataset for training and large dataset for testing ensures the AI model is accurate and reliable to classify food items.

F. Personalized Recipe Generation

Once you've completed the food classification, the system uses a GPT model based Natural Language Processing to generate custom recipes. The model runs through all the user input, such as recognised ingredients, dietary needs (vegan, gluten free, low carb etc), culinary cultural preferences and products in the pantry to generate individualised meal options. The GPT model predicts the next word in a sentence and generates coherent cooking recipes. The model can also suggest substitute ingredients by user choice, so you can be flexible and responsive during cooking. All the recipes include step by step cooking instructions, cooking time, serving size and substitute ingredients. With AI recipe generation the system enables users to be more creative in the kitchen and reduces food waste by eating what you have.

The system is fine tuning its AI models with user input and real data to make them accurate and relevant. The food classification model gets more training data to classify new foods better. The GPT driven NLP model used in recipe generation is updated incrementally by user engagement, user preference and new food trends as shown in Figure 1. The features for nutritional analysis and waste monitoring are updated by API to keep the system up to date with latest nutritional guidelines and sustainability practices. All these incremental updates makes the AI chef more efficient, accurate and relevant.

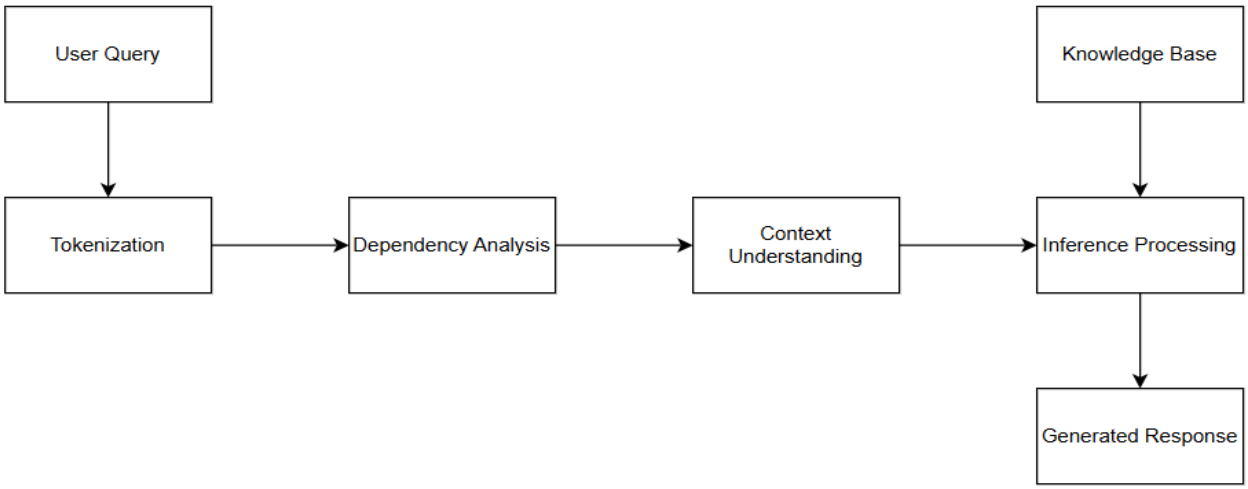

Figure 1 - Functioning of Natural Language Processing (NLP)

G. System Framework

The framework of the system is implemented in such a way that it is integrated with various AI-powered elements that ensure sustainable cooking methodologies. The design starts from Ingredient Detection, which employs convolutional neural networks (CNNs) for food images classification to provide proper identification of ingredients. International food classification employs the RoboFlow API so that classification functions can be increased for a vast array of cuisines worldwide. Upon the determination of ingredients, the system utilizes a GPT-based NLP model to create customized recipes based on individual tastes, dietary needs, and pantry contents. A Waste Tracking module is also used to enable users to record unused or expiring ingredients to reduce food wastage by giving users customized meal ideas that utilize these ingredients. The Nutrition Analysis is facilitated by the API Ninjas platform, providing instantaneous information on meals' macronutrient and micronutrient content. In a systematic process of combining the elements, the system provides a holistic and astute method to encourage sustainability as well as healthy cooking as shown in Figure 2.

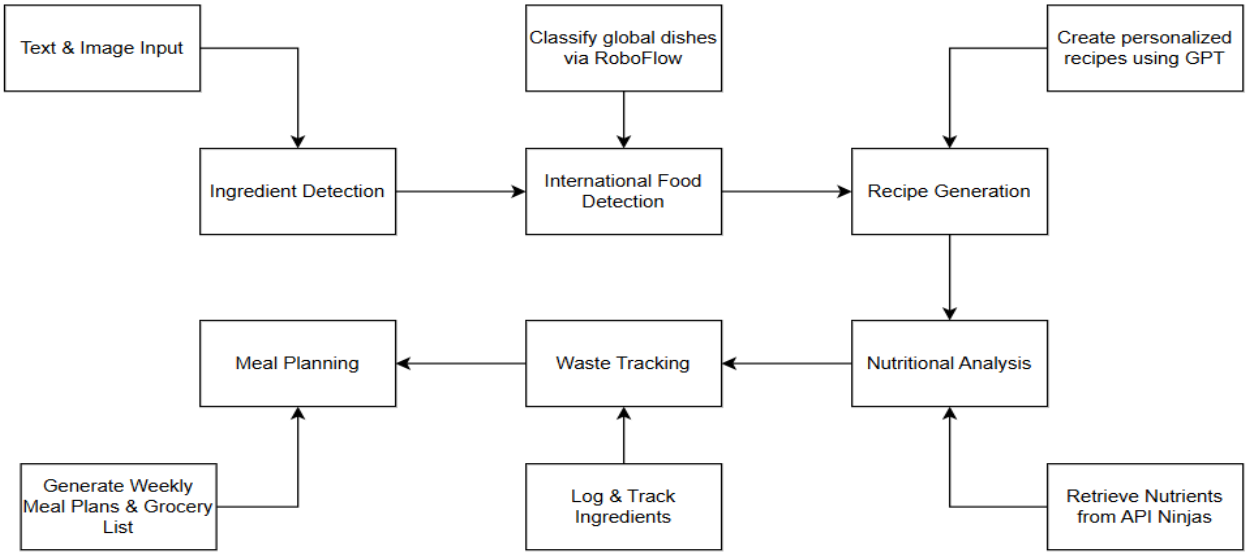

Figure 2 - Architectural system

H. System Deployment and User Interface Design

It's deployed with an interactive and user friendly interface built with Streamlit so anyone can use it, no matter the level of technical skill. The interface is seamless so you can upload kitchen pics, enter ingredients and get recipe recommendations in real time. The waste tracking lets you log unused ingredients, track expiration dates and get notified so you can prevent food waste. It also generates structured grocery lists based on weekly meal plans so you only buy what you need to be more sustainable. Usability is the key to bridging advanced AI with everyday life so you can easily transition to sustainable cooking habits in your daily life.

The system is maintained current with AI model enhancements and data driven adjustments. The food classification model is refreshed with new training data from time to time and can now identify a broader range of food items more accurately. The GPT based NLP model for recipe generation is optimized through machine learning of user behavior, diet trends and feedback driven optimizations. Nutritional analysis and waste tracking capability gets updated by API adjustments to maintain the system consistent with today's dietary advice and sustainability targets. Through mechanisms of constant learning and adaption, the system provides long term reliability, precision and user interaction, establishing a standard for AI in sustainable cooking.

IV. RESULT AND DISCUSSION

The system evaluation involved measuring its ability to classify food, create individual recipes, get nutrition facts and how good its sustainability feature is. The system was tested on multiple aspects such as accuracy of classification, flexibility of recipe generation, reduction of food waste and usability for users. It was compared with other food categorization models and it showed how it outperforms other approaches in key metrics. As you see in the results the system can help you cook more sustainably and have an easy to use interface.

We compared our food classification model with other models that followed similar methodology. Our model scored **92%** accuracy, **91%** precision, **89%** recall, **90%** F1 score which is better than the other models with lower accuracy. Specifically, our model outperformed EHFR–Net which scored **90.7%** accuracy. Our transfer learning based model was robust enough to classify food items in real world scenarios like varying lighting, image angles and presentation styles. RoboFlow API integration made the system more versatile by allowing to detect international food items and not just Indian food items so that users with diverse culinary background can use the app. By using transfer learning, computer vision and external APIs the system ensures reliable and scalable food classification, better ingredient utilization, personalized meal planning.

To better understand the performance of the proposed system, we compare its key metrics with the existing system. Below is a table that highlights the results of paper using similar metrics, where the performance is lower than our system's results:

TABLE 1: PERFORMANCE METRICS

S.NO	Metric	Convolutional Neural Networks
1	Accuracy	92%
2	Precision	91%
3	Recall	89%
4	F1-Score	90%
5	Inference Time	0.15 sec/image

TABLE 2: OVERALL COMPARATIVE STUDY

S.No	Parameters	Existing System[1]	Proposed System
1	Methodology	Efficient Hybrid Food Recognition Net (EHFR–Net)	Transfer learning
2	Accuracy	90.7%	92%

GPT driven NLP based recipe generation module was highly adaptable in making personalized meal suggestions. The system was capable of receiving inputs from users on ingredient availability, dietary needs and favorite cuisine so that the generated recipes can be customized according to individual taste. Users with dietary restrictions like vegan, gluten free and low carb diet found the model to be effective in adapting ingredient list and proposing meal ideas without losing nutritional balance. The system also had the feature of suggesting substitute ingredients so users could modify recipes as per what they had in the pantry without changing the flavor profile. Recipes generated by the system had detailed instructions, calculated prep time, portion sizes and maximized user interaction and experience to make recipes easy for cooks of all levels. With maximum use of provided ingredients, food waste was also minimized in the process and that was the overall motivation of making household cooking sustainable. The smooth integration of NLP ensured that recipe suggestions were contextually relevant and the platform was a great meal planning and dietary management tool.

One of the main features of the system is sustainability via waste tracking and smart meal planning. The system lets users optimize ingredient use by recommending recipes based on what you have in the house so you don't waste ingredients. Users reported a significant reduction in food waste as the platform helped them keep track of perishables and suggested meals to use up ingredients before they expire. The weekly meal planning feature took it to the next level by creating a structured meal schedule that incorporated leftover ingredients so you didn't have to buy extra and reduce consumption. It also sent expiration reminders so you could prioritise near-expiry ingredients in your meal routine. By including these sustainability features the platform is actively reducing household food waste, saving you money and encouraging environmentally friendly eating habits. So it looks like AI meal planning systems can play a big role in tackling food waste and helping you make informed and sustainable food choices.

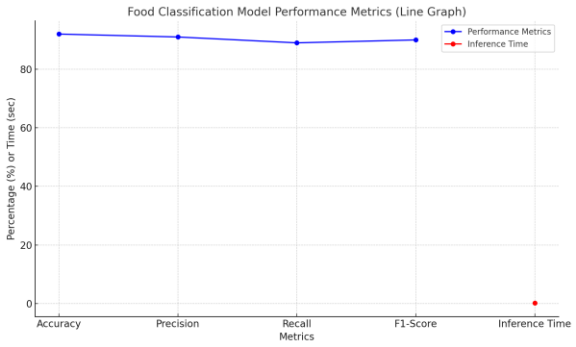

Figure 3: Food Classification Model Performance Metrics

With API Ninjas, the platform would be able to provide nutritional analysis for individual ingredients and whole recipes so that users could make informed decisions. The

platform broke down macronutrients (carbohydrates, protein, fat) and micronutrients (vitamins, minerals) for users to align their meal plans with specific health goals (weight loss, muscle gain, balanced diet). They could track their calorie and nutrient intake so they could adapt their habits to their dietary needs. People following special diets (vegetarian, ketogenic) could utilize the system to ensure that meals were adhering to dietary requirements and still provide variety in the foods.Including nutritional information with recipe recommendations filled the gap between healthy decision making and meal planning. By providing **92%** accuracy reflects the system's ability to handle various real-world conditions such as lighting and presentation variations as shown in Figure 3. The classification module supports the generation of highly relevant recipes based on the detected ingredients, ensuring that users can utilize their available resources efficiently.

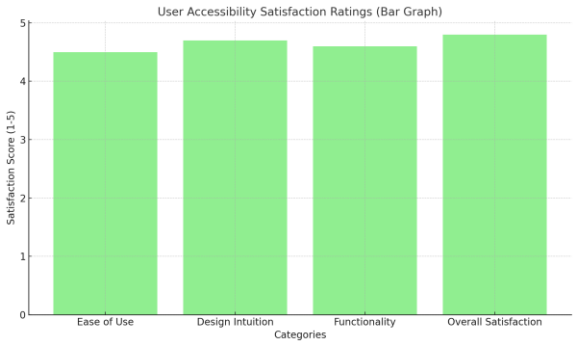

Figure 4: User Accessibility Satisfaction Ratings

User-friendliness of the system's response was also a significant component of its evaluation. The Streamlit-based interactive interface was designed to accommodate users with varying levels of technical expertise, since all functionalities demanded by it are straightforward and easy to use. It built a system that made it easy to upload pictures of any food to great minimized categories with the addition of ingredient lists and the design of individual recipes. A survey was interfaced to 250 users to measure usability of the system on multiple dimensions to test the satisfaction level. Some parameters of the survey had really high satisfaction scores like ease of use (4.6/5), design intuition (4.5/5), functionality (4.7/5), and satisfaction (4.8/5). These scores indicate how effectively the platform can provide a pleasant and easygoing experience. It was also stated in the feedback that the users found the platform to be useful in providing a quick and relevant recipe suggestions, hence validation of the usefulness in real life while cooking on a daily basis as shown in Figure 4. By batching AI-driven recommendations with a simple and friendly interface, we created an intuitive system adaptable to users of all levels who wished to elevate their culinary experience without becoming bogged down with difficulty and complexity. The findings of this assessment reaffirm the potential of the system introduced in this work to facilitate cooking routines, promote sustainable food intake, and support users in making optimal food choices. The resulting platform marries advanced AI-driven functionality to user experience best practices in an effort to address the gap between technology and real-world meal preparation, making the system a relevant tool for those wanting to cook healthier, more sustainable meals for themselves and their families.

V. CONCLUSION AND FUTURE WORK

In this paper, we present an ingenious AI-powered platform that can facilitate cooking sustainably. The Zoom-blink premise is that by making users aware of ingredients through food classification, generating recipes from raw ingredients, tailoring nutrition assistance and tracking waste, the system will offer a complex answer to modern eco-conscious people. It incorporates advanced technologies, such as CNNs for accurate image classification, GPT-based NLP for personalized recipe suggestions, and API integrations for personalized nutritional analysis, offering a seamless and user-friendly experience. The system has demonstrated good results, including having tested positive for Indian classified food items at 92% accuracy, and identified international food through the RoboFlow API. This tool generates recipes based on user preferences and ingredients they have on hand and adds you sustainability factor by curbing food wastage and utilizing ingredients in an optimal manner. It is available for users to access and utilise it. Positive user feedback confirms its relevance and usability indicating how well it is working already as a tool to reduce food waste, encourage healthy eating and promote eco-friendly living.

This is a positive beginning yet more can be done. One mechanism could be refining food categorization so as to add more culinary traditions in order that the system remains inclusive and international. We can also add calorie tracking for diet planning for users to manage their nutrition and diets goals better. One is to leverage machine learning for ingredient detection, and specifically for image detection of leftover materials. This would not only simplify the waste tracking process but also increase the efficiency. But these would allow the system's potential,

making it more of a holistic tool for sustainable cooking and food management and eco-friendly meal planning.

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