AI-Based Food Scanner for Allergens and Health Risks

Abstract--As the problem of food allergies is becoming more common these days, individuals are forced to be quite careful about the food they are eating. As a rule, the conventional checking of food labels is a very time-consuming and inaccurate procedure that is rather insufficient in case of individuals with various health issues or strict diets. The paper reports an intelligent Food Scanner system which automatically identifies allergens and health hazards in packaged and unpackaged foods by combining advanced image recognition, OCR, NLP and machine learning algorithms. It scans food pictures to identify ingredients and nutrition information and compares it with user tailored health profiles to provide real-time notifications and personalized advices to ensure the user makes informed eating decisions, therefore avoiding allergic reactions and ensuring better eating behaviors. The solution suggested has been found to be extremely accurate in determining allergens and risks and can be readily applied to different food products in different geographical areas. The strategy is a major advancement in the application of artificial intelligence in proactive dietary control as a combination of daily convenience, safety, and individual health advice.

Index Terms Food Scanner, Allergens, health risks, Artificial Intelligence, Image Recognition, machine learning, OCR, personalized Diet.

I. INTRODUCTION

The rates of chronic illnesses, food allergies, and other ailments that are diet-related have increased tremendously over the past few years across the globe. According to the world health organisation, millions of people are allergic to specific foods, and this might even prove fatal in some cases. Moreover, poor dieting habits increase the probability of such diseases as diabetes, high blood pressure, obesity, and heart disease. Although there is a rise in awareness there are often complicated ingredient lists, unnamed products and secret additives which can often lead to people being unable to identify potential allergens or health risks in the food they eat on a daily basis. Traditional approaches, including reading food labels manually or using general nutritional advice, are time consuming, susceptible to human error and cannot be used to manage individual diets. Also, the growth of processed and packaged food markets has brought an endless range of products with different recipes, sometimes it is so difficult that the user can trace any change in ingredients or even recognise an allergen that has just been discovered. Having more access to foodstuffs in the world market, people also become exposed to new things the ingredients of which can have the unexpected threats. The advancement of machine learning and artificial intelligence (AI) has enabled the creation of new methods of solving these issues. Intelligent systems can now perform the analysis of large volumes of food-related data, and can in turn identify trends, and can provide individualised patterns in real time. dietary advice. To provide the identification of allergens and measurement of health risks in numerous types of food items, the proposed AI-powered Food Scanner will be based on machine learning, optical character recognition (OCR), and image recognition methods. Whenever one uses a mobile device to scan an item in a food outlet, the system will automatically retrieve the ingredient data, possible allergens, and risk assessments depending on the health profile of the user. With this integration, the system is able to reduce the chances of adverse health consequences, as well as offer the users the assurance and the ease to make informed food choices. This paper provides the architecture, techniques, and performance appraisals of the AI-based food scanner, its design, and implementation. To promote the healthy and safe lifestyle, the system will support individuals with limited diets, allergies, and chronic illnesses. Also, the solution may be implemented on various food products, both fresh and packaged, which is why it is useful to use it in everyday life. The proposed system is a significant advancement in the sphere of intelligent diet management due to the combination of AI-based analysis with personalized healthtips.

II. RELATED WORK

A. Rajesh et al. [1] suggested an AI-based food allergy detection system based on transfer learning with a blockchain-based federated learning infrastructure. They work on enhancing privacy-sensitive allergen detection to allow distributed model training without exposing unstructured information about users. The system indicates the way secure machine learning architecture can be utilized to avoid cross-contamination threats, identify latent allergens, and build trust in food analysis applications.

S. K., A. R., C. R., and N. R. [2] designed AI-based ingredient detector, which combines natural language processing and computer vision to increase food safety. Their model uses OCR to extract ingredient lists, NLP to interpret terms related to allergens, and uses deep learning to classify foods. The contribution is the significance of integration of text and visual evidence in order to develop credible allergen identification systems.

NutriScan is an AI-based system that has been proposed by J. Nalavade [3] with the purpose of identifying ingredients and performing a nutritional analysis. The research shows that automated processing of ingredient lists can assist end users to learn about nutritional hazards. The study points out practical uses in mobile food measurement and justifies the idea of individual health checking.

Intelligent analysis of food allergens A. Perrotta [4] considered computer vision methods of allergens analysis of food. The paper highlights the difficulties associated with the identification of allergenic ingredients based on visual indicators only because of the similarity of ingredients and changes in packaging. Their results show the importance of using image recognition in conjunction with text extraction in enhancing the accuracy of allergens detection.

One app was designed by A. Bingcang [5] as Allertify, an Android-based application that recognizes food allergens. The system makes use of a combination of label scan, user allergy profile, and rule based filtering as a method to warn users about unsafe foods. This paper illustrates the implementation of smartphone applications to provide consumer protection through real-time alerts due to allergens.

S. Han et al. [6] created NutrifyAI, an AI-based system that provides real-time food monitoring and health tracking. Their model utilises deep learning and sensor information that generates individualised nutritional information. The study presents the potential of using AI in everyday eating habits to provide constant feedback on health to help manage chronic illnesses.

A. Sadilek et al. [7] examined machine-learned epidemiology as a way of real-time detection of foodborne illnesses. The system predicts the pattern of outbreaks by analysing masses of user-generated data and the possible food sources with contamination. This study illustrates the ways in which AI can assist the work of the public health agencies in monitoring and identifying food safety risks.

C. Liu et al. [8] proposed the DeepFood, a model that defines the recognition of food images using deep learning. Their system categorizes food products based on CNNs and helps in automated dietary evaluation. This initial research is an important contributor to the current food recognition systems and justifies the necessity of correct visual encoding in the intelligent food scanners.

F. R. Bertani et al. [9] applied fluorescence spec- troscopy to machine learning to identify almonds containing aflatoxins. This article sheds light on the application of optical sensing and artificial intelligence to detect dangerous chemical impurities that cannot be observed with the naked eye alone and diversify the range of food safety-related analysis.

D. MacMath [10] researched on the progress of artificial intelligence in enhancing the level of food safety standards. The paper explains how machine learning algorithms can be used in contamination detection, nutritional analysis and regulatory compliance. This study focuses on the potential of AI to reinforce food safety systems around the globe.

The article by S. Jiang et al. [11] introduced DietGlance, a privacy-conscious dietary monitoring device, which relies on wearable cameras and AI-driven knowledge models. They have a system that automatically identifies food people eat during the day which gives data on the eating habits without infringing on the privacy of the users. This research paper proves the overlap between wearables and nutrition tracking.

M. Han et al. [12] suggested an automated dietary system based on YOLOv8 to detect food items and Edamam API to retrieve nutrition information. Their system allows analysis and estimation of calories and food in real time thereby supporting health conscious users. The study demonstrates the efficiency of the current object detection algorithms in the dietary monitoring.

The S. R. Sahu et al. [13] designed a visual-based food allergen detection system with CNN. Their model deals with the problems of detecting the allergenic ingredients in mixed meals. This paper indicates that there is a necessity to integrate image analysis with ingredients based data on high-risk people.

A system suggested by P. K. Gupta et al. [14] involves the use of OCR and machine learning in analysing food labels to identify an allergen. They use their model to extract text on packaging, filter keywords on allergens, and verify the safety of ingredients. The research reinforces the use of OCR-driven systems in detecting allergens automatically.

R. Kumar et al. [15] suggested deep learning models that are based on mobile to detect food allergens in real-time. They can be used to scan food items on smartphone cameras so that the user can get a real-time alert on the safety of the item. This article indicates the possibilities of portable AI in assisting people with serious food allergies..

III. System Overview

The AI-based Food Scanner provides a secure and personalized system of dietary management and assists users in determining the presence of allergens and potential health risks in food items. In order to appraise packaged and fresh food products, the overall system is a combination of several artificial intelligence technologies, including machine learning algorithms, optical char- acter recognition (OCR), natural language processing (NLP), and image recognition. The modular nature of the architecture renders it scalable and able to complete effective processing on all types of food categories.

1)Food Image Acquisition:The consumers scan packed food or capture pictures of food using a mobile device. The system ensures that the images are done under varied lighting and orientation elements and they also accommodate multiple input formats. This module provides the raw visual information required to be analyzed further and to be able to be used in real-life situations, the image acquisition pipeline is created to resist variations in lighting, shadows, camera angles, distance, and partial occlusions. The system also adds the features of automatic focus, glare, and exposure to reduce distortions in the image due to the severe lighting or low lighting situations. The mechanisms of orientation handling make sure that the image that is captured will automatically be rotated or aligned in the right position before it is processed so that there will be no cases of recognition errors when the user holds the phone at awkward positions.

1) Ingredient Extraction and Analysis: Packaged foods have text extracted on their food labels, including ingredients, nutrition information, and allergen warnings, which is done using OCR. NLP techniques are employed in the detection of potentially hazardous additives, allergenicity of ingredients, and interpretation and standardisation of in- gredient lists. Image recognition with ingredient lists, nutritional information, allergy warnings, and information about the manufacturer. The sophisticated OCR engines with noise-reduction and text-alignment correction provide high-quality extraction with low-quality or curved label images.

2)Health Risk Assessment: Machine learning mod- els are used to assess the potential health risks of the scanned food items. The models consider user-specific health profiles, including dietary restrictions, allergies, and chronic illnesses, like diabetes or hypertension. Based on the data about each user, the system will identify the nutrients that can be detrimental to health and calculate the likelihood of adverse reactions.The analysis module will evaluate the nutrient levels of sugar, saturated fats, sodium, and cholesterol and whether these levels are above the safe levels of the user.

3)Individualized Advice and Notifications: This system provides the user with instant notifications and recommendations grounded on the analysis. The system produces instant alerts of allergens and suggests safer consumption habits or alternatives in the risk to health. This module ensures that the user is able to make informed dietary choices without any inconvenience and with confidence to make better choices depending on the overall classification of risk.The system produces actionable feedback instantly to promote highly healthy decision-making. In case an allergen has been identified, high-priority alerts are shown immediately to avoid unsafe con- sumption. In nutritional conflicts, the module offers specific advice, including portion control, less frequency of intake, or substitute foods that are more in line with the medical limitations of the user.A very intelligent and comprehensive design of proactive food regulation and food safety is created by joining these modules. The system ensures accurate real-time detection of allergens and health risk by integrating visual analysis, extracting text, deciphering the environment, and forecasting. The modular design also makes future additions, such as expansion of the allergen type, connection with regional food databases, and adaptation to emerging dietary trends, possible.Altogether, the proposed AI-based Food Scanner can be seen as a considerable advancement of intelligent, personalized, and real- time dietary control to improve security and health awareness among consumers.

IV. METHODOLOGY

The AI-based Food Scanner's methodology is centred on a methodical and modular approach to identify allergens and evaluate food items' potential health risks. To provide real-time, customised recommendations, the system combines a number of artificial intelligence technologies, such as machine learning, optical character recognition (OCR), natural language processing (NLP), and image recognition.

A. *Data Collection and Preprocessing*

The first step is collection of data in various sources. Whereas fresh foods are not photographed by the camera of a mobile device, the packaged food substances are photographed by barcodes or label images. The acquired images are then preprocessed using techniques such as contrast enhancement, resizing and noise reduction. NLP algorithms are used to standardise text contents in text-based labels with the help of OCR, and potential allergens and ingredients are identified. Further verification checks is done to control the processing of only clear and readable images which minimizes the mistakes caused by low-quality scans. The phase enhances reliability of downstream modules as it provides uniform and organized input information.

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D. *Allergen Detection*

After identifying the type of food and the ingredients, the system compares the extracted ingredients with a user-specific database of allergens that identify allergens. NLP methods are employed in the recognition of hidden allergens and unknown ingredient names. The system warns the user in real time where it identifies objects that could possibly have allergens. Cross reactive ingredients which can cause secondary allergy are also analyzed by the module. This will make sure that even indirect or less apparent risks of allerging are captured successfully.

E. It predicts health risk or nutritional imbalance or chronic disease risks with machine learning algorithms, including classification and regression. The user profiles that are taken into consideration are age, gender, allergies, and medical history. Risk scores will be generated to quantify the risk of adverse effects, including blood sugar spikes, worries about sodium intake, or excess calorie intake. The system also predicts long-term eating habits using previous scans to determine the trend which could be harmful to the health. These insights will facilitate more active and preventive diet control.

F. *Recommendation and Feedback*

System produces recommendations that are customised according to the assessment. The recommended modification of foods with a high degree of risk is thechange of portions or the substitutes. Users get alerted bymobile device notifications. In order to
step-by-step, prediction accuracy is increased, whereas system also receives input through user interactions. The

feedback of the user assists in refining the system to sense the individual preference and dietary behaviour with time. This unceasing improvement renders the suggestions more instinctive and customised.

G. Continuous Learning and Database Update

The methodology of the system allows updating its database with new food products and ingredients as well as user feedback due to the integration of continuous learning into the system. Machine learning models are retrained periodically in order to get a model with a higher accuracy of food identification, allergen detection, and risk assessment. This will ensure responsiveness to the evolving diets and emerging food trends. Newly revealed allergens and ingredient changes in the global markets are also incorporated during the dynamic update process.

H. Image Quality Assessment and Correction

Each captured image is subjected to an image quality assessment module before passing it to the recognition and the analysis stages. This unit verifies the lack of focus, the improper light, the occlusion, and the wrong frame. When the system identifies bad quality, it will automatically initiate correction measures like brightness adjustment, perspective fixing and deblurring. Where there are inadequate corrections the user is requested to retake the picture. This feature will make sure that the data that goes into the CNN and OCR pipelines is reliable and this will eventually enhance the precision of food identification and labeling.

I. Ingredient Classification and Hazard Categorization

Once ingredient text has been extracted, the system assigns each item to predefined hazard categories such as allergens, preservatives, artificial additives, and high-risk nutrients. A hybrid model combining rule-based logic with trained classifiers examines lexical patterns and ingredient behaviour. For instance, compounds like “sodium benzoate” or “tert-butylhydroquinone (TBHQ)” are flagged under chemical additives, while ingredients such as “lactose” or “caseinate” are mapped to allergen groups. This categorization allows the system to interpret ingredient lists more meaningfully and detect multiple health risks that may not be apparent to users.

J. User Context Adaptation and Personalisation

After the extraction of ingredient text, the system then puts each item into the predetermined hazard groups of allergens, preservatives, artificial additives, and high-risk nutrients. A lexical patterns and ingredient behaviour analysis model based on a hybrid model with a combination of rule-based logic and trained classifiers. As an example, such compound names as sodium benzoate, tert-butylhydroquinone (TBHQ) are assigned as chemical additives, but ingredi-ents like lactose or caseinate are associated with allergens. This classification enables the system to read ingredient lists in a more meaningful way and identify several health risks which might not be evident to users.

K. Performance Optimization and Real-Time Processing

To increase personalisation, the system modifies its analysis according to the context of a certain user. The contextual factors are the daily food consumption, activity, history of scans, and commonly activated alerts. Some of the patterns of behaviour that have been identified in the module include habitual intake of high-sugar snacks or allergen-prone foods. The system adapts to the sensitivity of the alert and the type of recommendation as time progresses- such as giving stronger warnings to those who have been exposed to harmful ingredients many times. This type of personalisation will make the food scanner favourableTo guarantee fast delivery of output, the system will use a range of performance optimisation methods. Reduced ver- sions of lightweight models.

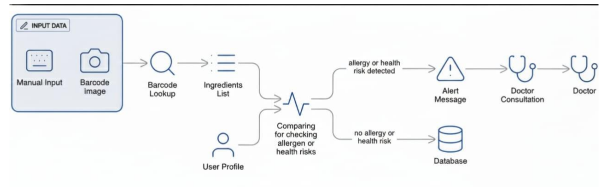

Fig. 1. System Architecture for Proposed Methodology

V. Results and Discussion

The Food Scanner with the help of AI can recognise both packaged and fresh food products successfully and with accuracy. Whereas OCR and NLP algorithms can accurately find ingredients on the labels, Convolutional Neural Networks (CNNs) in image recognition offer a reliable classification of a variety of food items. The system is efficient in determining the prevalent allergens such as dairy, seafood, gluten, and peanuts. It also provides personalised health risk tests based on user-profiles, which considers dietary limitations and chronic diseases. The system can be used in everyday operations due to the real time performance of the system and the analysis of most food items can be done in several seconds.

The recommendations and alerts are practical, unambiguous and understandable as indicated by user feedback. The system helps users to make informed choices by promoting healthier food choices and reducing the risk of allergic reactions. There was sometimes misclassification of the visually similar food, and handwritten or partially covered labels were difficult to read among other restrictions. To further enhance accuracy and coverage, the developments could be enhanced with future developments including expanding the food database, and incorporating regional and homemade food varieties, as well as improving the adaptability of the model.

VI. Conclusion

The presented paper describes an open-source AI-based food scanner capable of analyzing allergens and determining the risk of poor health conditions in packaged and fresh food. The system can provide focused recommendations on specific health profiles of the user and accurate real-time analysis through a combination of image recognition, OCR, NLP, and machine learning method. Based on the analysis, the system enhances diet safety and the usability of the system by identifying food stuffs accurately, identifying common allergens, and offering practical health recommendations.

The proposed system is an important step to intelligent and customised food safety management. Further development of the system will entail the addition of additional health parameters, improved handwritten or regional food label recognition, and expansion of the food and ingredient database to make the system more accurate and easier to use. Consequently, the AI-based Food Scanner will be in a position to act as a holistic instrument in the promotion of safer and healthier eating patterns..

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