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Implementation of Health Impact Assessment of PackagedFoods through Nutritional Label Recognition using OCR

Dr. Shanti Guru[1], Dr. Kalyan D. Bamane[2], Dr. Abhjit Patankar[3] . Mr.Chandan Chandwani[4] Mrs.Apurva Katre[5] , Dipak Vyavahare[6]

[1]Department of Computer Engineering Assistant Professor , D Y Patil College of Engineering, Pune, India
[2]Department of Computer Engineering, Associate Professor D Y Patil College of Engineering, Pune, India
[3]Department of Computer Engineering ,Associate Professor, D.Y.Patil College of Engineerin akurdi , Pune, India
[4] S&C Consulting Vastrapur Ahemadabad and Research Scholar Department of Computer Science and EngineeringGandhinagar University ,Gujrat ,India
[5] Department of Electronics and Telelcommunication Engineering, Assistant Professor D.Y.Patil College of Engineeringand technology, Kolhapur
[6] Department of Computer Engineering, D Y Patil College of Engineering, Pune, India

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ABSTRACT
High food processing, in combination with the increase in people living an unhealthy lifestyle, has contributed to a rising rate of diet-related diseases like obesity, diabetes, heart disease, and hypertension. Because of illiteracy of food ingredients, consumers choosing wrong product which worsen their health balance. In this study, an AI-powered solution that employs text extraction and natural language processing (NLP) is presented for the analysis of food ingredients and assessments of the effects those ingredients have on health. The work allows a user to scan food packaging and will instantly provide a comprehensive review of the nutritional content and potential health effects of each ingredient used. This study help user to avoid health problems causing due to processed ingredients. By providing health insights, this study holds a good chance of hugely contributing to public health and nurturing healthy eating habits around the world.
Keywords:
Optical Character Recognition (OCR),Artificial intelligence (AI), Machine learning (ML),Image Recognition, Large Language Model (LLM), health impact analysis, Food Ingredients,Natural Language Processing (NLP)

INTRODUCTION

With the global rise in consumption of packaged and processed foods, there is growing concern about how they directly affect public health. Studies have shown a direct correlation between the high intake of packaged foods to diet- related illnesses; these range from obesity, diabetes, cardiovascular diseases, and certain cancers. Most of these health problems are complicated by ingredients such as sugars and unhealthy fats and, sometimes, additives and preservatives, many of which are difficult for consumers to interpret or evaluate because of the complex nature of labeling. Consequently, consumers frequently make uninformed dietary choices that adversely impact their health.

To address such an issue, our system is an AI-assisted application that helps consumers quickly and accurately comprehend the health effects of ingredients in packaged food. Utilizing image recognition and natural language processing(NLP) technologies, the beginning is designed to allow users to scan food packaging and have instant lists of ingredients analyzed, with a health-oriented insight provided. This real-time analysis provides user-friendly nutritional breakdowns and reports on the potential health effects of each ingredient, thereby empowering users with knowledge to make healthier dietary decisions.

Our system stands out as an affordable and scalable tool that promotes health literacy by making nutritional information accessible and actionable for everyone. As a mobile or web application, this system provides access to dietary insights, thereby reducing chronic diet-related diseases through informed food choices. Lastly, the AI model's capability to learn continuously ensures that a physician's accuracy improves over time as per dietary preferences and ingredient profiles evolve.

This paper describes the design and development of our technology, including methodology behind the image recognitionand NLP technology for ingredient analysis, as well as the probable effects of the technology on public health. Emboldening consumers on the essentials of what they consume is a giant leap towards a more health-conscious and

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nutrient-aware society, and the technology represents exactly that.

2. RESEARCH OBJECTIVES

The primary objective of this research is to:

- Design and Develop a Model for text extraction:
Create a machine learning (ML) model to precisely extract text from ingredient table of packed food labels.

- Identify ingredients from extracted text: Separate ingredients name from extracted text.
- Provide Detailed Nutritional Reporting and Health Impact Analysis: Generate comprehensive healthreports, including ingredient classifications, nutritional value breakdowns.

Ensure a Cost-Effective and User-Friendly Interface: Develop a platform that is both affordable and easy to use.

3. LITERATURE REVIEW

In the last decade, a number of researchers have come up with ML and DL algorithms to further consumer health by analyzing food ingredients and nutritional levels. This technology enables nutrient and ingredient information extraction from food labels to promote better consumer choices. OCR and NLP are popularmodels for the analysis of ingredient lists and nutritional values. However, challenges such as diverse label formats, varying label quality, and limited access to extensive, well-labeled datasets for training persist. To address the above issues, data augmentation techniques and model optimizations are often used.

Our project uses models of OCR and NLP as the starting point for food ingredients and nutrient analysis. OCR can capture text data from various food labels, while NLP allows the interpretation of ingredient lists to evaluate nutritional quality and impacts on health. Using these techniques in mind, our objective is to enhance access to critical food information for consumers. Optimizing model parameters and data augmentation to boost the dataset will reduce overfitting and enhance model performance on key metrics including ingredient recognition accuracy, precision, and consumer satisfaction.

Sr.No.	Authors /Title	Published Year	Advantages	Challenges	Summary
1	Ratisoontorn, N., & Chatwattanasiri, N., “Integrated Image Processing Framework to Determine Nutrient Quantities from Guideline Daily Amount (GDA) Label”	2021	Allows for precise nutrient extraction from GDA labels, aiding in food label analysis.	Limited to GDA format, may not cover all label types.	Discusses an image processing framework to identify nutrient quantities on food labels, targeting GDA labels for clear nutritional analysis.
2	Poonsri, A., et al., “The Method to Read Nutrient Quantity in Guideline Daily Amounts Label by Image Processing”	2021	Provides a specialized method for extracting nutrient data from GDA labels, improving nutritional transparency.	Limited applicability to non-GDA labels and might need adaptation.	Describes an image processing technique for reading nutrient quantities from GDA labels, which can support accurate nutritional information extraction.

3	Priya, K. M., & Alur, S., "Analyzing Consumer Behavior Towards Food and Nutrition Labeling: A Comprehensive Review"	2023	Provides insight into consumer behavior regardingfood labels, supporting improved user engagement with food information.	Does not include automated orreal-time consumer behavior analysis.	Examines consumer responses to food labeling, highlighting ways to optimize labelsfor better nutritional choices.
4	Shah, Y., et al., "Delving Deep into NutriScan: Automated Nutrition Table Extraction and Ingredient Recognition"	2023	Enables precise extraction of nutrition and ingredient data through OCR and deep learning.	Requires extensive testing on diverse food labels for generalization.	Discusses the automated extraction of nutritional and ingredient data from food packaging using NutriScan's OCR and machine learning techniques.
5	Hu, G., et al., "Natural language processing and machine learning approaches for food categorization and nutrition quality prediction	2023	Applies NLP and ML to categorize food items and predict nutrition quality, offering a comprehensive method for dietary analysis.	May face difficulties with non-standard or multi-lingual food labels.	Compares traditional and ML-based methods for categorizing food and estimating nutrition quality, showing promise in enhancing dietary analysis accuracy.

	compared with traditional methods”				
6	Werle, C. O. C., et al., “How a food scanner app influences healthy food choice”	2024	Demonstrates how food scanner apps affect healthier choices in real-time consumer decision-making.	Scanner apps may be less effective than front-of-pack labels in promoting healthy choices.	Studies the impact of food scanner apps on consumer behavior, analyzing their influence on healthy food selection compared to traditional labels.

	Javadi, B., et al., “Smart Food Scanner System Based on Mobile Edge Computing”	2024	Reduces latency and enhances user experience in food scanning via mobile edge computing.	Limited by the need for edge infrastructure and mobile device compatibility.	Explores a food scanner system that uses mobile edge computing to minimize response time andimprove usabilityfor mobile food analysis.
8	Davies, T., et al., “An Innovative Machine Learning Approach to Predict the Dietary Fiber Content of Packaged	2021	Provides accurate dietary fiber predictions for packaged foods, improving ingredient analysis.	Requires extensive data to cover diverse packaged food types.	Uses machine learning to predict dietary fiber content in packaged foods, aiding consumers in understanding ingredient quality.

	Foods"				
9	Kim, D., et al., "Innovative AI methods for monitoring front-of-package information: A case study on infant foods"	2024	Monitors FOP labels effectively using AI, providing essential data on infant food quality.	Limited to specific FOP labels and infant food categories.	Explores AI applications in monitoring front-of-package information, focusing on improving quality assessments for infant foods.
10	Gauthier, C., et al., "How a food scanner app influences healthy food choice"	2024	Highlights the role of food scanner apps in promoting healthier food choices.	Shows varied effectiveness compared to front-of-pack labels.	Investigates consumer behavior impacts of food scanner apps in grocery shopping, showing their influence on promoting healthy choices.

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4. PROPOSED APPROACH

The system architecture is in place for real-time analysis of packaged food ingredients, providing users with more insightful nutrition and health impact reports. Architecture considers three main components.

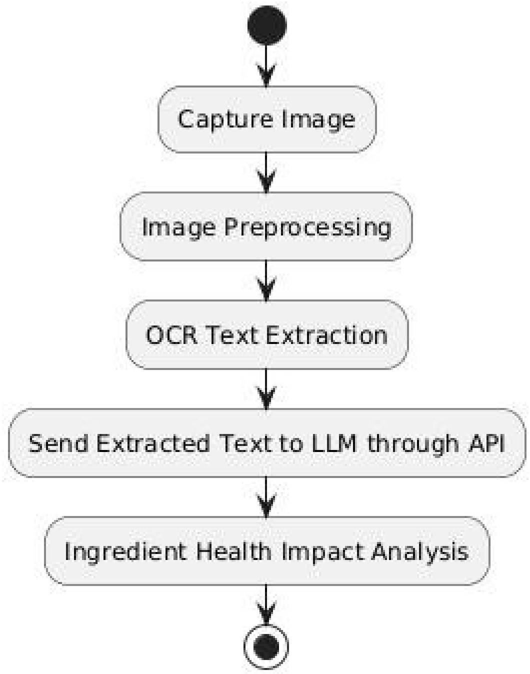


Figure 1. Workflow [1]

A. Image Capture and Preprocessing:

Acquiring an image of packaged food labels, preprocessing is undertaken to enhance the quality and possibility of an analysis on ingredient extraction. The efficiency of this module is critical for correctly and clearly recognizing ingredient text because, indeed, good preprocessing is the basis of the success of the extraction module.

An user captures an image of or uploads the image of the ingredient table of the food packet. The imageneeds to be clear so that the text can be extracted with greater accuracy. Preprocessing is a key step in increasing text extraction accuracy. Noise reduction is applied to the image using Gaussian and median filters. All those processes may be considered an essential step of the process concerning reducing distracting background information interfering with text recognition when low light or highly textured backgrounds exist. The contrast in the image needs to be adjusted so that the text becomes clearer from its background. Histogram Equalization or Adaptive Thresholding may be applied to make the text appear clear. To simplify processing, the color image is converted into grayscale. This reduces the volume of data that the system has to process, which, in turn, improves the system's subsequent performance. A grayscale image is converted into a binary image as a means to make the text line stands out in the OCR engine. This step is particularly useful in improving the clarity of the edges of the text, thereby aiding more precise character recognition.

B. Optical Character Recognition (OCR) and Ingredient Extraction:

It extracts relevant ingredient information from the object. It uses an optical character recognition (OCR) engine such as Tesseract. This module allows the system to extract ingredient details more effectively. Italso examines things like text layout and font diversity present in a variety of food ingredients. It is a flexible and highly accurate application. The OCR engine analyzes the segments of the image: characters, words, and phrases. The state of art in most character recognition systems has been provided by long short-term memories (LSTM) based on convolutional neural networks (CNNs), used for both classes of variations: among types and their appearances.

C. Health Impact Analysis and Nutritional Assessment:

In this module we send extracted text to LLM through API. It eliminates the requirement of large database. Even if food product contains new ingredient or substance LLM model able to detect it. Prompt is

already provided to LLM. This prompt is written to get health impact of each ingredient, safe consumption quantity, potential health risks and benefits of consumption.

5. ALGORITHM

Step 1: Image Capturing and Preprocessing

- User uploads an image of ingredients.
- Apply various image preprocessing techniques (e.g., noise reduction, contrast adjustment) to enhance the OCR performance in terms of text extraction quality.

Step 2: Text Extraction (Optical Character Recognition)

- Use OCR software, such as Tesseract, to extract text from the image.
- Filter non-essential text and focus on identifying food ingredients.

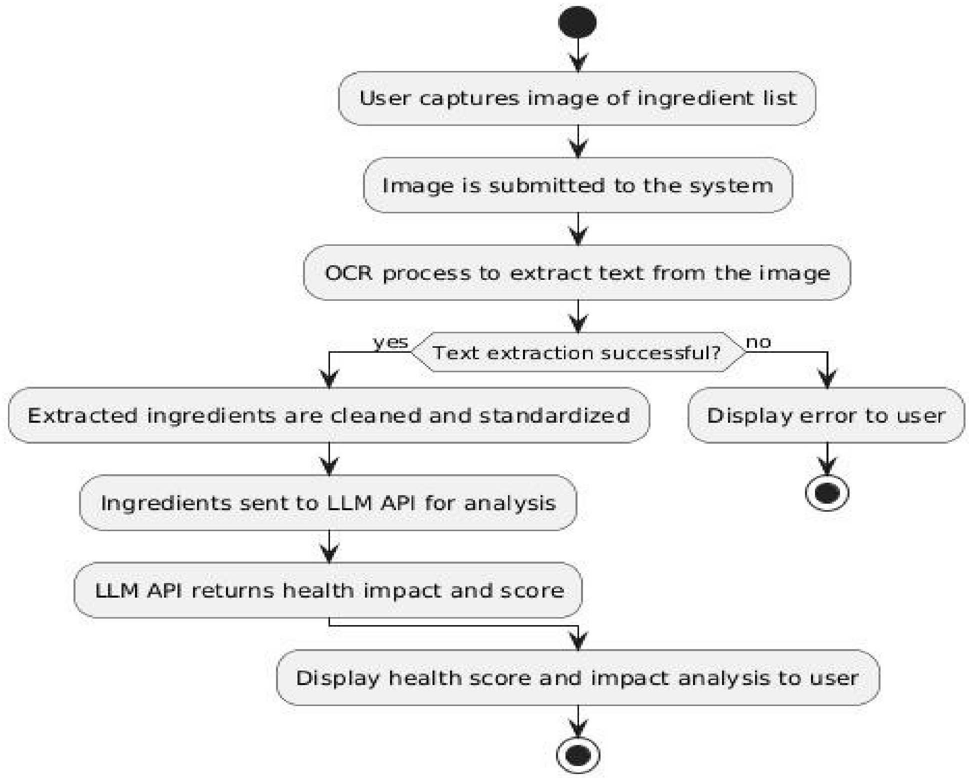
Step 3: Ingredient Processing

- Parse the extracted text and singulate the ingredients.
- Clean and standardize the ingredients list (remove duplicates, fix misspellings, etc.).

Step 4: Health Impact Evaluation (via LLM API)

- Pass the cleaned ingredient list to the LLM API.
- The API processes this list by cross-referencing a health database (e.g. looking for allergens, crude estimates of unhealthy additives and sugar content).
- Get the health impact score for each ingredient and a mean score for the whole product.

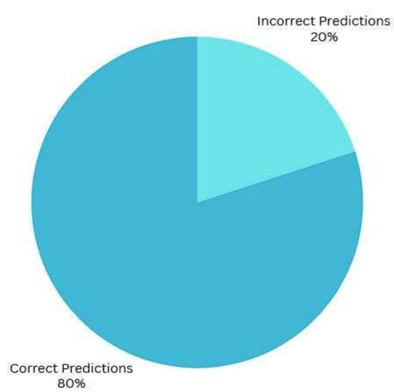
Step 5: Score Aggregation and OutputUse the averaging or weighting procedure to combine the separate health scores of theingredients into a final score on a scale of 100.



❒ The score will be presented to the user with a detailed breakdown.1234

6. EXPECTED RESULT

We are aiming for an accuracy rate of around 80% with the identification and analysis of ingredients on packaged food labels. This expectation for accuracy is based on a combination of OCR processing, ingredient extraction techniques, and LLM-based analysis. By combining image pre- processing and text recognition methods with real-time health impact assessment through a large languagemodel, system aims to deliver trustworthy and actionable nutritional insights for the consumers.



Performance Evaluation:

To measure how accurately the OCR identifies characters, words, and phrases we use two commonOCR metrics Character Error Rate (CER) and Word Error Rate (WER). Character Error Rate (CER) calculate the percentage of incorrect characters compared to the total number of characters in the ground truth and Word Error Rate (WER) calculate the percentage of words that were incorrectly identified. Precision is percentage of correctly identified ingredients out of all ingredients identified by system. and Recall is the percentage of ground truth ingredients correctly. F1 Score combines precision and recall to give performance. After processing with the LLM we check if the identified ingredients match the list of ingredients of that product to calculate accuracy.

7. CONCLUSION

In the proposed study, we'll make use of our unique method in analyzing the packaged food ingredients health impact using advanced AI and machine learning. We tap into the great power of image recognition capabilities and NLP that a system possesses to give high accuracy towards nutritional and health information via assessment of ingredient lists of packaged foods. This purpose is to aid consumers by providing them with fast and accurate information on their foods, therefore, healthy behavior in eating.System improves access to remote access networks with better accessibility of nutrition information to themajority, especially a place from where health sources are very hard to reach. It is in the interest of users that assess foods through easy interfaces, from mobile or web, that grow to improve awareness, access, and impact in shaping healthful dietary choices.

8. FUTURE SCOPE

While there are several key areas for enhancement, the potential for system to revolutionize food ingredient analysis and support healthier consumer choices is promising.

Health Impact Analysis of General Medicines and Supplements: Adding medicine and dietarysupplement recognition in system would give users a clue on how their diet interacts with medications, which is more of the possible side effects brought about by the interaction of the ingredients in packaged foods and their medicines.

Promotion of Health-Conscious Brands: Partner with brands focused on transparency and healthy ingredients, allowing to recommend products aligned with users' health objectives, and topromote healthier choices.

Enhanced Analytics and Tracking: Introduce data analytics to help users monitor their nutritional intake over time, providing insights into trends and helping them set and reach health goals.

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