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AI Based AR Application for Packaged Food Ingredients Analysis

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ABSTRACT:

Groceries shopping forms the everyday need of most people. However, there is a large variety of almost similar products that can be found lined up on the shelf in the supermarket. Customers spend most of the time in the supermarket while reading the ingredient list on the nutrition facts label to select the best product they want. Despite being time-consuming, the greatest challenge that a shopper faces are being able to limit and search for products that do not contain any allergy ingredients at all. Therefore, it is proposed that a smart grocery shopping application supported with AR technology in filtering ingredients be provided. Therefore, the proposed application has the capability to help the user filter and customize the ingredient that a user wants. In this development, AR technology is utilized in this project in the form of marker-based AR.

Keywords: Artificial Intelligence, Augmented reality, AI Agents, Health Alternatives, CNN, LLM

Introduction:

It has been richly noted that information technology could catalyze an important set of benefits in the healthcare area which would include improving quality and reducing the cost of healthcare. The emergence of sensor-rich powerful smart phones to provide a rich set of user contextual information in real time made it feasible to provide effective and affordable healthcare to nearly everyone via smartphones. More specifically, well-designed mobile phone applications can empower individuals to proactively embrace health and wellness. No longer is the health care system made of a reactive system or placed sitting back waiting for medical attention to surface via an ER visit. What once belonged to the clinic was now patient centered care. What once focused on the disease agenda is now wellness in health care.

Based on the sheer number of excellent justifications for applying smartphones, cloud computing, mobile augmented reality and other information technologies to improve health and well-being in society, this paper examines the interactive, creative, and user-friendly health mobile applications. Previous studies have clearly established a correlation between low levels of nutritional intake and the rising prevalence of unhealthy conditions such as obesity and lifestyle diseases such as heart disease and diabetes.

A lack of healthy food consumption coupled with physical inactivity is two key causes of an epidemic of overweight persons and cases of obesity in the United States. The betterment of a person's diet begins with the betterment of the nutritional quality of food he or she chooses. This makes it nearly impossible for the average consumer to make better choices when a food supply contains tens of thousands of processed and packaged foods with different messages on bags, boxes, bottles, jars, and cans. Consumers report they know what is healthy and what isn't, but say they are confused over how to implement general nutritional advice.

The application of technology in diet management has been perceived as a useful tool and resource in helping to reduce poor health conditions and foster good well-being generally among people. Mobile augmented reality in supermarkets is one of the proposed solutions to this very pressing problem of enriching the quality of nutrition in food choices while shopping at point-of-sale. One of the more interesting emerging technologies AR exemplifies, in very simple words, simply offers rich visual interaction with the real world by overlaying or augmenting the elements the camera view contains with useful information with relevance to the objects appearing in the video screen of the camera. With an AR-based smartphone application, the user now experiences a direct interactive or context-rich experience. It is just recently that AR gained much mindshare as an exciting new technology for the mobile smartphone. [1]

Literature Survey:

There are some works regarding shopping assistants that has done by other researchers. However, there are still many challenges and limitations exist in their works. Hence, several relevant methods regarding shopping in AR.

In one of the most prolific papers presented in [1], "Personalized In-store E Commerce with the PromoPad". This paper introduces PromoPad, an in-store e-commerce system that enhances shopping assistance and personalized advertising through dynamic contextualization, a novel extension of context-aware computing. Using augmented reality (AR) technologies on a hand-held Tablet PC, PromoPad enables real-time context modification by altering the perception of products on store shelves through see-through vision with augmentations.

The paper "PHARA: an augmented reality grocery store assistant" [2] introduced PHARA, an AR system to support decision-making at grocery stores and described its use fulness in a real-world scenario. It also discusses the different strategies to improve diversity and precision of food recommendations in future studies, and different visualizations to be evaluated to better understand how to effectively communicate personal health data to users.

This paper [3] has presented a mobile-based augmented reality system to help improve the ability of shoppers to find healthy food products in a grocery store aisle. It has shown that application's colour-based AR tagging functionality substantially reduces the amount of time it takes for shoppers to find desired healthy food products and avoid unhealthy ones.

The paper "A Mobile Adviser of Healthy Eating by Reading Ingredient Labels" [4] The paper presented a prototype of a food ingredient analysis mobile app which can scan the barcode or ingredients label on packaged food products to obtain included ingredients and provide proper health suggestions. A preliminary user study reveals that our application is ease to use and potentially helpful to promote healthy di etary to the general public. The prototype should be further improved with the speed of scanning ingredient labels and multiple languages support. This enables users to identify the potential allergens and additive for imported ingredient labels written in a foreign language.

This paper [5] measured and compared the object recognition performance of the commercial AR frameworks (i.e., MAXST, Vuforia, and ARCore) and identified issues that may occur in the actual application environment. The study assumes a real-world scenario where AR content is displayed on a smartphone by recognizing food products and uses four performance metrics to assess effectiveness. Experimental results show that Vuforia outperforms the other frameworks in recognition accuracy and performance.

For experiments, we assumed a situation in which a consumer purchases food products at a place, such as a grocery store, and we considered an application scenario in which AR content related to the products was displayed on a smartphone screen by recognizing such products.

This paper [6] explores the impact of Augmented Reality (AR) technology in the food and beverage industry, highlighting its ability to enhance customer experience and influence purchasing behavior. While AR is gaining traction in the industry, academic research on its consumer effects remains limited. The study finds that AR previewing of food items increases purchase likelihood by enhancing mental simulation and personal relevance, leading to greater consumer engagement. The study highlights the potential of AR to transform dining experiences and influence consumer decisions, suggesting that AR could be a valuable tool for food establishments and brands aiming to enhance customer engagement and drive sales.

The paper "How a food scanner app influences healthy food choice" [7] investigates the impact of food scanner apps on consumers' healthy food choices. Through four studies, it compares the effectiveness of app-provided nutritional information against no information and front-of-pack (FOP) labels. Results show that while food scanner apps enhance hypothetical purchase intentions for healthy products, they do not significantly influence real behaviour in experimental settings. FOP labels consistently outperform food scanner apps in promoting healthier choices due to their simplicity and ease of processing. The research highlights the need for further exploration of digital tools in influencing actual consumer behaviour in grocery shopping contexts.

In the paper "Food4.0: Implementation of the Augmented Reality Systems in the Food Industry" [8] As food manufacturing operations become more complex, Industry 4.0 technologies such as digitalization, data analytics, robotization, and automation will play a crucial role. However, to enhance the resources, manufacturing operations and food products must also be digitally connected. In this context, it becomes clear that AR technology will play a vital role in providing this connection for all the entities within the food supply chain. As the Industrial Internet of Things (IIoT) continues to grow, so will the adoption of AR applications in the food industry will continue to grow. Hence, this paper offers a simple definition of AR and its challenges, benefits as well as a framework for AR technologies implementation within the food industry.

This paper "Identifying Ingredient Substitutions Using a Knowledge Graph of Food"[9]. Focuses on managing and modifying nutritional intake from food is a meaningful way to maintain and improve personal health. Substituting ingredients is one way to help people improve their diets, but it can be difficult for people to identify viable substitutes for ingredients in a recipe and determine which substitutions are "healthier" for their particular dietary needs. This paper presents DIISH (Diet-Improvement Ingredient Substitutability Heuristic), an approach to assist users in modifying recipes by identifying and ranking viable ingredient substitutions based on dietary needs, allergies, and nutritional goals. DIISH demonstrates superior performance in ranking healthier ingredient replacements. The study highlights its potential for AI-powered diet planning, smart grocery shopping applications, and personalized nutrition systems, making food choices more accessible and health-conscious.

Methodology:

The proposed system utilizes Augmented Reality (AR) and Artificial Intelligence (AI) to enhance grocery shopping by analyzing food ingredients and providing personalized recommendations. The frontend handles user interactions, including barcode scanning, OCR-based ingredient extraction, and AR-based result visualization. The backend processes ingredient data, performs AI-driven analysis, and generates health-based recommendations. The following sections detail the implementation of these components.

A. Frontend Methodology

The frontend of the proposed system serves as the user interface and interaction layer, allowing users to scan packaged food products, analyze ingredients, and receive recommendations based on health preferences. The frontend is developed using a cross-platform framework to ensure accessibility on multiple devices. The key steps involved in the frontend workflow are as follows:

1. User Authentication and Profile Setup : Users register and log in securely using authentication protocols, after which they can set up a profile by inputting health conditions, dietary preferences, and lifestyle choices to receive personalized recommendations.
2. Ingredient Retrieval Methods : Users can obtain ingredient details through three different approaches. The first method involves barcode scanning, where the system scans the product's barcode and retrieves ingredient details from an external API. The second method utilizes Optical Character Recognition (OCR) to extract text from product labels, converting it into a structured ingredient list for analysis. If barcode scanning or OCR is not feasible, users can manually enter ingredient details to proceed with the analysis.
3. Ingredient Analysis and Augmented Reality (AR) Visualization : The AR-based visualization interactively presents insights by highlighting harmful and beneficial ingredients in real time, and if the scanned product is not recommended, it suggests alternative healthier products within the AR environment.
4. Preference Customization and Scan History : Users can personalize their dietary preferences to refine analysis results, while a dedicated history page maintains records of previous scans, allowing them to track their consumption patterns and product safety over time.

B. Backend Methodology

The backend is responsible for handling user authentication, retrieving ingredient data, analyzing ingredients using AI-based models, and generating personalized recommendations. The backend consists of several modules.

1. User Management and Authentication : A structured database stores ingredient information, including scientific names, nutritional values, health impacts, and regulatory warnings, sourced from open food databases, research papers, and food safety guidelines.
2. Ingredient Database Management : APIs are integrated to retrieve transaction details, such as transaction hashes, donation status,
3. AI-based Ingredient Analysis : Upon receiving the ingredient list, an AI agent queries the database to retrieve relevant details, assessing potential health risks, recommended intake limits, and associated warnings.
4. Personalized Recommendation System : A recommendation engine evaluates ingredient safety based on the user's dietary preferences and health conditions, categorizing products as safe, moderate, or hazardous, and providing a JSON response with key insights, including overall health impact, safe consumption limits, and alternative product recommendations.
5. Data Storage and User History : Scan results and product analyses are stored in a database for future reference, allowing users to access past scans and track trends in their food choices.

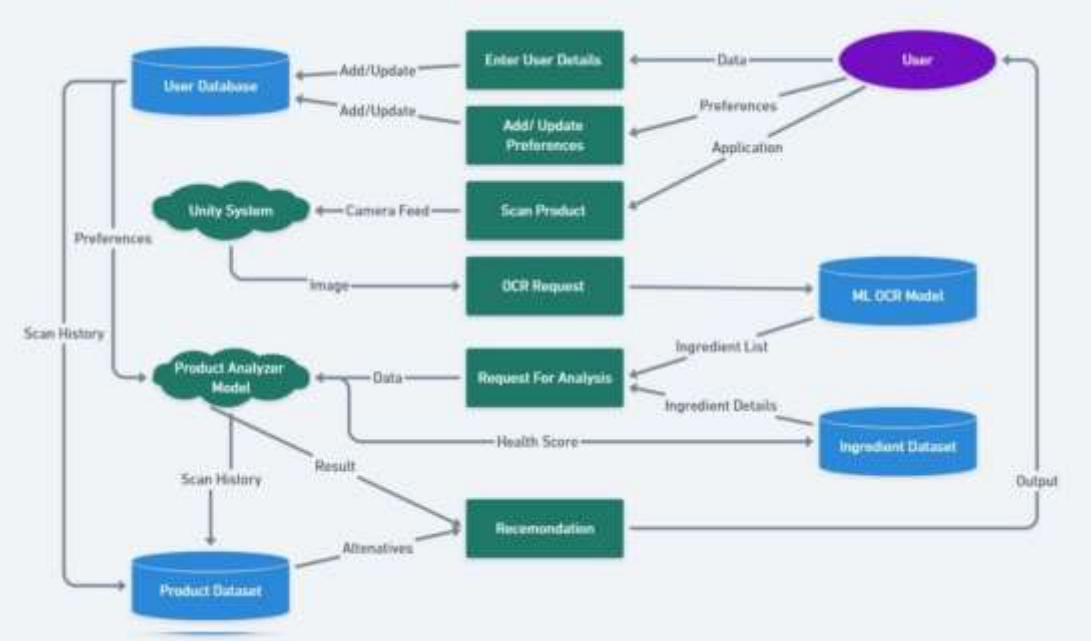

Fig. 1 – Data Flow Diagram.

C. AI Agent: Algorithmic Framework

1. Perception Module (Environmental Sensing and Analysis): The goal-based AI agent begins its operational sequence through a sophisticated perception mechanism. This critical initial stage involves comprehensive environmental scanning, where advanced sensory inputs are meticulously processed to capture intricate contextual details. The agent transforms raw sensory data into a structured representational model, enabling precise interpretation of the surrounding spatial and contextual landscape.
2. Goal Representation(Objective Decomposition and Strategic Mapping): Goal representation transcends simple destination identification, involving a nuanced decomposition of the primary objective into discrete, measurable components. The agent creates a hierarchical understanding of its target, breaking down complex goals into manageable strategic elements. This approach allows for sophisticated navigation strategies that can adapt to multidimensional challenge environments.
3. Path Generation(Heuristic-Based Action Sequence Construction): The core decision-making mechanism emerges through an intelligent path generation algorithm. Multiple potential action sequences are constructed and evaluated using advanced heuristic techniques. Each potential path receives a probabilistic score considering goal proximity, resource efficiency, and potential risk factors. This dynamic approach transforms traditional linear decision-making into an adaptive, predictive strategy.
4. Action Selection(Strategic Implementation and Validation): Action selection represents a pivotal computational stage where theoretical path evaluation transitions into practical implementation. The chosen action balances immediate goal progression with systemic adaptability. Integrated monitoring mechanisms continuously validate the action's effectiveness, enabling real-time recalculation and strategic adjustment if the selected path demonstrates suboptimal performance.
5. Learning and Adaptation(Knowledge Accumulation Module): The learning module transforms the agent from a reactive system into an evolving intelligent entity. Each executed action becomes a data point in an expanding knowledge repository, enabling progressive refinement of decision-making algorithms. Mechanisms similar to reinforcement learning allow the agent to develop increasingly sophisticated navigation strategies by learning from both successful trajectories and encountered challenges.
6. Computational Resource Management: Computational resources are strategically allocated to maintain a delicate balance between comprehensive environmental analysis and timely decision execution. Advanced pruning techniques and parallel processing strategies optimize performance, ensuring that complex computational processes do not compromise the immediacy required in dynamic operational environments.
7. Algorithmic Integration(Holistic Autonomous Behavior Model): The goal-based AI agent's algorithmic architecture represents a significant advancement in artificial intelligence. By integrating sophisticated perception, strategic reasoning, dynamic action selection, and continuous learning mechanisms, the algorithm demonstrates an unprecedented capacity to simulate purposeful, context-aware autonomous behavior.

Results

The AR-based ai system effectively extracts and analyzes product details using AR-based scanning, OCR, and ML-powered ingredient classification. It accurately identifies ingredients, classifies them based on health constraints, and provides personalized dietary recommendations. The system cross-references online databases for validation and suggests alternative products when needed. This approach enhances accuracy in ingredient evaluation and simplifies grocery shopping by offering real-time insights into product suitability.

Fig. 2 – Sample Output of the Application.

Conclusion

The proposed system leverages augmented reality (AR) and artificial intelligence (AI) to transform grocery shopping into a more informed and health-conscious experience. By integrating barcode scanning, optical character recognition (OCR), and manual input options, the system enables users to retrieve ingredient information seamlessly. The ai-powered backend processes these ingredients, evaluates their potential health impact, and provides personalized recommendations based on user preferences. Through an interactive AR interface, users can visualize ingredient insights in real time, ensuring a more engaging and transparent product analysis process. Additionally, the system offers customization features that allow users to refine recommendations according to their dietary needs, along with a history tracking function to monitor past scans and food choices.

This innovative approach not only enhances consumer awareness but also promotes healthier purchasing decisions by identifying harmful ingredients and suggesting better alternatives. By combining AR for visualization and AI for intelligent analysis, the system provides a unique solution to the growing demand for ingredient transparency in packaged foods. The integration of user preferences further enhances its adaptability, making it a valuable tool for individuals with specific dietary concerns. As technology advances, future improvements could include expanding the ingredient database, enhancing AI accuracy, and incorporating real-time health impact assessments to provide even more precise recommendations.

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