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AI Based AR Application For Food Ingredients Analysis: A Systematic Review

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Abstract
Groceries shopping forms the everyday need of most the person. However, there is a large variety of almost similar products that can be found lined up at the shelf in the supermarket. Customers spend the most 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 is being able to limit and search for products that do not contain any allergy ingredients at all. Therefore, it is proposed that a grocery smart 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: *Autism, Convolutional neural network (CNN); Artificial Neural Network (ANN); K- Nearest Neighbors (KNN); Logistic Regression (LR); Support Vector Machine (SVM) [5].*

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I. Introduction

It has been richly noted that information technology could catalyze an important set of benefits in the healthcare area which would include improving the 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 is 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 the 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. Actually, it is just recently that AR gained much mindshare as an exciting new technology for the mobile smartphone. [1]

Some examples of such applications are an augmented reality range finder for golf lovers, Cape GPS Rangefinder; AR application for color-blind people; Google Sky Map, that is an AR application for amateur astronomers; Word Lens, that translates a foreign language captured by the mobile camera and overlays the result on top of the text; and many more. As the user continues walking down an aisle to get an item, its AR tag grows in size. When the tags of the thing are clicked, it provides nutrition information about that product. Tags are colored. Therefore, for example, green would be nutritionally preferable items-low calorie and gluten-free. Red would be used to mark bad products to avoid. For example, those that have a high cholesterol level or peanut contents. Additionally, the consumers can upload health profiles that might have an influence on their purchasing of food products such as weight watch, heart condition, and food allergies, etc. We observe that the product to be recommended will differ because the user has provided an input health condition/cue. To our knowledge system, we strongly believe that we are the first ones that introduce AR tagging with pedometric-based localization along with back-end health-based grocery recommendation at point of purchase.

Point-of-purchase nutrition information probably would have greater impacts on dietary quality because it better primes consumers for decisions about healthy foods than the traditional generic messages of "eat better.".

II. Review

There are some works regarding shopping assistant that has done by other researchers. However, there are still many challenges and limitation exist in their works. Hence, several relevant methods regarding shopping in AR will be reviewed including the limitations and some proposed solutions.

AR Frameworks in the Food Industry

There are numerous sources that detail multiple AR frameworks, like Vuforia and ARCore and MAXST, and usage of the tool while going for grocery shopping in such an industry.

Source [1] compares the functionality of the three frameworks for creation of a mobile AR grocery shopping app. Here, it scans a product and gives information and shows them on the smartphone screen. This paper is a performance evaluation for target recognition and tracking in the real world, wherein a grocery store was selected to run experiments. The development teams checked the proposed architectures by using three food packaging types: box-type, cup-type, and pouch-type. AR content is a simple 2D image, name of the product 4. Fig. 1. Some of the target image features of these packages from the source.

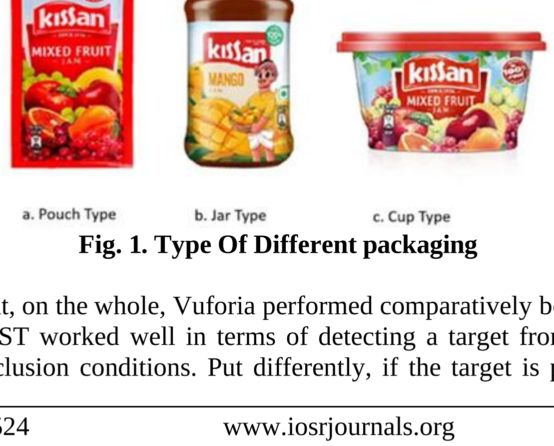

Fig. 1. Type Of Different packaging

The conclusion is that, on the whole, Vuforia performed comparatively better than these two, which are MAXST and ARCore. MAXST worked well in terms of detecting a target from afar, but Vuforia has more robustness with regard to occlusion conditions. Put differently, if the target is partially hidden, then Vuforia would perform better in that context than MAXST. On the other hand, the ARCore was the lowest of the three and could only capture one target at a go [1].

Other scope of applications of AR in the food industry is discussed along with sharing the vision of potential roles for AR as a part of progression in the advanced concept of Industry 4.0. The author indicates that AR is seen as a digital facility connecting various entities involved in the food supply chain, and all the merits can vary from enhanced employee safety and training to developing products up to marketing. Although this resource is not very descriptive on frameworks for AR, it does give a good starting point in understanding the continually growing role that AR is starting to play within the food industry.

According to sources, the AR frameworks can revolutionize the food industry. First, they will create applications, which can provide information regarding the products of food so that good decisions and experiences in shopping are made. AR can be integrated into almost all aspects of the food supply chain for efficiency, safety, and innovation.

Target Recognition and Tracking in AR

The AR enriches the grocery shop consumer experience by projecting virtual content including nutritional information, recommendations, and interactive displays onto real-world objects, Using OCR tools and AR frameworks like ARCore and ARFusion. It, therefore, has to exploit the most advanced benefits of target recognition and tracking capabilities in overlaying adequate content. It is required to detect and track the target objects under dynamically changing conditions such as grocery stores whose lighting conditions, placements of products or movements of users can affect its performance [2, 3, 4] .

The functionalities and performance of target recognition and tracking capabilities are different in every AR framework. Some very popular ones are Vuforia, ARCore, and MAXST [2] . It proposes various techniques like marker-based tracking, image recognition, etc. for the identification of target objects.

Marker-based tracking places AR markers on products or on the shelves, for tracking [2, 3] . These markers act as references from which the AR system can perceive with ease and accuracy the position and orientation of an object in space. Identification of a product is performed via image recognition techniques, based on analysis of visual features on the packaging of a product [3] . Current AR applications are engaged in the practice of recognizing a vast range of product features with some advanced computer vision algorithms.

The type of AR framework selected determines the performance in recognizing and tracking the target. A comparative analysis between Vuforia, ARCore, and MAXST revealed each to have its strengths and weaknesses in the process [2] . Strength of MAXST was maximum recognizable distance as it could identify targets from a higher distance. Strength of Vuforia is maximum recognizable occlusion since it can recognize occluded targets as well when partially covered by some other objects. Vuforia was also superior in terms of the number of targets that it could simultaneously recognize and track. ARCore only recognized and tracked one target at a time.

Target recognition and tracking accuracy with reliability will thus validate that the AR experience at grocery stores continues being seamless and informative to the users. Techniques are thus being researched into ways that will make these systems better, such as data caching and adaptive AR tag presentation [2] . These ought to be able enough to overcome dynamic grocery store environments in the presentation of enhanced consumer shopping experiences.

Related Work on Mobile AR Applications for Food-Related Tasks

Sources point out numerous cases of applications of mobile AR designed to support in different procedures related to food. In general, they create images of the real world using the camera of a smartphone, applying digital information, or data about the nutrient content, ingredients analysis, health-related information, etc.

One of the key applications is "ARFusion," which is about healthy grocery shopping. This application relies on a pedometric, image recognition, and a backend server to deliver recommendations based on a health profile defined by the user.

Figure 2 demonstrated that nutrition is the leading qualitative characteristic of foods for consumers, which led the developers to the nutrition-led approach. [3]

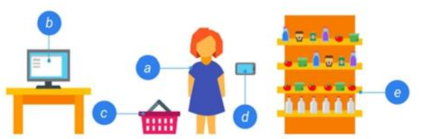

Fig 2: Use case of PHARA: a) user, b) desktop interface to create or edit the user profile, c) basket to place the food products d) PHARA mobile app e) store shelf

For instance, there is "PHARA" that is a product-based AR solution that is supposed to aid consumers to select healthy grocery foods. The primary screen of the application, as displayed in Figure 2 of Reference, indicates one of its key functionalities making use of AR markers of products in the display of information attached to them. This method, as expected, provides visual cues for scanning information for the user [3].

According to source [3] , the iterative design process of PHARA starts from paper prototypes to a fully functional mobile AR prototype. The system bases its architecture on a client-server architecture, whereby the visual components are rendered at the client end by mobile clients using frameworks like Unity and Vuforia [5].

Besides the above two examples in particular, many other research studies test mobile AR applications for food preparation tasks along other lines:

Ingredient Analysis: A research developed a mobile application that scans an ingredient list directly from the product labels using OCR. Such a step is quite beneficial for users who have food allergy by warning them of the presence of allergens. Generally, how such a system works is depicted in figure 3 [5] . It mashes barcode scanning with OCR techniques to fetch ingredient information and offer health advice. Preliminary user study results show that for concerned consumers of their diet, the app is found useful [5,1] .

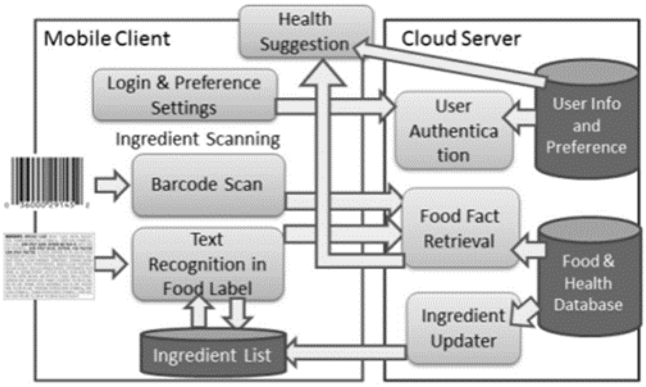

Fig 3: An overview of PHARA system.

Customized Recommendations: A study in Source [6] has been released with comparative performance of several AR frameworks to grocery shopping applications based on the AR. Target recognition and tracking, a technical approach towards overlaying digital information over real-world objects, have mainly comprised this paper. This paper stresses the point of choosing a proper AR framework based on application needs [6, 7] .

Nutritional Information: A recently published research work examines the impact of an application of a food scanner on consumer choice compared to FOP labels and no information at all. In the study, it is already found that the application actually enhanced the purchase intentions of healthy products, but it did not affect the actual choices regarding the grocery shopping environment [7] . They further argue that perhaps this is because the weakness of the application is due to the added complexity of a situation when one scans a barcode in a retail shop by the ease in calculation in FOP tags [4].

Food Industry Applications: Reference Source [4] for applications in the food industry generally, based on transparency and improved procedures. It even provides a framework for the three-phase implementation of AR in the food sector. Such studies demonstrate that mobile AR applications can actually change the eating habits of humans and the entire capability of consumers to make healthy and informed diet and health choices.

Today, it is indeed in the area of interface design and data analysis that computer vision research and development are concentrated, leading to continuous stretches in the features of these applications-more and more personalized, engaging, and effective food-related AR experiences.

Food Ingredient Databases

Accessible and comprehensive food ingredient databases are a benchmark for mobile applications meant to enhance dietary choices and outcomes. It contains detailed data of food products, among which are the ingredients, nutritional values, and potential allergens. [4] One such example includes the open source database known as Open Food Facts, containing over 50,000 entries of food products present in 134 countries. [5] However, often, custom databases need to be created with regard to specific requirements so that local food products may be covered. [8]

One is PHARA, which uses a client-server architecture with a MongoDB database to implement recommendations of healthy foods. The database contains items as well as user profiles. It feeds this information into the application's recommendation engine whereby consumers marked out healthier foods they liked and wanted by preference and need[5] .

Another application is regarding ingredient analysis especially concerning food allergies. This is done using a barcode scanner and OCR by scanning the ingredients against a food and health database having known allergens. Ingredients scanned will alert the users on those materials that can cause allergic reactions. [5]

ARFusion is the grocery shopping application enabled with AR based on a health-based model of nutrition, and has personal and family profiles filled into it. It requires relating data from product database tracking information of every product's ingredient, nutrient, and the location in the grocery, which information allows the application to make real-time personalized recommendations on healthy products. [9]

Moreover, the substitution of ingredients is performed using knowledge graphs. One such system was created based on a knowledge graph called FoodKG which interconnected the ingredients with the food ontology named FoodOn and even nutritional information by USDA. This system points out healthy alternatives according to dietary restrictions. [10]

Therefore, there is a great need to establish such comprehensive food ingredient databases that would be accessible for consumers so that they might choose their foods wisely, where they would enjoy better habits of consumption and general well-being. [4]

UI/UX in Food-Related Mobile Applications: A Balancing Act

But of both, what shines through is the role that well-designed UIs and UXs play especially for the mobile applications concerning food. Rather more salient considerations piling too much information on users or taking them through complicated navigation is more nuisance to engagement and effectiveness resulting from balancing clamor for quick and easy access of such applications.

One of the ways through which complicated information can be made accessible is through visual, such as color-coded tags and intuitive layouts. The result of the study was that the color-coded AR tags were very easy for the users to distinguish between the healthy and unhealthy products. The developers of the PHARA attempted to develop modular visual parts that would pass relevant information in a clear-cut manner. Figure 8 of this source shows several layouts of PHARA in making food product information understandable. [3].

For example, the design of a mobile application concerning the ingredient analysis is essential to make sure it becomes user friendly, considering there are food allergic users who might at some point require assistance. The interface of the application focused on simplicity in daily use. [3]

Therefore, developers have to face the specific functional-related issues pertaining to such applications. For example, food scanner applications require one to scan the barcodes of each article purchased in the market. It is cumbersome and time-consuming in the process. These features, combined with overall information regarding nutritional content usually available, pose a burdensome job for the user to go through the information and take the right decisions. [3]

On the contrary, FOP labels present a much less complicated approach. FOP labeling acquires the real simplified nutritional information on product packaging. This ease of access and processing becomes a good reason why FOP labels are more effective in determining consumer choices compared to food scanner apps. [11]

Another great UI/UX is restaurant AR menus. With restaurant AR, the wish of the customers can be satisfied with three-dimensional images of dishes and even whole lists of ingredients; the menu can be interactive. The value of the information should be conserved rather than speed up the generation of the content. In order to get success, the entire AR experience has to be intuitive as well as informative. [4]

More generally, the sources emphasize that the development of successful food-related mobile apps will require special attention to UI/UX principles. Balancing 'complexity' of features with the need for a seamless user experience is key to user engagement and, in the end, the impact of the app toward changing users' healthy choices.

AR's Influence on Consumer Behaivour: Potential and Pitfalls

More generally, the sources emphasize that the development of successful food-related mobile apps will require special attention to UI/UX principles. Balancing 'complexity' of features with the need for a seamless user experience is key to user engagement and, in the end, the impact of the app toward changing users' healthy choices.

Sources investigate the effects of Augmented Reality on consumer behavior, from developing the shopping experience to more challenges entailed in increasing complexity and ease of use. Although AR brings some innovative ways of interaction with the consumer in order to provide information effectiveness is lower than the other, much more common influences, such as FOP labels.

A number of studies demonstrate the potential of AR to encourage healthier food choices. A study [9] explored the feasibility of an AR application which gives users personalized suggestions of healthy products to purchase in supermarkets. The application identified shelf products and overlaid color-coded flags, thus allowing users to point out healthy foods quickly along with bad guys to avoid them. Another app [1] aimed to guide consumers toward making healthier selections focusing on diet. It relied on the color-coded classification between healthy and unhealthy foods.

Source [11] would propose an AR application, PHARA, to aid in grocery store food product choice decision making. The application of AR is applied to represent information about food products to a user.

Another study [1] uses a mobile application-based AR, which provides information to consumers on products using AR and suggests healthy and similar products to the people.

Furthermore, researchers [12] conducted four studies to investigate the influence of a food scanner app (Yuka) on consumer choice. They found that, whereas the app increased intentions to buy healthier products in hypothetical situations, it had no impact on real behavior in the grocery store itself during an experimental supermarket setting. This gap between intentions and actual choices also points to the effort which may be required to utilize it while shopping, thus constituting a barrier toward the effectiveness of the application of the app.

All these sources point out that in almost all conditions, consumer behavior affects AR interventions less compared to the traditional methods such as FOP labeling. A comparative study [7] where a head-to-head comparison of the app on the food scanner versus FOP labeling came out indicated that in all situations, FOP labeling always outscored the application.

There are several reasons that can explain differences in performance. FOPs give consumers a look from the front of the package nutrition information directly accessible and easy to process. With AR applications, especially if they require scanning the barcode, their use will require more effort from the user-which may interfere with the proper processing of the information or even reduce the making of an informed choice.

Source [13] concludes that food scanner apps are ineffective as substitutes to FOP labels since the information is far more extensive and multiple scans are required for comparison of packaged products. Such multilevel processing of information might, in turn, sub-optimally affect consumers' choices.

Sources admit that, despite the problems in AR, it has uses and future directions.

- AR can be used to create interactive menus in restaurants so that customers can view three-dimensional visualizations of the dishes and the lists of ingredients in detail [4] . It may enhance customer engagement and possibly your customer choice.
- AR can be embedded in food packaging so that consumers get a rich interaction experience [4] . Scanning the packaging shall unlock for users information regarding the nutritional data, the origin, and the process of manufacture along with virtual representations of the food. Such enhanced transparency and engagement might impact the purchasing decision.
- AR applications can be further developed to aid in new food product development [4] . Developers can easily identify possible problems and then optimize a product for actual production by virtue of virtualization of the product followed by its analysis in real environments or simulated environments.
- Further studies may be conducted to ascertain whether AR with other modes like FOP labels push consumers toward healthier diets [14] . Perhaps, in isolation, the strategy can do little but when merged, the constraints are crossed, and intervention becomes that much stronger. All levelled off, taken broadly, in a rather convex shape to reveal the impact of AR on consumer behavior. Promises of AR about enhancing shopping experiences and healthy choices seem alluringly good but simplifying complexity and ease of use seem the biggest hurdles. Further research and development of optimal applications are required in their realization as regards their potential in shaping consumer behavior.

Ingredient Substitutions

Source [10] has examined all possible identification directions and the suggestion of ingredient alternatives. FoodKG is described in one of the references as a knowledge graph that allows ranking the most plausible alternatives for explicit semantic information as well as the implicit semantics captured by word embeddings that lead the users toward healthy choices along with their dietary requirements and preferences.

FoodKG: A Food Knowledge Graph

FoodKG is a knowledge graph of recipes and their ingredients. There are thousands of sources that feed this knowledge graph.

- Food Category: FoodKG utilizes the knowledge from an ontology on food named FoodOn to classify the ingredients.
- Nutritional Content: FoodKG associates the ingredients with data from the USDA, thus yielding in-depth

nutritional content about calories, macronutrients, and micronutrients.

- Recipes: FoodKG contains various recipes so that the ingredient conccurrences as well as recipe contexts could be analyzed.

Figure 4 and reference [15] shows how FoodKG really connects ingredient information with FoodOn ontology and even USDA nutritional data:

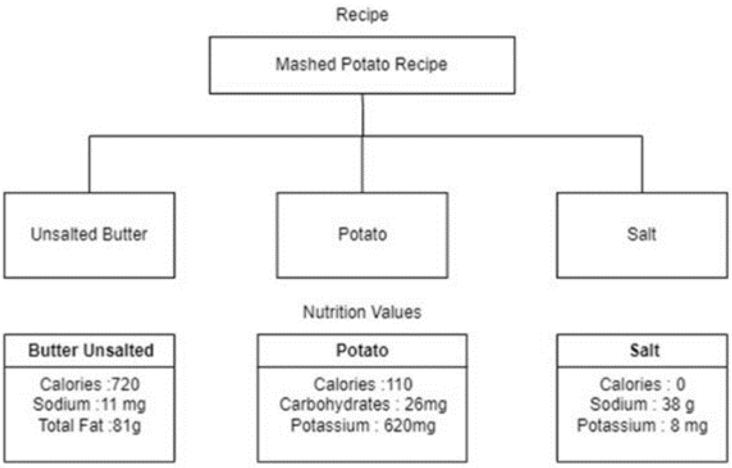

Fig 4: Example of linked ingredient information in FoodKG for the ingredient "Unsalted Butter" to the matching class in FoodOn's ontology and the USDA's nutritional information.

Figure 4 and reference [15] shows how FoodKG really connects ingredient information with FoodOn ontology and even USDA nutritional data:

Naming Target Ingredients and Healthy Alternatives

- It identifies the ingredient to be replaced, basis specific dietary restrictions that can either be ingredient specific or carry some specific nutritional content.
- Ingredient type restrictions: By the class hierarchy in FoodOn, the system can infer automatically the ingredients of proscribed types-for example, meat for vegetarians.
- Nutritional Content Constraints: Based on the user-defined dietary goals such as carbs, the app computes nutritional content values of all the ingredients using USDA data and catches on which ingredients are the major contributors to restricted nutritional content.

Ranking Possible Substitutions: the DIISH Heuristic

- Source [8] then devises the Diet-Improvement Ingredient Substitutability Heuristic: explicit semantics makes use of knowledge learnt from FoodKG while using implicit semantics predominantly through word embeddings. It makes use of four scoring metrics.
- It employs two word embedding models namely, Word2Vec, and spaCy for the embedding of latent semantic similarities between the names of the ingredients.
- Co-occurrence Similarity: It measures the co-occurrence similarity of ingredients which often co-occurs with the target ingredient in recipes, generalized by FoodOn's class hierarchy.

 Recipe Context Similarity: Based on the Positive Pointwise Mutual Information (PPMI) metric, this score captures the similarity in recipe contexts between the target ingredient and potential substitutes, again utilizing FoodOn links for generalization.

These four scores DIISH combines into an ultimate ranking of possible substitutes through a weighted formula. The system also removes any substitutes that are either a super class or subclass of the target ingredient for more meaningful suggestions.

Evaluation and Samples

Source [16] tested the effectiveness of DIISH on three ingredient substitution datasets constructed from diverse online sources and user reviews. Results report that DIISH performs better than baselines and thus point out the value added by the combination of explicit and implicit semantics for ranking ingredient substitutions.

As presented in Table 1, the DIISH substitutions made have some examples which show promise toward producing acceptable analogues:

Target ingredient	Ground-truth substitutes	DIISH's top 5 ranked substitutes
Arugula	Watercress Belgian endive Radicchio Escarole	Watercress Frisee Radicchio Romain lettuce Butter lettuce
Lard	Vegetable oil Shortening Margarine Bacon fat Butter	Vegetable shortening Shortening Margarine Bacon fat Butter

Table 1: Examples of ground-truth substitutions compared to substitute options ranked by our approach.

Source [15] also demonstrates DIISH's practical application through a hypothetical use case involving a diabetic patient aiming to reduce carbohydrate intake. The system identifies potatoes as the primary contributor to carbohydrates in a chosen recipe and suggests healthier substitutes with lower carbohydrate content. Table 2 presents the top five ranked substitutes:

Target ingredient: potatoes	
Ranked substitutes	**Carbohydrates per 100 g**
1. Turnip	6.4 g
2. Squash	6.9 g
3. Cauliflower	5.0 g
4. Butternut squash	11.7 g
5. Zucchini	3.1 g

Table 2: Top five potato substitutions containing fewer carbohydrates than potatoes.

Custom Databases and Local Food Products

While FoodKG provides a comprehensive knowledge graph for food, the sources also discuss the development of custom databases to address specific needs, such as local food products. For example, the development of a mobile application that combines barcode scanning with OCR technology to identify food ingredients and provide health advice. To support this application, the developers created a custom database tailored for local food products, supplementing information from open-source databases like Open Food Facts. [17]

III. Challenges

- Real World Performance Limitations. Grocery stores offer a very challenging real world in which AR frameworks operate, including product density, shelf guardrails and lighting conditions. These may limit recognition distance; therefore, the possibility of distinguishing unique products at greater distances is reduced and may also make it difficult to recognize multiple instances of product simultaneously.
- Misidentification and Display Issues: Misidentification appears to occur often with AR systems due to similar appearances in packaging. Thus, displays are incorrect information. Again, when the consumer display AR information within cluttered shop environments, overlapping or obscured views may prevent the user from seeing and picking up products correctly.
- Intentions do not correlate with behavior: Food scanner apps may impact intentions to make healthier choices, but these intentions often don't continue into actual purchasing behavior. Scanning every product is tedious and time-consuming, discouraging consistent use and, therefore limiting the overall impact of the app.
- Data Gaps in Ingredient Substitution Systems: Besides ensuring adequate data about ingredients, developing robust systems of substitution requires complete ingredient information. This includes ingredients specific to regional or cultural environments. Where the available data is scarce and exact nutritional computation cannot be correctly surmised, the system cannot adequately determine the ingredient substitution to be done.
- Customization vs. Guidance. Ingredient substitution systems balance such user flexibility with effective guidance. When customization is desired so that the system can consider the needs of dietary preferences, too much freedom may dilute the system's capability in guiding a healthy choice. Too many choices are also overwhelming for users and may decrease the likelihood of selecting the best alternative.
- Engagement and Usability: The main challenge in developing AR-based food scanners and ingredient substitution systems is very poor retention of users' engagement. A complicated interface, slow responses, or the feeling that the scanning and substitution processes are too laborious forces the usage to decline over time. Simplify interaction with relevant guidance so people stay on the system.

IV. Future Scope

- Advancing AR Technology: Improvement in better object recognition by AR in real-world use cases can be highly regarded. Algorithms, improved by overcoming lighting, occlusion, and product density issues, will make applications like food scanners much more accurate and usable.

- Simultaneous and Accurate Identification: In this concern, much work is required in the arena of simultaneous identification of products and individualized items with correct algorithms so that misidentifications can be reduced with overall enriched user experience at grocery stores.
- AR content optimization: Improvement in the delivery of AR content through enhancements in adaptive systems so that sensitivity to the viewer's proximity and angle of view is greatly enhanced to filter the context so that the amount of appearing content is user-friendly.

Using customization attributes that incorporate recommendation and gamification, and also personalizing the content to the person, will make the AR-based food application more interactive for users.

- Therefore, the drivers of this gap between healthy intentions and actual behavior of users, will therefore lead to better tools for the facilitation of healthier choice.
- Expanding ingredient libraries: The further an ingredient database is expanded with local and cultural ingredients, the more ingredient-substitution systems will both accurately and more appropriately react to diverse diets. AI and Machine Learning: AI-based personalization and prediction upgrade the food apps' brains to give smart suggestions and perfect substitutes for ingredients. Advanced data structures, such as a knowledge graph, make this system even more accurate.

V. Conclusion

Figure 4 and reference [15] shows how FoodKG really connects ingredient information with FoodOn ontology and even USDA nutritional data:

Debates abound for or against the notion that AR has transformative power to alter people's relationship with food. Using real-time nutritional information and making ingredient substitutions through upscaling manufacturing processes in food, promises better experience in food.

It indicates a future course of research and development toward the full realization of AR capabilities.

Technological upgrading is necessary for accurate object recognition, effortless delivery of content, and effective engagement of the user in dynamic environments.

Finally, the authors emphasize that real change in behavior "depends on the knowledge base established by proper information" and applied in appropriate action, and the literature underlines that this "can only be achieved through further understanding of the complex interplay between consumer intentions and actual purchasing behavior.".

Also, it's worth establishing comprehensive and diverse food databases and integrating AI and knowledge graphs, in which personalized recommendations, intelligent ingredient substitutions, and deeper understanding of multifaceted relationship of food, nutrition, and needs can be really integrated.

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