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AlertGen: Advanced Allergen Detection for Labelled and Non-labelled Foods

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Abstract - *In this study, artificial intelligence–driven analysis and optical character recognition (OCR) technology were utilized to enhance food safety by detecting allergens in both labelled and unlabelled foods through the development of the AlertGen mobile application. Individuals with food allergies play a crucial role in identifying the challenges associated with allergen detection, particularly in recognizing hidden allergens, interpreting unclear or misleading ingredient labels, finding safe food alternatives, and addressing the absence of allergen information in non-labelled foods. Their experiences and insights contributed significantly to understanding real-world difficulties in food allergen awareness and management. The researchers based the project design on a descriptive and developmental research method to better understand the existing challenges in allergen detection and to support the systematic development of the proposed application. For the design and development of the system, the SCRUM framework was adopted to ensure iterative improvement and alignment with user requirements. The study was conducted in the province of Pangasinan, and the participants were composed of individuals with food allergies selected through purposive sampling. Their feedback, together with data gathered from related studies and system usability evaluation using the System Usability Scale (SUS), proved essential in the successful design, development, and usability assessment of the AlertGen application.*

Keywords - *Artificial Intelligence, Optical Character Recognition (OCR), Food Allergies, Allergen Detection, AlertGen, SCRUM Framework, System Usability Scale (SUS).*

INTRODUCTION

Food allergies are a growing global health concern, affecting millions of individuals and posing serious risks for those exposed to allergenic ingredients. Durban et al., (2021) estimate that between 1.1% and 10.8% of the global population has a food allergy, with prevalence rates increasing over time.

Food allergies occur when the body mistakenly identifies certain foods as harmful triggering an inflammatory response of varying severity. Symptoms can range from mild, such as rashes and hives, to severe, including difficulty breathing, throat swelling, or anaphylaxis, a life-threatening condition where the body goes into shock. Risk factors include asthma, family allergy history, or prior reactions, with 15% of cases emerging in adulthood (Fetter, 2022).

Globally, food allergies are not only widespread but are also a leading cause of anaphylaxis, a severe and potentially life-threatening allergic reaction. According to Capulong (2024), nearly half of patients with food allergies have experienced anaphylaxis at some point, with crustaceans, cow's milk, eggs, nuts, wheat, and shellfish being among the most common triggers for both children and adults.

In the Philippines, some of the most prevalent food allergens include eggs, milk, peanuts, soy, and

seafood such as shrimp and shellfish (Romero, 2020). These allergens are often easily recognizable if individuals are aware of the typical symptoms and reactions.

Symptoms of food allergies can vary in intensity and include gastrointestinal discomfort, skin reactions like hives and itching, and respiratory issues such as difficulty breathing. In more severe cases, individuals may suffer from low blood pressure or anaphylaxis, which requires immediate medical intervention (Perpetual Help Medical Center, 2025). Early diagnosis and medical guidance are crucial for managing food allergies and avoiding serious health complications. Increased awareness and understanding of common allergens can significantly contribute to better prevention and management strategies.

According to Rosero et al. (2024), over a five-year period (2018–2022), 97 pediatric anaphylaxis cases at Ospital ng Makati were reported, with food as the primary trigger, accounting for 86.65% occurrences, led by fish, chicken, shrimp, and egg. Furthermore, fish is a staple in the diet from an early age and fish sauce is a common ingredient of Filipinos. Fish allergies affect 2.29% of Filipinos, with 40% developing later in life (Wai et al., 2021). While shellfish allergies rise from 0.9%–1.19% in children under 7 years old to 5.12%–7.71% in adults (Davis et al., 2020).

In addition to the prevalence of allergies, the risks associated with food allergies, particularly when considering packaged cooked foods and non-packaged (freshly prepared) foods. Both types of food pose distinct challenges for individuals with food allergies, influencing the likelihood of exposure to allergens and the ability to manage dietary restrictions effectively (Tracy, 2024; NHS 24, 2025).

Additionally, the issue of undeclared allergens in food poses a serious risk to allergic patients. Studies show that 10% of allergic patients experience annual reactions despite avoidance efforts (Peters et al., 2021). Food mislabeling is on the rise and does not always adequately contain information about the allergens present, which implies a risk for allergic patients. As a result, the presence of undeclared allergens in food labeling is considered a significant public health concern for the population within the European Union (Martínez-Pineda & Yagüe-Ruiz, 2022).

The Food Allergen Labeling and Consumer Protection Act (FALCPA) is a law enforced by the U.S. Food and Drug Administration (FDA) that requires manufacturers to label eight major allergens: milk, egg, peanut, tree nuts, soybean, fish, shellfish, and wheat with sesame added recently in January 2023 (Nutrition, C. for F. S. and A., 2021). However, food labeling issues persist, including incomplete or unclear information and the inclusion of numerous ingredients, often listed in unfamiliar terms, complicating allergen identification for consumers. Warnings such as “may contain” allergens are optional under FALCPA, leading to ambiguity creating uncertainty for consumers assessing potential allergen exposure (Center for Food Safety and Applied Nutrition, 2022).

Avoiding the allergen is crucial in managing food allergies (Cafarotti et al., 2023), but accidental exposure can still occur potentially leading to severe reactions like anaphylaxis (Muraro et al., 2022). A major cause of unintentional ingestion is forgetfulness, lack of supervision, or failure to check product ingredients. This risk is especially high when consuming non-prepackaged foods from catering establishments, self-service stores, bakeries, and restaurants frequently contributes to these incidents, likely due to the absence of direct allergen information on such products (Martínez-Pineda & Yagüe-Ruiz, 2022).

Despite the critical role of food labels in preventing allergic reactions, consumer engagement remains low. Studies show that only 19.6% of Filipino adults consistently read food labels, while 45.9% never

read them at all (Javier et al., 2023). Another study conducted in Los Baños, Laguna, reported a higher prevalence, with 87.73% of adults using nutrition labels (Sy & Bullecer, 2020).

This limited engagement highlights the need for efficient and accessible solutions to allergen detection. One of the promising solutions is the use of Optical Character Recognition (OCR) which can help bridge the gap between consumers and critical allergen information. OCR, is a branch of image recognition that identifies text in scanned documents or images. Mahesh et al. (2025) stated that advancements in OCR, Natural Language Processing (NLP), and machine learning technologies provide promising solutions for improving allergen detection. OCR facilitates automated text extraction from images, enabling real-time scanning of food product labels.

Mobile applications have emerged as user-friendly tools to support allergen management. One such tool is Nutricates, a mobile application that seeks to assist users in making well-informed decisions regarding their allergies. The app uses OCR technology in scanning ingredient labels and identifying allergens and therefore provides accurate allergen-based information to enable better food choices, however the database was manually created by the developers and only contains a small number of food items.

Many commonly available supermarket foods are not included, which limits the application's effectiveness. Issues occur especially in conditions like low lighting, poor focus, low resolution, or oblique angles when capturing images. Errors include missing or adding hyphens, slashes, or apostrophes incorrectly.

Similarly, focusing on addressing allergen identification, Eñano et al. (2024) evaluated the effectiveness of Allertify, an android application that identifies allergens through barcode scanning and image recognition. The application was inaccurate because it used a limited dataset and similar product packaging could be visually ambiguous. Its improvements were suggested through the use of a more diverse dataset.

In spite of the potential of existing tools, there is still a significant gap in allergen detection, especially for non-prepackaged or fresh foods. The adoption of digital non-destructive solutions is becoming essential to ensure food safety and increase processing efficiency. These solutions combine sensors and machine learning to provide reliable detection and quantification. Consumers need to be able to assess foods themselves on the spot, for example a celiac patient should be able to determine if a product contains sufficient gluten to harm them before they make a purchasing decision. These are all critical needs that highlight the importance of developing non-destructive methods for allergen detection and quantification. The current tools in allergen detection are efficient but are mostly chemical or biochemical assays that require sample preparation, are slow in providing feedback, and lead to the production of wastes. The major limitation is the high cost of implementation, which is currently being addressed through innovative solutions that are making the method become increasingly affordable. (Adedeji et al., 2024).

The researchers are proposing AlertGen, the next generation of allergen detection. Building on advanced multimodal capabilities of Gemini 2.5 Pro for image analysis and robust OCR, AlertGen improves accuracy and speed in allergen identification by scanning both labelled and unlabelled foods. This is achieved through the integration of a Human-in-the-Loop (HITL) validation system and an intelligent caching mechanism. This combined approach directly resolves the fundamental challenge of visual ambiguity and the limitation of scarce datasets that constrained previous apps.

For new or visually ambiguous food items, the Gemini 2.5 Pro vision system provides up to three identification results with confidence percentages. The

user intervenes to select the correct food item, thereby validating the AI's prediction. Once the correct dish is selected, the AI retrieves the ingredient, simplifies the list, and analyzes the ingredients to detect potential allergens. This user-validated data is then stored in a cache. Subsequent scans of the same food item will bypass the user selection screen, instantly providing the result from the cache, ensuring high speed and continuous data improvement. This enables consumers to easily and confidently make informed choices. AlertGen's ability to handle diverse food items positions it as a crucial tool for anyone with food allergies, offering a level of convenience and safety that existing apps lack. With AI's predictive abilities, AlertGen could also provide personalized allergen warnings based on user preferences and known allergies ensuring a personalized and proactive approach to food safety.

MATERIALS AND METHOD

The researchers utilized both descriptive and developmental methodologies for the development of the AlertGen: Advanced Allergen Detection for labelled and non-labelled foods

According to MCCombes (2023), descriptive research aims to accurately and systematically describe a population, situation or phenomenon. It can answer what, where, when and how questions, but not why questions. In line with this, Petrović & Jovanović (2021) highlights that descriptive research design is applied in case studies, naturalistic observations, and surveys, involving comprehensive data collection, analysis, and presentation to describe the existing conditions. To assess the system's user requirements and test the proposed application's usability, the developers utilized survey questionnaires as a data-gathering method for descriptive design.

Richey and Klein (2014) defined development research design as the systematic study of design, development, and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development (Nurul Auji Hasbullah et al., 2022). The study adopted developmental research design, which was a systematic and iterative approach focused on designing, testing, and refining a product based on user feedback and empirical data. This design was specifically useful in user-centered research, as it supported continuous improvement and adaptation to user needs. This approach was particularly suitable for developing an allergen detection application that evolved based on user feedback. The AlertGen app used the Scrum methodology, where the vision of Scrum was to make high-value products in terms of creativity and productivity (Kurniawan et al. 2022). Scrum was a five-phased process that is focused on Agile principles: (a) initiate, (b) plan and estimate, (c) execute, (d) review and evaluate, and (e) release. Iterations of the Scrum Methodology's design and creation phases aided in the delivery of the initial prototype. Every two and a half weeks, the researchers held "sprints." Sprints were iterations in the development of prototypes that continued until the entire application was created and implemented for end-users (Retrieved from SCRUMstudy, 2020).

Initiation. In the Initiation phase, the researchers functioned as a scrum team. Project vision was defined, establishing clear objectives that served as the basis for developing epics. The target population of this study included individuals with food allergies. To gather relevant data, the team utilized purposive sampling, surveying 20 individuals from this population. Based on the Project Vision and stakeholder input, the team then created epics, which were large user stories that represented significant app features or functionalities. These epics served as the foundation for breaking down tasks into smaller user stories in future phases. The product backlog, which consisted of tasks that had to be completed, was identified. Additionally, the team conducted a discussion for the product backlog

content to ensure it was aligned with the objectives and user requirement. Along with that, the team also established a release planning schedule as part of the release planning process. This schedule outlined how the app would be delivered in phases, with key milestones and timelines that guided the development process.

Planning and Estimate. In this phase, the researchers planned how to design and develop an application that would accomplish satisfaction based on the end users' requirements. The researchers set what would be the expected result of the application by creating user Stories, approving the estimate, committing the user stories, creating the tasks and preparations needed, and lastly, creating the Sprint Backlog.

Implementation Phase. In this phase, the team worked on the tasks in the Sprint Backlog to create Sprint Deliverables. A daily standup meeting was held where the Scrum Team discussed their progress and challenges. The Product Backlog was continuously refined throughout the project. Any issues raised in the sprint, may have resulted in updates to the backlog for future sprints.

Review and Retrospective Phase. This phase involved reviewing the completed deliverables. During a sprint review and retrospective meeting, the proponents demonstrated and validated the sprint while also identifying areas that need improvement.

Release Phase. This was the final phase of the project, and it focused on implementation and accurate documentation of the proponents' insights learned during development.

RESULTS AND DISCUSSION

The development of the AlertGen successfully addressed the major challenges encountered by individuals with food sensitivities in detecting hidden allergens, interpreting misleading ingredient labels, and navigating non-labeled foods. The developed system provided a highly usable platform based on essential user requirements, where individuals could effectively detect specific allergens and easily discover safe, personalized food alternatives.

The following section presents the visual interface of AlertGen, followed by a detailed analysis of its usability and practical impact on managing food sensitivities.

A.System Interface

To provide a clear understanding of AlertGen's architecture and user experience, the researchers documented the final output of the system.

Figure 1. Introductory Screen

Figure 1 shows one of the introductory screens that appear when the app AlertGen is newly installed on a device. These screens highlight the valuable features of the mobile application, which the user can view one by one or skip.

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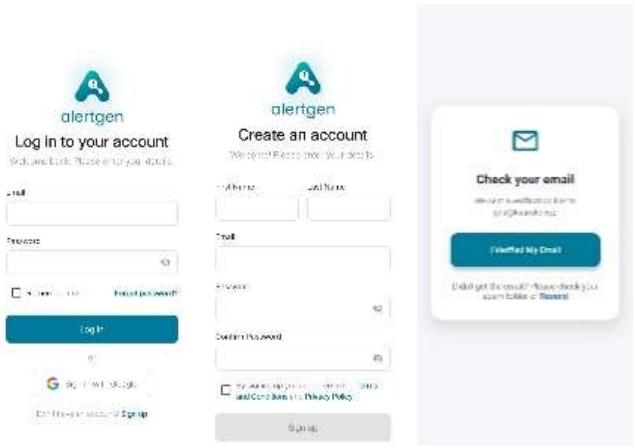

Figure 2. Log In and Sign-Up Screens

Figure 2 features AlertGen's secure authentication interfaces. It allows returning users to log in using their email and password, and enables new users to register, securely store their profiles, and activate their accounts through email verification.

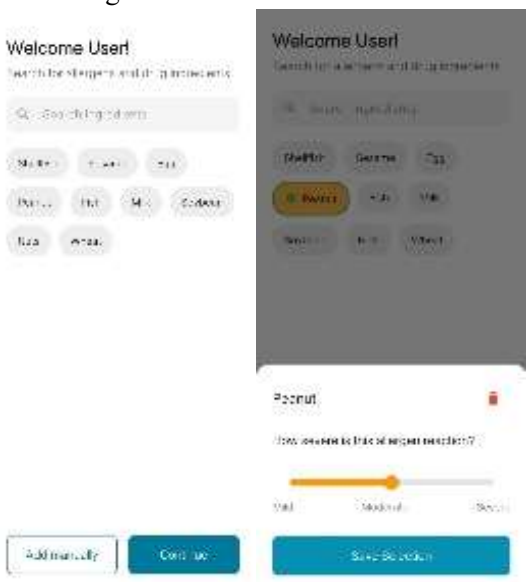

Figure 3. Profile Setup: Allergens

Figure 3 shows that during the onboarding process, this screen allows users to select allergens that are relevant to their health profile and specify the severity of each allergy as mild, moderate, or severe. It ensures that the system tailors' detection, alerts, and food recommendations according to individual needs.

Figure 4. Main Screen

Figure 4 screen serves as the central navigation hub of the application. It provides users with quick access to essential features such as scanning, allergen and profile management, scanned products history and emergency tools.

Figure 5. First Aid Screen

Figure 5 shows the first aid screen that provides clear, step-by-step instructions for managing allergic reactions. It ensures users have immediate guidance in

critical situations even without medical personnel present.

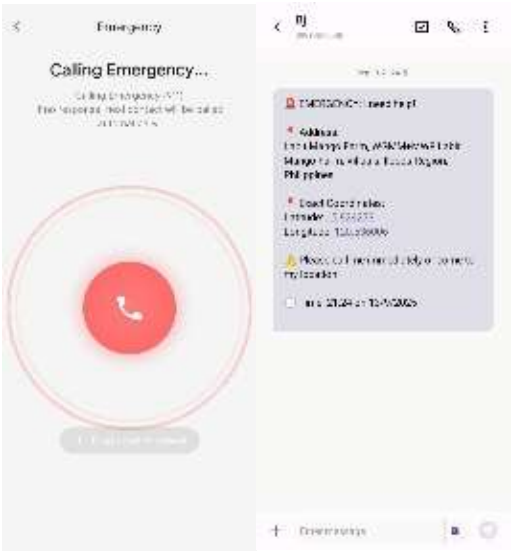

Figure 6. Emergency Screen

Figure 6 provides a one-touch emergency assistance feature. The app first calls the primary emergency contact; if unanswered, it automatically tries the remaining contacts. If no one responds, it redirects the call to 911 and sends alert messages to all emergency contacts.

Figure 7. Scanner Screen

Figure 7 shows the Food Scanner feature of the AlertGen App, which uses OCR and AI-Powered analysis to detect allergens in both labeled and non-labeled foods. The screens demonstrate how the app scans and recognize text from food labels, extracts ingredient information, and identifies any hidden allergens to ensure user safety.

Figure 8. User Selection Screen

This screen appears when the app has no cached match in Firebase. Using a Human-in-the-Loop (HIL) process, the user selects the correct item from three AI-generated options, each showing a percentage match. This helps ensure accurate allergen detection.

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Figure 9. Manual Food Ingredient Input

Figure 9 shows the Manual Food Input Screen of the AlertGen App. Users can enter a food name and its ingredients to check for potential allergens, providing a personalized allergen safety check.

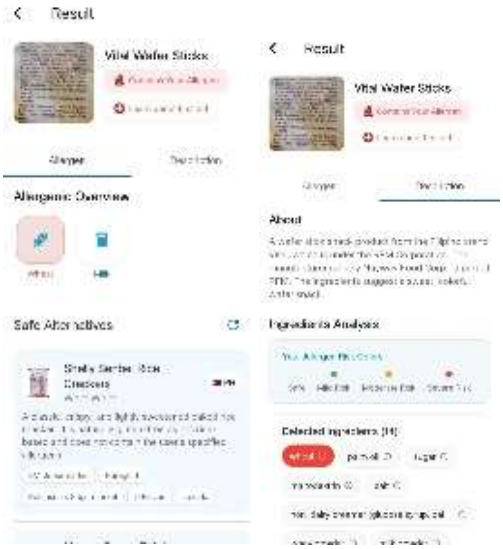

Figure 10. Scan Result Screen

Plate 10 shows the Scan Result Screen of the AlertGen App. It displays the detected allergens, a short description of the scanned food, and a quick ingredient analysis to help users identify any potential risks.

Figure 11. Food Alternatives Screen

Figure 11 shows the Food Alternatives Screen of the AlertGen App. It suggests safe substitute products specifically for labeled foods that contain allergens, helping users make allergen-friendly choices.

Figure 12. Allergen Profile Screen

Figure 12 allows users to input, view, and customize their allergen information. Personalized allergen profiles ensure accurate detection and tailored recommendations.

B. System Usability Scale (SUS) Result

To evaluate the challenges of allergen detection and identify user requirements, the researchers administered a comprehensively validated survey questionnaire and utilized a System Usability Scale (SUS) survey to evaluate the proposed mobile application. To ensure a focused evaluation, data were gathered from purposively selected individuals within the province of Pangasinan, providing a relevant representative sample for this preliminary local study.

To assess the system's overall usability, a SUS questionnaire was administered to a total of 20 respondents. The SUS is a widely used tool for measuring user perception of system usability based on a 10-item questionnaire.

Table 1. SUS Evaluation Results

Usability Question	SUS Score	Descriptive Equivalent	Descriptive Interpretation
1. I think that I would like to use this system frequently.	87.50	Best Imaginable	Usable
2. I found the system unnecessarily complex.	65.00	Okay	Usable
3. I thought the system was easy to use.	80.00	Excellent	Usable
4. I think that I would need the support of a technical person to be able to use this system.	75.00	Good	Usable
5. I found the various functions in this system were well integrated.	85.00	Best Imaginable	Usable
6. I thought there was too much inconsistency in this system.	67.50	Okay	Usable
7. I would imagine that most people would learn to use this system very quickly.	90.00	Best Imaginable	Usable
8. I found the system very cumbersome to use.	75.00	Good	Usable
9. I felt very confident using the system.	85.00	Best Imaginable	Usable
10. I needed to learn a lot of things before I could get going with this system.	67.50	Okay	Usable
Total	**77.75**	**Excellent**	**Usable**

Table 1 shows the conducted usability testing using the System Usability Scale (SUS) yielded a high

overall score of 77.75, earning an "Excellent" grade and confirming the system's general "Usable" status.

This strong rating is primarily driven by high agreement on the positively-worded statements, which highlight the system's strong core appeal: users reported high scores for frequent use (87.50), strong functional integration (85.00), high user confidence (85.00), and exceptional ease of quick learning (90.00). However, a deeper analysis reveals friction points in the negatively-worded items, with the lowest scores recorded for unnecessary complexity (65.00) and user perception of inconsistency (67.50), indicating that while the system is highly effective and desirable, its design requires focused effort to simplify workflows and standardize the interface to overcome current usability hurdles.

CONCLUSION

The study concluded that the AlertGen mobile application is an effective solution for mitigating the daily challenges encountered by individuals with food sensitivities. The system successfully addressed critical user requirements by providing a reliable platform to detect hidden allergens, clarify misleading ingredient labels, and recommend personalized safe food alternatives.

The use of the SCRUM framework contributed significantly to the successful development of the application by enabling rapid iteration and efficient implementation within a short timeframe. The developed system provided a highly usable and user-friendly platform that successfully incorporated data-driven insights to meet the exact needs of its target users without compromising the overall user experience.

Overall, AlertGen has the potential to significantly improve the daily lives of individuals managing food allergies and contribute to a safer, more informed, and digitally supported approach to dietary management.

RECOMMENDATION

Based on the findings and conclusions of the study, the following recommendations are proposed:

The university may officially adopt and implement the Student Organization Portal across all recognized student organizations within PSU.

Future developers should focus on innovating and improving AlertGen's core functionality by enhancing machine learning capabilities for better allergen detection in complex regional and international foods. Additionally, implementing features such as an iOS version, comprehensive educational video modules, and advanced community moderation tools, including spam filters and offensive content detection will ensure the application remains accessible, safe, and effective for a diverse and expanding community.

In addition, the researchers recommend Agile Scrum Methodology to any study related to this from which it is flexible and effective enough to improve the development of the application.

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