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Jackfruit Disease Recognition Using Image Processing in Non-Destructive Method with Alternative Treatment Recommender

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Abstract: This study focuses on developing a mobile application for jackfruit disease recognition using advanced image processing techniques and hybrid algorithms. The proposed system combines Convolutional Neural Networks (CNN) with Support Vector Machines (SVM) to create a non-destructive method for accurately diagnosing jackfruit disease, particularly Rhizopus disease, through image analysis. By addressing the limitations of traditional disease detection methods, this application aims to provide a rapid, reliable, and automated solution for monitoring jackfruit health. Additionally, the study integrates an alternative treatment recommender that suggests organic and eco-friendly solutions for disease management, enhancing the sustainability and effectiveness of jackfruit cultivation. The system's performance was evaluated using metrics such as accuracy, precision, recall, and F1 score, with the goal of creating a high-quality, user-friendly application based on ISO 25010 software quality standards.

Keywords: Jackfruit, Rhizopus rot, Convolutional Neural Networks, Support Vector Machines, Non-destructive methods, Alternative Treatments Recommender

1. Introduction

Jackfruit (Artocarpus heterophyllus) is a vital tropical fruit extensively cultivated in various Asian countries. It is highly regarded for its large size, distinctive texture, and rich nutritional benefits [1], making it an essential part of the diet in many regions. Beyond its dietary value, jackfruit plays a significant economic role, especially in rural communities where it serves as a primary source of income [2]. However, jackfruit cultivation is increasingly challenged by diseases such as Rhizopus rot and brown rot, which can drastically reduce both yield and fruit quality. Brown rot has been observed in Los Baños, Laguna, Philippines, characterized by dark brown to black discoloration at the center of lesions, spreading radially with a yellow to brown margin [3]. Traditional disease detection methods often rely on visual inspections, which are time-consuming and prone to errors. By the time symptoms become visible, the disease may have

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progressed to a stage where control is difficult, leading to substantial economic losses for farmers [4].

With the rapid advancement of mobile technology, the widespread adoption of smartphones [5], and the growing accessibility of internet connectivity, mobile-based applications have become valuable tools in enhancing agricultural practices. The system not only aimed to support farmers by providing timely and accurate disease identification but also served as a practical tool for researchers. Additionally, the inclusion of alternative treatment recommendations enhanced the system's functionality, promoting more sustainable and effective disease management strategies.

To address these challenges, the study aims to develop a mobile application that utilizes image processing and machine learning techniques to detect jackfruit Rhizopus disease accurately and non-destructively. Specifically, the system integrates a hybrid algorithm in combination with a Convolutional Neural Network (CNN) and Support Vector Machine (SVM) for disease recognition and offers eco-friendly treatment recommendations to promote sustainable farming practices [6][7]. The study focuses on four key objectives, such as developing a mobile application that uses the CNN-SVM hybrid algorithm for non-destructive disease recognition, comparing the performance metrics of the hybrid model with a basic CNN in terms of accuracy, precision, recall, and F1 score, providing an alternative treatment recommender to support farmers with effective disease management strategies, and evaluating the application based on ISO/IEC 25010 software quality standards for product quality and quality in use. These objectives aim to enhance disease detection accuracy, offer timely treatments, and support sustainable agricultural practices.

This study aims to address these challenges by developing a mobile application that leverages modern image processing and machine learning technologies for the early and accurate detection of jackfruit diseases. The proposed system will utilize a hybrid algorithm combining Convolutional Neural Networks (CNN) and Support Vector Machines (SVM) to analyze images of jackfruit and identify signs of disease like Rhizopus rot. The non-destructive nature of this approach allows for ongoing monitoring of the fruit without compromising its integrity. Additionally, the mobile application will include an alternative treatment recommender system, which will suggest eco-friendly and organic solutions for managing identified diseases. This feature aligns with the growing demand for sustainable agricultural practices, offering farmers practical and environmentally responsible options for disease management.

2. Related Literature

Jackfruit is abundant in several nutrients and has many health benefits. The mature jackfruit flesh and seeds contain more protein, calcium, iron, and thiamine than other tropical fruits. The fruit contains substantial amounts of B vitamins, vitamin C, potassium, calcium, iron, proteins, and carbohydrates [8]. It underscores the importance of protecting jackfruit trees from diseases to ensure the health and yield of this highly nutritious fruit.

In the study of Oraño *et al.* [6], an Android mobile app was presented using convolutional neural networks (CNN) to detect and diagnose jackfruit damage, achieving high accuracy in identifying pest and disease issues. The app provides real-time assessments and recommendations for fruit protection. The research aims to further develop a hybrid algorithm (CNN and SVM) for early and accurate jackfruit disease detection. A recommender system designed for clinical applications was introduced by Sarangi [9], focusing on disease recognition and treatment recommendations. This aims to develop a mobile application for jackfruit disease recognition using image processing and machine learning. Designed for diagnosing and recommending treatments for primary lung diseases, the study of Habib *et al.* [10] aims to enhance agricultural efficiency by providing accurate diagnoses and recommending treatments, similar to how expert systems optimize healthcare outcomes.

3. Methodology

This chapter provides the overall structure for the method and procedures used in the conduct of the study. It discusses the research method used, the population frame sampling scheme, the subject of the study, the instrumentation, the data collection and procedures, and the statistical treatment of data.

The study was conducted in developing a non-destructive method for recognizing jackfruit diseases using image processing [11], as well as an alternative treatment recommender system. Software developers use agile techniques to reduce the problems faced by the traditional waterfall process [12]. The researcher used an Agile methodology under the Software Development Life Cycle [13], and it focused on descriptive developmental design that was based on prototyping and iterative development. The process of the software itself involved the planning required for developing the mobile application. Several key steps, beginning with the collection of a comprehensive dataset of jackfruit images, both healthy and diseased, and distinguished based on visual patterns. Performance metrics such as accuracy, precision, recall, and F1 score are used in evaluating the effectiveness of the hybrid model compared to a basic CNN model.

Table 1. Likert Scale Rating

Mean Value	Rating	Interpretation
4.21-5.00	Excellent	It has superior or extraordinary attributes.
3.31-4.20	Very Satisfactory	It is very satisfactory and shows above-average qualities or abilities.
2.61-3.30	Satisfactory	It meets the minimum required standards.
1.81-2.60	Fair	It is fairly suitable but lacks exceptional quality or ability.
1.00-1.80	Poor	It is deficient in quality and ability.

The evaluation of the Jackfruit Disease Recognition System aligns with ISO 25010 software quality standards, focusing on product quality and quality in use. Product quality is assessed through functionality, measuring accuracy in disease detection and treatment recommendations; reliability, ensuring consistent performance; usability, evaluating ease of use; performance efficiency, analyzing responsiveness and processing speed; maintainability, determining ease of updates; and portability, ensuring compatibility across Android devices. Quality in use covers effectiveness in identifying diseases and providing recommendations; efficiency in task completion; satisfaction with the app's performance; and freedom from risk, minimizing diagnostic errors. Each criterion is rated on a Likert scale with the following interpretation: 4.21–5.00 (Excellent), 3.31–4.20 (Very Satisfactory), 2.61–3.30 (Satisfactory), 1.81–2.60 (Fair), and 1.00–1.80 (Poor). This structured assessment provides insight into the system's overall performance and user experience. The Likert Scale ratings and their corresponding interpretations were depicted in Table 1.

The respondents of this survey were eighteen (18) farmers, one (1) agriculturist, six (6) jackfruit enthusiasts, five (5) in IT-related professions, and ten (10) technical experts. A total of forty (40) users participated in the evaluation of Jackfruit Disease Recognition Using Image Processing in the Non-Destructive Method with Alternative Treatment Recommender, providing feedback based on the ISO/IEC 25010 software quality standards.

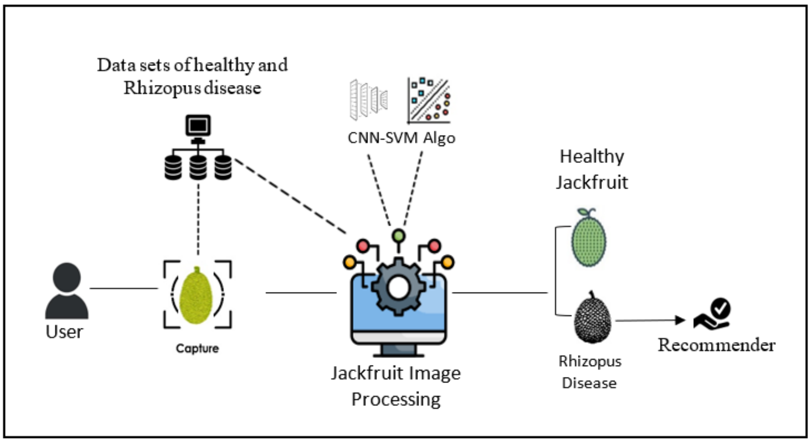

Figure 1. The Operational Framework

Figure 1 shows the operational framework for jackfruit disease recognition using image processing in a non-destructive method with an alternative treatment recommender. This is how the data was executed from input to output.

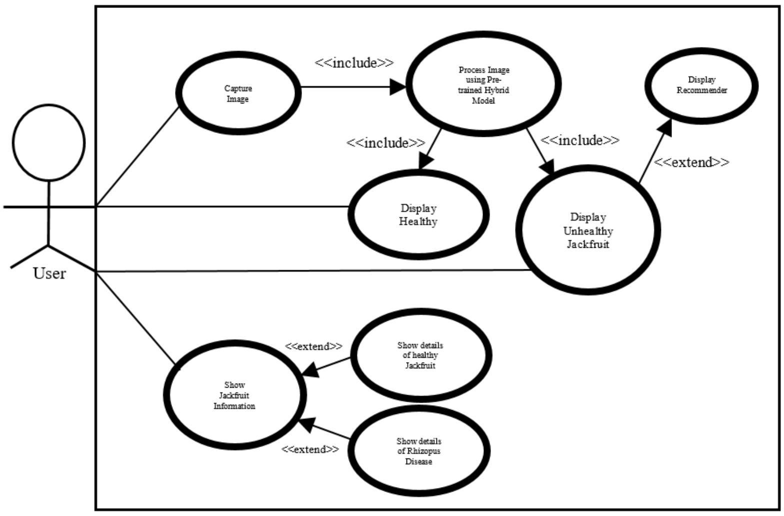

Figure 2. Use Case Diagram

In Figure 2, the use case diagram illustrates the interactions between the system and its users, such as farmers, jackfruit enthusiasts, and agriculturists.

A farmer captures an image of a jackfruit using a system camera or smartphone app. The system processes the image with a hybrid algorithm to detect if the fruit is healthy or infected with Rhizopus, providing confidence scores. If Rhizopus is detected, the system recommends treatments such as organic pesticides, better irrigation, or removing infected fruits. This helps simplify disease management, improve crop quality, and reduce losses.

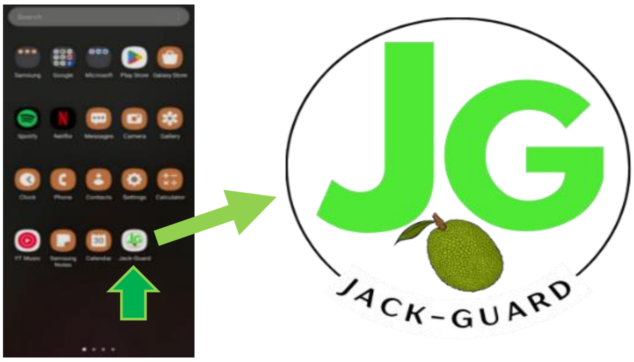

Figure 3. The Mobile Icon

The provided image, as shown in Figure 3, showcases an icon design for the mobile application "Jack-Guard," which is aimed at recognizing jackfruit diseases using a non-destructive image processing method and providing alternative treatment recommendations. The "Jack-Guard" app icon features a bold "JG" and a jackfruit image on a green background, symbolizing its focus on jackfruit health.

Figure 4. The Mobile Splash Screen or Loading Screen

Figure 4 depicts the design that illustrates its purpose and functionality. It shows a stylized image of a person analyzing a jackfruit displayed on a digital screen, symbolizing the app's use of image processing for disease detection. The stack of books represents knowledge and research, while the vibrant design conveys innovation and accessibility. The progress bar suggests the app's real-time processing capabilities. This visual reinforces the app's role in assisting users with jackfruit health management through non-destructive methods.

Figure 5. The Mobile Main Screen

Figure 5, the main screen interface, signifies two individuals interacting with the system using mobile devices, symbolizing accessibility and user engagement. The design reflects the app's user-friendly approach to disease recognition and treatment guidance. The inclusion of a jackfruit highlights the app's focus on analyzing and diagnosing the fruit's health. The question mark provides communication and information from the app, emphasizing the healthy and Rhizopus disease. The "Detected result is:" area displays diagnosis results after an image was analyzed. The "Take Action" button with a camera icon allows users to capture an image to start the diagnostic process.

4. Results and Discussion

The mobile application was developed using a hybrid CNN-SVM algorithm for non-destructive image processing to detect jackfruit diseases. The study demonstrated the algorithm's accuracy and effectiveness, evaluated through performance metrics like accuracy, precision, recall, and F1 score. A comparison with a basic CNN model highlighted the advantages of the hybrid approach, showing improved detection performance.

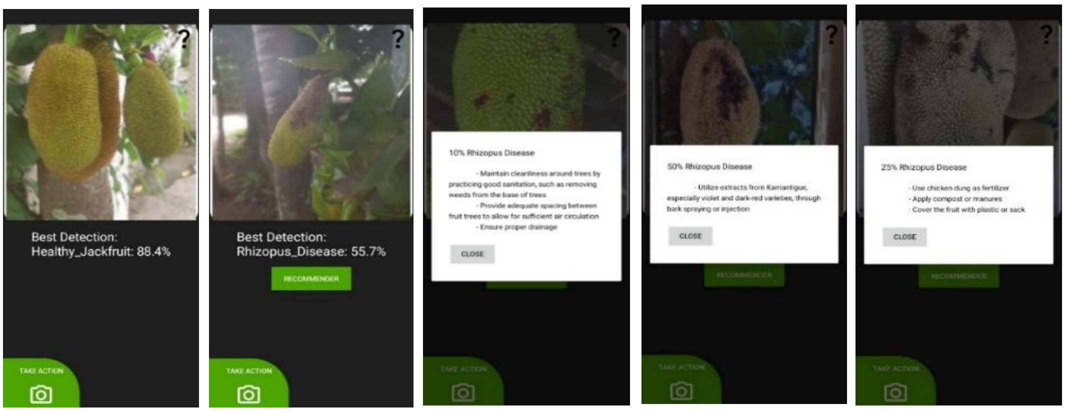

Figure 6. Sample Detection of Healthy and Unhealthy Jackfruit

The set of images depicted in Figure 6 shows the app identifying jackfruit health status using image processing. It detects and labels whether a jackfruit is "healthy" or affected by "Rhizopus disease," displaying a confidence score for each diagnosis. This visual summary highlights the app's capability to assess jackfruit condition accurately, supporting farmers with early disease detection and potential treatment recommendations.

The respondents of the survey were eighteen (18) farmers, one (1) agriculturist, six (6) jackfruit enthusiasts, five (5) IT-related professionals, and ten (10) technical experts. A total of forty (40) users participated in the evaluation of Jackfruit Disease Recognition Using Image Processing in the Non-Destructive Method with Alternative Treatment Recommender, providing feedback based on the ISO/IEC 25010 software quality standards. Respondents' evaluation results used the five-point Likert scale as the basis for evaluators in rating the mobile app. Considering the criteria such as performance efficiency, compatibility, usability, reliability, security, maintainability, efficiency, portability, effectiveness, satisfaction, freedom from risk, and context coverage. The respondents' evaluation results were summarized in Table 2 and Table 3.

Table 2. Respondents' Evaluation Results Using the Five-Point Likert Scale in Terms of Product Quality

Objectives	**Characteristics**	**Mean**	**Interpretation**
Functional Suitability	Functional Completeness	4.58	Excellent
	Functional Correctness	4.57	Excellent
	Functional Appropriateness	4.60	Excellent
Performance Efficiency	Time-Behavior	4.67	Excellent
	Resource Utilization	4.50	Excellent
	Capacity	4.52	Excellent
Compatibility	Co-existence	4.33	Excellent
	Interoperability	4.38	Excellent
Usability	Appropriateness recognizability	4.60	Excellent
	Learnability	4.63	Excellent
	Operability	4.77	Excellent
	User error protection	4.13	Very Satisfactory
	User Interface aesthetics	4.13	Very Satisfactory
	Accessibility	4.53	Excellent

Reliability	Maturity	4.43	Excellent
	Availability	4.72	Excellent
	Fault tolerance	4.13	Very Satisfactory
	Recoverability	4.50	Excellent
Security	Confidentiality	4.50	Excellent
	Integrity	4.13	Very Satisfactory
	Non-repudiation	4.57	Excellent
	Accountability	4.35	Excellent
	Authenticity	4.62	Excellent
Maintainability	Modularity	4.47	Excellent
	Reusability	4.65	Excellent
	Analyzability	4.57	Excellent
	Modifiability	4.19	Very Satisfactory
	Testability	4.53	Excellent
Portability	Adaptability	4.45	Excellent
	Installability	4.52	Excellent
	Replaceability	4.52	Excellent
Total		**4.48**	**Excellent**

Table 3. Respondents' Evaluation Results Using the Five-Point Likert Scale in Quality in Use

Objectives	Characteristics	Mean	Interpretation
Effectiveness		4.70	Excellent
Efficiency		4.67	Excellent
Satisfaction	Usefulness	4.75	Excellent
	Trust	4.36	Excellent
	Pleasure	4.58	Excellent
	Comfort	4.65	Excellent

	Economic Risk Mitigation	4.55	Excellent
	Health and Safety Risk Mitigation	4.73	Excellent
Freedom from risk	Environmental Risk Mitigation	4.58	Excellent
	Context Completeness	4.48	Excellent
	Flexibility	4.58	Excellent
Total		**4.62**	**Excellent**

The results of this study confirm the feasibility and effectiveness of the proposed Jackfruit Disease Recognition system. The hybrid CNN-SVM model provides accurate disease detection, while the alternative treatment recommender offers valuable insights for managing identified diseases. These findings contribute to the broader goal of improving agricultural practices through technological innovation, ultimately supporting the sustainable cultivation of jackfruit.

5. Conclusion and Recommendations

In conclusion, this study introduced a novel approach to managing jackfruit disease through the development of a mobile application that integrated advanced image processing and machine learning techniques with sustainable treatment options. By addressing the limitations of traditional disease detection methods, this research contributed to the advancement of agricultural practices, providing farmers with a powerful tool to protect and improve their crops. The success of this study had significant implications for the broader field of agricultural technology, potentially paving the way for similar innovations in other crops and regions.

To further enhance the jackfruit disease recognition system, the study recommended expanding the dataset, continuously training the model, and integrating IoT devices for real-time monitoring. Additionally, it suggested providing user education and support, as well as conducting further research to validate and refine the proposed treatment options.

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