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Designing an Application for Detecting Diseases of Rice Plants Using OOAD Method

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Abstract: In the development of the Android-based Smart Farm application to support Indonesia's food security, this research employs the Object-Oriented Analysis and Design (OOAD) methodology. OOAD is systematically utilized to delineate the functional and non-functional requirements of the application and to design the object structure and inter-object interactions. Requirements analysis involves a literature review and field observations in the Bandung Regency, forming the foundation for designing an application that utilizes image processing and artificial intelligence technologies to aid farmers in identifying leaf diseases in rice plants. Class modeling, use case diagrams, and activity diagrams are employed in the design phase to illustrate the application's structure and workflow. Implementation utilizes object-oriented programming, enabling the translation of the design structure into well-organized and comprehensible code. Validation results demonstrate a 100% functionality rate and an 80% accuracy in disease detection, yet the study highlights the need to enhance accuracy by providing more training data and improving image quality. Thus, the application of OOAD not only ensures an organized structure but also supports the research goal of enhancing farmers' knowledge, reducing dependency on pesticides, and promoting sustainable agriculture in the future.

Keywords: Rice; application; disease; plant; detection

INTRODUCTION

Recognizing the critical challenges faced by rice farmers in Indonesia, particularly concerning the escalating threats of pests and diseases in rice plants, the development of an Android-based Smart Farm application emerges as a timely and innovative solution. The limited knowledge among farmers about diverse pathogens affecting rice plants, coupled with the adverse environmental impacts of heavy pesticide use, underscores the urgency for a comprehensive and accessible technology-driven intervention. The proposed application, utilizing image processing technology and artificial intelligence, aims to empower farmers by providing accurate disease identification and environmentally friendly treatment options. To ensure the application's effectiveness and user-friendliness, the study will employ the Object-Oriented Analysis & Design (OOAD) method, aligning the technology with the practical needs of farmers. Through this initiative, the goal is not only to enhance farmers' capacity to combat diseases but also to contribute significantly to the sustainability and welfare of agriculture in Indonesia.

Rice plants grow in tropical and subtropical regions. This plant produces rice, which is a staple food in Indonesia. Rice plants have the scientific name *Oryza sativa* (paddy rice) or *Oryza glaberrima* (upland rice) are one of the food sources that are rich in nutrients and provide important strength for the human body. This is due to its nutrient content which is easily converted into energy needed by the body (Budiyono, 2020). Rice can be grown on watery or dry land and has high economic value and ecological benefits in maintaining the balance of the agricultural ecosystem, apart from being a source of rice, rice also has high economic value in the agricultural and agribusiness industries. Rice plants also provide ecological benefits, such as providing habitat for wildlife and playing a role in maintaining the balance of agricultural ecosystems. However, many agricultural ecosystems are currently not maintained, so rice pests and diseases are increasing.

Diseases in rice plants can be caused by various factors. One of them is the presence of pathogens such as fungi, bacteria, viruses, and nematodes. These pathogens attack rice plants and cause damage to the leaves, stems, roots, and grains. Farmers often face difficulties in defining diseases that attack rice plants. They do not have enough knowledge to identify diseases that may appear and also lack understanding of how to handle them. In addition, farmers also do not have an in-depth understanding of the various diseases that can attack rice plants

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and how to prevent them. This limited knowledge has an impact on the productivity and quality of their harvest. Indonesian people's knowledge about pests and diseases of rice plants is still relatively low, including in terms of handling them. Pest attacks, such as paddy rats, and various diseases in rice plants still cannot be controlled optimally. This causes farmers to still rely heavily on the use of pesticides. High dependence on pesticides is an issue that needs attention because it can have a negative impact on the environment and human health. Therefore, a technology is needed to improve farmers' knowledge. Efforts to increase farmers' knowledge about pests and diseases of rice plants and environmentally friendly alternative treatments need to be encouraged in order to achieve better agricultural sustainability in the future (Aeni, 2018).

In this context, the development of Android-based applications is the right solution to overcome challenges in agriculture, especially in dealing with pests and diseases in rice plants. This application can provide farmers with a deeper understanding of the types of diseases, how to identify them, and environmentally friendly handling methods. Through its innovative features, the app can provide guidance that is easily understood and accessed by farmers through their Android devices. Currently, the development of Android-based technology has been easily accepted by the wider community from various circles and professions. This is due to its ease of use(Cholifah et al., 2018). Thus, the creation of an Android-based application as a solution to the problem of pests and diseases in rice plants is not only an innovative step, but also a concrete step towards improving farmers' welfare and agricultural sustainability. This application will not only help farmers in identifying and overcoming plant diseases more effectively, but also potentially reduce the negative impact of pesticide use on the environment and human health. Thus, the creation of this software becomes a relevant and powerful solution in responding to the problems faced in agriculture in Indonesia.

Android is an operating system created by Google using the Linux kernel as its base, specifically designed to support touch-screen electronic devices such as tablets and smartphones(Yusuf & Afandi, 2020). The Android operating system is an important foundation for designing an Android-based rice plant leaf disease detection application. Android provides a solid framework and supports the development of sophisticated applications, such as rice plant leaf disease detection applications that can provide innovative solutions for farmers. Through this application, farmers can easily identify diseases on their rice plants by using Android mobile devices, combining the advantages of the Android operating system with leaf disease detection technology that is accurate, efficient, and easy to use. Thus, Android becomes an ideal platform to design a practical and effective leaf disease detection application for rice plants, in accordance with the needs of farmers.

The purpose of this final project is to develop a Smart Farm application that can assist farmers in analyzing plant leaf diseases using image processing technology and artificial intelligence. This application is designed to recognize common plant leaf diseases such as fungi, bacteria, and viruses with high accuracy. In addition, another objective is to evaluate the design of the Smart Farm application according to user needs, including designing an intuitive and responsive user interface. Through user testing, the app will be evaluated to ensure its effectiveness using the Object-Oriented Analysis & Design (OOAD) method. OOAD is an approach to formulating system requirements from the point of view of object classes, based on concepts found in real-world situations(Rahmawati et al., 2022). So that the result is an application that is easy to use and useful for farmers in overcoming disease problems in their rice plants.

LITERATURE REVIEW

Object-Oriented Analysis and Design (OOAD)

Object-Oriented Analysis and Design (OOAD) methodology covers the process of analyzing and designing systems using an object approach, consisting of two key phases, namely object-oriented analysis (OOA) and object-oriented design (OOD). OOA is an analysis method that examines in depth the requirements that a system must fulfill, focusing on the classes and objects that can be identified within the scope of the system. In this phase, an in-depth exploration of the relationships between classes and essential object characteristics is conducted. Meanwhile, OOD involves more detailed design steps utilizing the results of the OOA analysis to build a coherent and efficient system structure. This approach not only provides a comprehensive view of the system requirements but also ensures an organized and easy-to-understand design structure. OOAD is an innovative approach in addressing a problem by using models that are represented based on real-world concepts(Marini & Sarwindah, 2020).

The OOAD method utilizes object-oriented system modeling standards presented through the Unified Modeling Language (UML). In analyzing the needs and design of this research using the UML diagram method. UML is a visual language standard used to plan, document, and build software models. In the development of object-based systems, the use of UML is a very effective approach. In this research, several types of UML diagrams are used, including use case diagrams, class diagrams, activity diagrams, sequence diagrams, state diagrams, and collaboration diagrams(Hendra, 2018).

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Rice Plant Diseases

Rice is an industrial plantation crop or plant that is used as the main source of food, both for industrial needs and as a source of energy. The rice plant has several types, such as Oryza sativa and Oryza glaberrima, which are grown commercially for the production of rice, food, and industrial purposes such as adhesives and animal feed. The region in Indonesia is one of the largest rice-producing areas in the world. According to data from the Central Bureau of Statistics (2015), the total area of rice farms in Indonesia reached 8,087,393 hectares. And in 2021, the rice harvest area reached around 10.41 million hectares with a rice production of 54.42 million tons of milled dry grain (MDG). If converted into rice, rice production in 2021 reached around 31.36 million tons. Therefore, efforts are needed to increase rice production. However, rice plants are also susceptible to diseases and pests that can cause losses to farmers, hampering growth and production yields. Many diseases have been reported as threats to planted food crops, including rice. Each pathogen can disrupt several varieties of rice plants, and each variety of rice plants can be infected by more than one type of pathogen(Nuryanto, 2018). Each disease has different symptoms and treatments. Overall, there are four categories of diseases that commonly attack rice plants on the leaf surface, such as leaf blight, blast disease, stem blight, crackle, and other types of diseases(Sitompul et al., 2022). According to data from the Central Bureau of Statistics (2018), Central Java province is the province most affected by tungro, blast, and bacterial blight.

Figure 1. Bacterial Blight

Figure 2. Blast disease

Figure 3. Tungro pests and their symptoms

Figure 4. Brown spot disease

Figures 1, 2, 3, and 4 are examples of datasets of images of rice plant conditions that will be analyzed by classification. By applying artificial intelligence-based image processing technology, this research seeks to support farmers in reducing errors in identifying pests and diseases in rice plants through images or photos of plants. It is expected that the application of this application can provide convenience for rice farmers.

METHOD

In the software development process, it is important to have a method that can ensure that the development is structured and efficient. A well-planned approach will help in overcoming challenges that may arise during the development process. This research applies the Software Development Life Cycle (SDLC) methodology with a waterfall approach, hereafter referred to as the waterfall method. This decision was taken because this method offers systematic stages and can be applied easily. The stages involved requirements analysis, system design, implementation, testing, and maintenance. Maintenance, however, will not be discussed in detail in this research because the stage is more focused on keeping the application growing. In collecting data for problem identification, the researcher used an unstructured interview method with several sources around the Bandung Regency area.

In the application design, the rice plant disease detection system is integrated with machine learning using the Convolutional Neural Network (CNN) algorithm. CNN is a type of architecture in the world of artificial intelligence, especially in the field of image processing and pattern recognition. CNN has often been used in various applications, such as image and video identification, recommendation systems, visual classification, medical image analysis, and natural language processing(Rasywir et al., 2020). In addition, this application storage

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is connected to the MongoDB database to store customer data. The focus of this research is on designing the application interface using the Object-Oriented Analysis and Design (OOAD) method. The structure of the application framework can be seen in Figure 5, providing a clear visual description of the framework used in the development of this application.

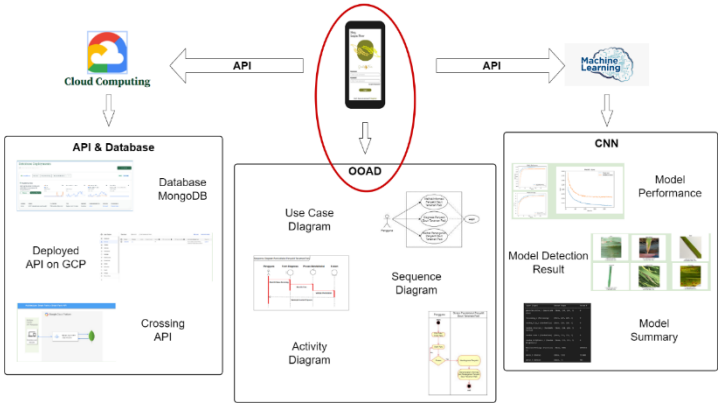

Figure 5. Application Framework.

Requirement Analysis

The selection of potential users is determined based on the context in the system environment who will act as actors. Functionality is obtained through a series of interviews and observations, which will then be described as a use case diagram. Use case diagram is one type of diagram in system modeling techniques used to describe the interaction between external actors and a system and how the system responds to the actions performed by these actors. Each use case presents a specification of the behavior or functionality of the system being described, which is required by actors to achieve their goals (Kurniawan, 2018). The results of the author's needs analysis get user actors who are suitable for this system. Where users interact directly with the system to carry out the disease detection process on the leaves of rice plants. Then the system use case diagram is obtained which can be seen in Figure 6.

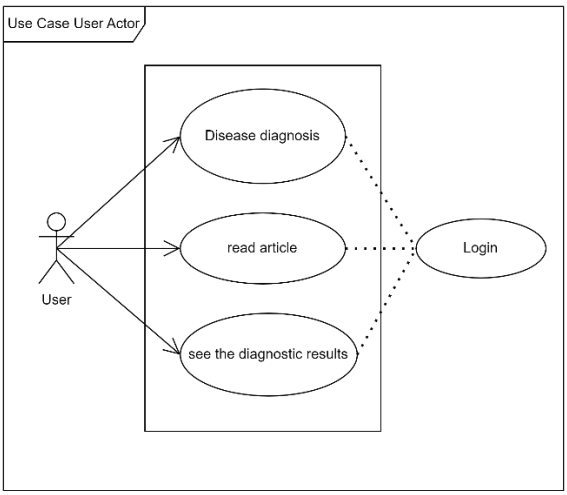

Figure 6. Use Case Diagram of User Actor

In Figure 6 above, in the operation of this system there is one actor, namely the user. Users have functions such as 'access to diagnose diseases', 'access to read articles', and 'access to view diagnosis results' can only be done when the user has logged in to the system.

RESULT

Application Architecture Design

The design of the Smart farm application covers several aspects, from designing the system architecture to designing the algorithms. In the system architecture design stage, the main focus is to provide an overview of how the system works. Photo scanning is the main function of the system. Field trials by farmers proved a significant improvement in detecting rice plant diseases, allowing them to take the necessary preventive and treatment measures efficiently. In photo scanning, we can select photos from the photo gallery or can also take a photo of

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the object directly using the CameraX feature. CameraX is an add-on to Jetpack that makes it easy to add camera capabilities to applications provided by Android Studio. A particular disease may exhibit a number of symptoms. Disease symptoms are represented as documents and coded. User input, which can consist of multiple symptoms, is represented as a query. The input identification process compares the similarity between each symptom of all diseases with the query, resulting in a list of symptoms as feedback for the disease determination process.

In the input identification process, CNNs are used to find similarities between symptoms and queries. CNN works by transforming the input data into a higher feature representation through convolution and pooling layers. Then, these representations are connected to the fully connected layer for the final similarity calculation. Before the convolution stage, a preprocessing stage is performed on the document data consisting of symptoms and queries. After that, word or term weighting is performed on the data. Next, convolution is performed to extract important features and pooling to reduce the data dimension. After that, the resulting feature representation is connected to the fully connected layer for the final similarity calculation between the query and symptoms.

The results of the CNN calculation provide a list of symptoms that may be referred to by the user, with the final value of the similarity calculation as the result of the comparison between the symptom and the query. Ranking is done by sorting the symptoms based on the highest value, and the symptom with the highest value is considered as the result of the disease diagnosis.

Use case diagrams provide a comprehensive view of the activities and interactions between components in a sequential manner. Sequence diagrams illustrate the interactions between actors and classes in the system, ensuring the fulfillment of each functional requirement. An example of a sequence diagram can be found in Figure 7 and 8.

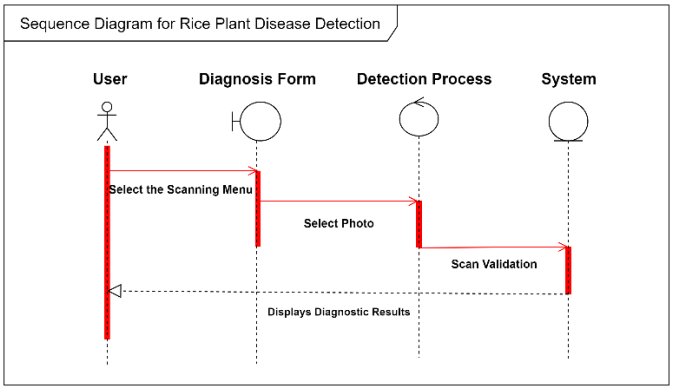

Figure 7. Sequance Diagram of Rice Plant Disease Detection

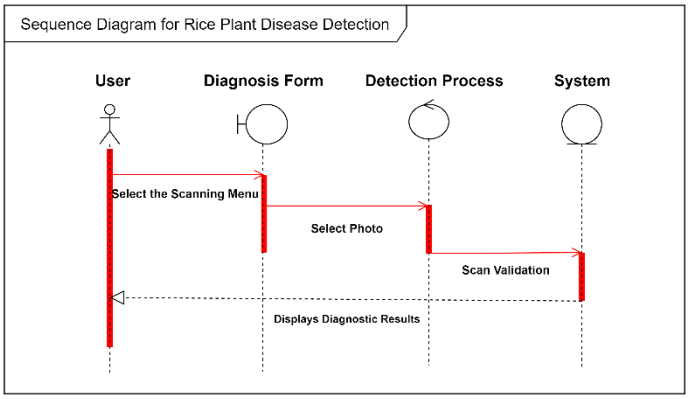

Figure 8. Sequance Diagram of Rice Plant Disease Article

In addition to sequence diagrams, the design stage also creates activity diagrams that are useful for describing activities in a system. The main function of the activity diagram is to provide a visual description of the workflow or business process in a system. For example, the activity diagram for the Smarfarm application can be seen in Figure 9 and 10.

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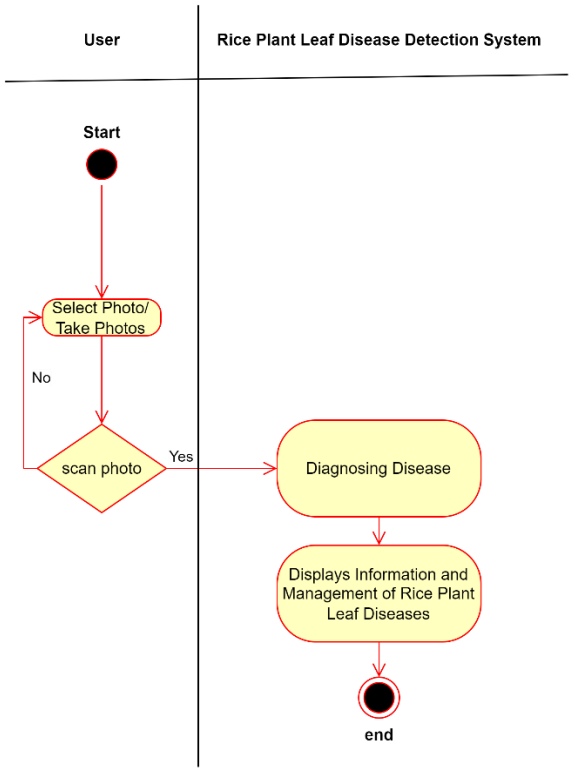

Figure 9. Activity Diagram of Diagnosing Rice Plant Disease

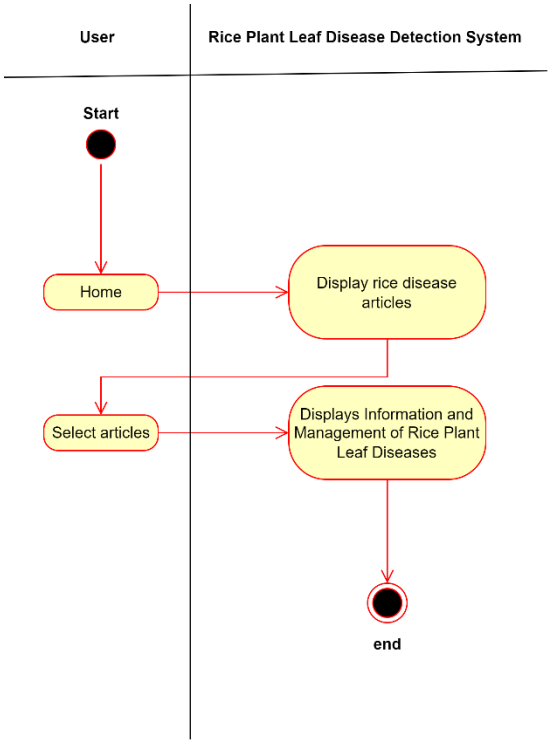

Figure 10. Activity Diagram of Diagnosing Rice Plant Disease

Testing

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In testing the features in the application, several scenarios are carried out to ensure the application functions properly. First, testing is carried out to load identified the Camera X feature scanning can identify or not, then try to identify the scanning results from photos that have been stored in the Gallery, Testing will later confirm how accurate the application will run or may be null (unable to detect anything), Testing will also later validate the contents of what has been identified, whether it matches the image that was captured or not, starting from the completeness of the explanation of the description of skin diseases and the solutions provided, Finally there will be a test whether the identification results are stored in the History feature or not.

	Test Case Name:	Scan Images		**Test ID #:**	Robot-AT-01
	Description:	Perform Live Testing on the application while it is running, and also with the efficientNetV2 module, to better know how accurate the results of the tests carried out are		**Type:**	□ white box ☑ black box
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**
1	Make sure Camera X can function properly (Can be turned on and connected to the mobile)	Camera X can open and take pictures	***Yes***		
2	Make sure the image scanning feature from the mobile gallery can run or not (the scanning feature uses existing images stored in the gallery)	Can open the mobile gallery and scan images	***Yes***		
3	Perform accurate scanning directly from Camera X and scan results from images selected from the local mobile gallery	Accuracy results can exceed expectations, namely above 0.8 or 80%	***Yes***		
4	Test whether the identification results are successful and come out with explanations and solutions	The Explanation Page opens for the image that has been captured, and the contents of the explanation, as well as the solution according to the image	***Yes***		
	Overall test result:		***Yes (4)***		

Table 1. Black box testing

In the above table, it is evident that each action runs smoothly. Through a more detailed observation of the table, it can be affirmed that every aspect of the smart farm application has been thoroughly tested. The success of various actions demonstrates the reliability and efficiency of the system as a whole. Consequently, this application can be relied upon to effectively support operational and management aspects in the context of agriculture.

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Figure 15. Rice plant disease diagnosis testing

In Figure 15 above, we tested the performance of CameraX on an Android mobile device. The test results show that the camera functions run well and can be used optimally. The use of CameraX on this device provides satisfactory results, with reliable capabilities for the purposes of diagnosing rice diseases.

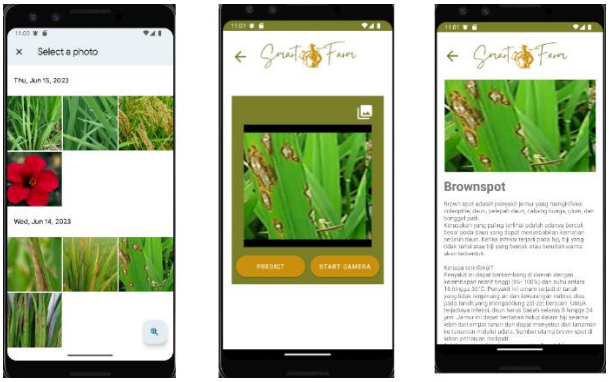

Figure 16. Rice plant disease diagnosis testing

In Figure 16 above, we can clearly see the process of testing the disease diagnosis feature on rice plants. The photos used are taken from files already available in the device, followed by a scanning stage to detect and analyze the diagnostic results in more depth. This process demonstrates the accuracy and sophistication of the evaluation method applied in analyzing the health condition of rice plants using scanning technology.

DISCUSSIONS

The adoption of the Object-Oriented Analysis and Design (OOAD) methodology in developing the Android-based Smart Farm application for Indonesia's food security manifests a systematic approach to delineate functional and non-functional requirements. Rooted in a literature review and field observations in Bandung Regency, the requirements analysis lays a robust foundation for creating an application that employs image processing and artificial intelligence for identifying rice plant leaf diseases. The design phase utilizes class modeling, use case diagrams, and activity diagrams, visually representing the application's structure and workflow. Through object-oriented programming, the implementation phase translates the organized design into comprehensible code, resulting in a 100% functionality rate. Despite achieving an 80% accuracy in disease detection, the study acknowledges the need for improved precision, suggesting additional training data and enhanced image quality. The discussion underscores OOAD's role in creating an organized structure, while recognizing areas for refinement to better fulfill the overarching research goal of empowering farmers, reducing pesticide dependency, and fostering sustainable agriculture.

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CONCLUSION

In conclusion, the development of the Android-based Smart Farm application addresses the critical challenges faced by rice farmers in Indonesia. The existing flow diagram reflects a comprehensive approach, encompassing needs analysis through literature study and field observations, actor identification, and system requirements modeling. The application caters to three functional needs, including the management and diagnosis of rice leaf diseases, along with the display of relevant information. Additionally, it fulfills two non-functional needs, allowing users to switch languages and toggle a dark mode theme. The validation testing affirms the application's 100% functionality level, albeit with a recognized need for improvement in the accuracy of disease detection. The identified challenges stem from insufficient training data and variations in image quality. Despite these obstacles, the Smart Farm application stands as a promising and timely solution to empower farmers in combating pests and diseases while promoting sustainable agricultural practices in Indonesia.

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