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Application of the Case-Based Reasoning (CBR) Method in the Web-Based Rice Plant Disease Diagnosis Expert System

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Abstract

The agricultural sector is the main pillar of the Indonesian economy with rice as a strategic commodity for food security. Rice production faces serious challenges, such as climate change and bacterial blight and blast disease attacks that have reduced productivity by up to 40% in Pahunga Lodu District, East Sumba. Limited experts and access to information hinder effective disease management. This research develops a web-based expert system using the Case-Based Reasoning (CBR) method to help farmers diagnose rice diseases quickly and accurately. The development of the system used the Waterfall model, with data obtained through observation, interviews, and documentation. The implementation results show that all key features such as login, symptom input, disease data management, and diagnostic process work well through black-box testing. In addition, through a 10-case test scenario, the system is able to provide diagnostic results with an accuracy rate of 80%. This proves that the system can be an effective solution in supporting the management of rice plant diseases. It is hoped that this system can increase the independence and productivity of farmers and support food security in the region

Keywords: *Expert System, Case-Based Reasoning (CBR), Rice Disease Diagnosis, Disease Symptoms, Artificial Intelligence.*

1. Introduction

The agricultural sector is one of the main pillars of the Indonesian economy with a large contribution to the national GDP and the provision of jobs. In 2021, the sector grew by 1.84% and contributed 13.28% to the national GDP [1]. In addition to supporting food security, agriculture also plays an important role in overcoming poverty and supporting the lives of rural communities. Rice plants as the main commodity are a staple food for the majority of the Indonesian population. Nevertheless, national rice production faces various challenges, such as climate change and pest and plant disease attacks that cause a decline in crop yields.

In 2024, national rice production will be recorded at 53.14 million tons of dry milled grain, a decrease of 1.55% compared to the previous year. This decrease is caused by disease disorders such as blast, bacterial leaf blight, and tungro. The Ministry of Agriculture (2024) reports that losses due to this disease can reach 20–30% of total rice production every year [2]. This problem is increasingly complex in areas that have limited access to agricultural information and technology, such as East Sumba Regency.
Pahunga Lodu District in East Sumba is one of the affected rice production centers. Based on data from the local Agriculture Office (2024), around 40% of rice fields in this region have experienced a decrease in productivity due to plant disease attacks. Ngallu Village, one of the administrative areas in the sub-district, recorded a harvest area of 683 hectares with a production of 2,628 tons and a productivity of 38.48 kw/ha. This figure decreased compared to the previous year, influenced by disease attacks and limited irrigation facilities and production inputs[3].

Ngallu Village was chosen as the location of the research because it is a rice-producing area with a community that is highly dependent on the agricultural sector. However, farmers often face obstacles in identifying and dealing with rice diseases due to limited experts and access to information. Geographical conditions and the lack of information technology infrastructure have also slowed down the treatment of diseases. Therefore, the development of a web-based expert system with the Case-Based Reasoning (CBR) method is a potential solution. This method works by comparing new cases with the old case base to suggest appropriate diagnosis and action.

The CBR-based expert system is able to provide rapid and accurate diagnosis of rice diseases, even without the direct presence of agricultural experts. With this technology, farmers in remote areas like Ngallu can be more independent in detecting and managing plant diseases. The implementation of this system is expected not only to increase agricultural productivity, but also to strengthen food security and farmers' welfare[4].

2. Literature Review

2.1. Expert System

Expert systems are systems that seek to adopt human knowledge to computers can solve problems as usual by experts [5]. Specialist systems are designed to assist the work of specialists who determine diseases based on existing symptoms.

2.2. Case-Based Reasoning (CBR)

Case Based Reasoning (CBR) is the process of remembering a case in the past, then reusing it to adapt in a new case [6]. The flow of this method can be seen in the image below:

1. Retrive
   The system searches for and retrieves the New Case that most closely resembles the symptoms entered by the user.
2. Reuse
   Solutions from previous cases are used as a basis for solving current problems.
3. Review
   If the previous solution is not fully suitable, then the system will make adjustments or revisions based on additional information or expert consultation
4. Retain
   After the solution is confirmed to be effective, the new case and its solution are included as learned cases.

2.3. Simple Matching Coefficient (SMC)

Simple Matching Coefficient (SMC) is a statistical method used to measure the degree of similarity between two objects or data that have binary attributes (value 0 or 1). SMC calculates the proportion of attributes that have the same value between two objects compared to the total existing attributes [7]. The following is the SMC formula:

$$SMC = \frac{M_{11} + M_{00}}{M_1 + M_{00} + M_{10} + M_{01}}$$

2.4. Waterfall Method

The Waterfall method is one of the software development models that is sequential and systematic, where each stage must be completed completely before moving on to the next stage. The development process follows the implementation stages of the Waterfall model, with the following steps:

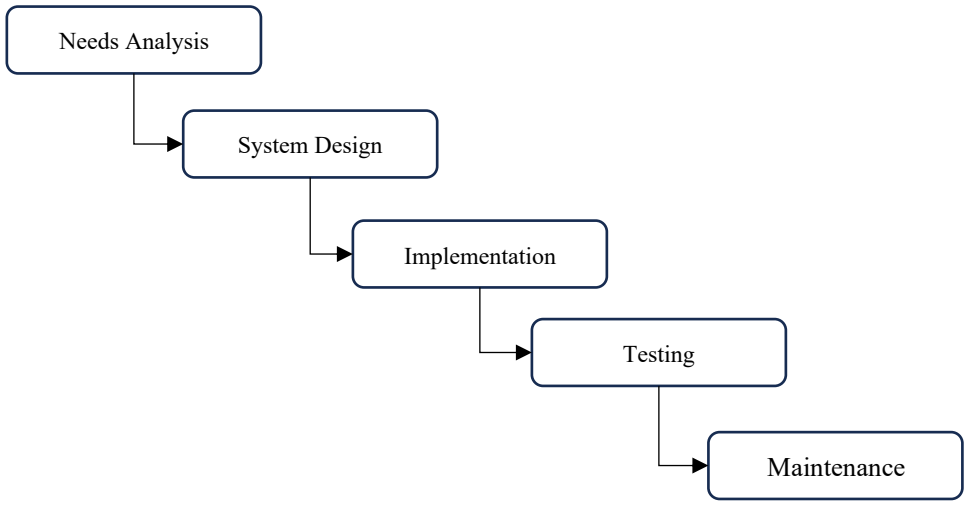

Fig. 1: Waterfall Method

2.5. Diseases in Rice Plants

Rice is the main food commodity that is a source of carbohydrates for most Indonesians. However, rice plants have a high susceptibility to various types of diseases that can interfere with growth and reduce crop productivity [8].
In the context of the rice crop disease diagnosis system, some of the types of diseases that are often used as the main object of study include:

1. Blast
2. Bacterial Leaf Blight
3. Brown Leaf Spot
4. Rotten Rod
5. Tungro Disease

3. Methodology

3.1. Profile of the research object

The object of this research is rice farmers in Pahunga Lodu District who have limited knowledge in diagnosing rice plant diseases. Pahunga Lodu District was chosen because it is an agrarian area with the majority of people earning a living as rice farmers. The problem that farmers often face is the lack of access to information about rice plant diseases and how to handle them.
The subjects of the study include farmers in Pahunga Lodu District, especially in Kaliuda village who need the support of an expert system in improving the ability to diagnose diseases in rice plants and improve their agricultural production.

3.2. Research Flow

The flow of this research was carried out for the application of the Case-Based Reasoning method in the expert system of disease diagnosis on web-based rice plants in Ngallu Village, Pahunga Lodu District. The following is a picture of the research flow:

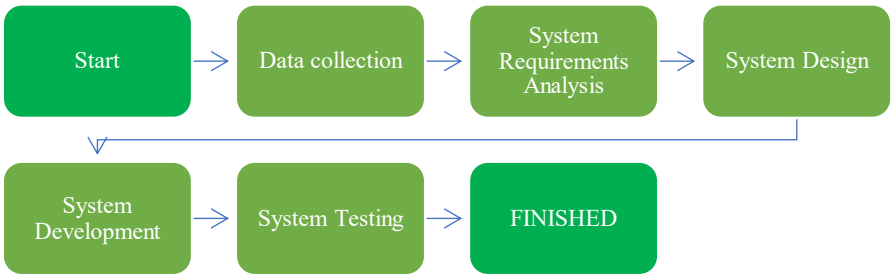

Fig. 2: Research flow

The research flow in figure 3 shows the research flow consisting of several stages, 1 Data collection: Direct observation to agricultural land to see the symptoms of the disease, interviews with farmers and extension workers to find out the type of disease and its handling, literature study and documentation from books, journals, and reports from the agriculture office to complete the data on symptoms, diseases, and solutions. 2 System Analysis: The analysis is conducted to understand the needs of the expert system, including the workflow, data needed, and the diagnosis process. The system is designed to be able to diagnose rice crop diseases based on symptom inputs compared to the old case-based basis using the Case-Based Reasoning (CBR) method. 3 System Design: The system is designed using a CBR approach with four main stages: Retrieve, Reuse, Revise, and Retain. The design includes database design (table of symptoms, diseases, cases), system architecture, and farmer-friendly user interface. 4 System Development: development is carried out using the Waterfall method. The system is built using PHP, MySQL, HTML, and Bootstrap. The symptom matching process uses the calculation of the Simple Matching Coefficient (SMC) to determine the similarity between new cases and old cases. 5 System testing: Testing is done using the black-box testing method to ensure that each feature performs as intended. In addition, case tests were carried out on 10 symptom data, with results showing that the accuracy of the system diagnosis reached 80%, proving that the system was effective and suitable for use by farmers.

4. Results and conclusions

4.1. Analysis

The system analysis is carried out to understand the needs and workflow of the expert system for the diagnosis of rice plant diseases. This system was developed because of farmers' problems in recognizing rice plant diseases early, which can cause delays in handling and declining crop yields.

The system built will receive input in the form of symptoms seen in rice plants. After that, the system will match the symptom data with the existing disease case database using the Case-Based Reasoning (CBR) method. The matching process is carried out by calculating the similarity value using the Simple Matching Coefficient (SMC) method, and the system will return the diagnosis results along with appropriate treatment solutions.

4.2. Planning

At the system design stage, it is done to describe the workflow and structure of the system. This system is designed using the Case-Based Reasoning (CBR) approach with a matching algorithm model using a Simple Matching Coefficient (SMC). The case base is compiled based on previously classified symptom and disease data.

4.3. Implementation

The results of this implementation were carried out with the aim of explaining to every user how to use the web expert system for disease diagnosis in rice plants according to its function. For now, the website of the expert system for diagnosing diseases in rice plants can still only be accessed through localhost.
The following are the results of the system implemented on the website of the expert system for diagnosing diseases in rice plants:

Fig. 3: Home view

The home page image shows the main information of the system after a successful login. The purpose of this page is to welcome users and make it easy to navigate to the core features of the system.

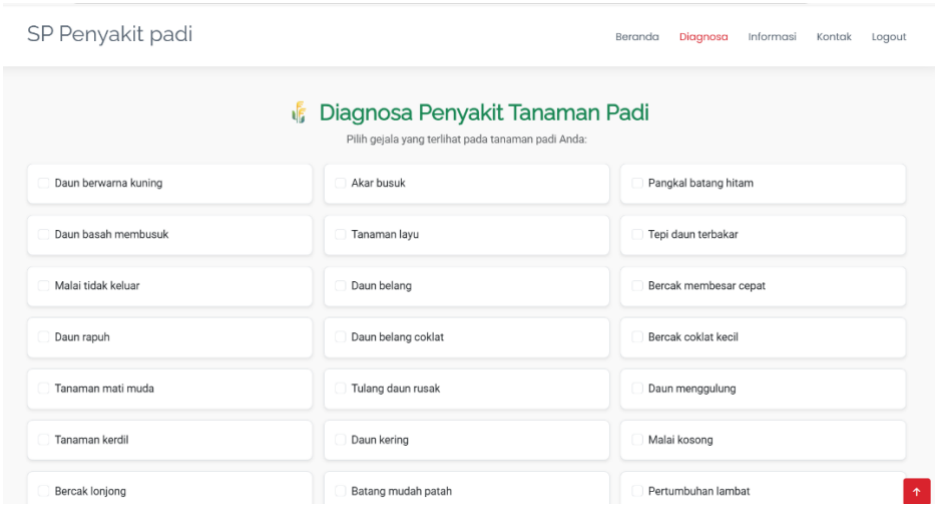

Fig. 4: Diagnosis page view

This image depicts the disease symptom input page, the User selects the symptoms that are in accordance with the condition of the rice plant, then the system processes and displays the diagnostic results.

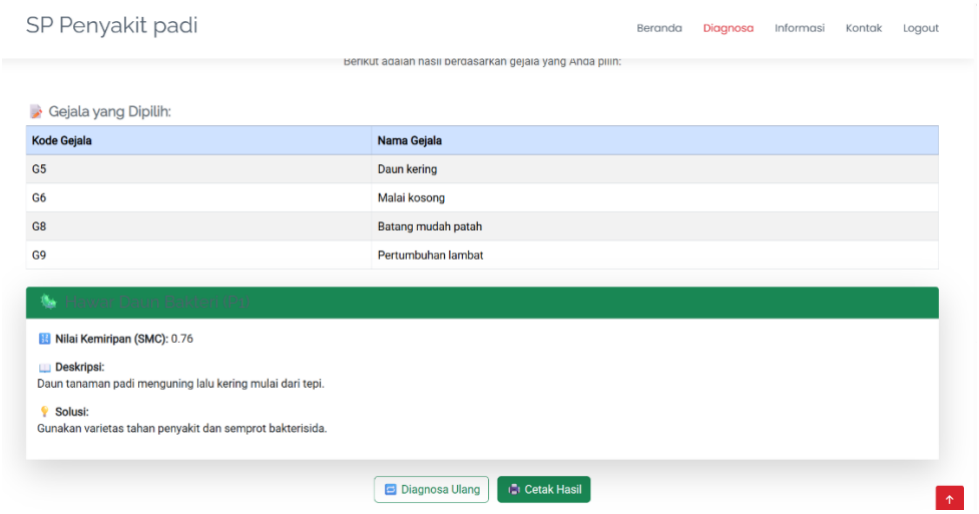

Fig. 5: Display of diagnostic results

The image of the diagnostic results displays, This output provides an instant overview to the user of the results of identification and action recommendations.

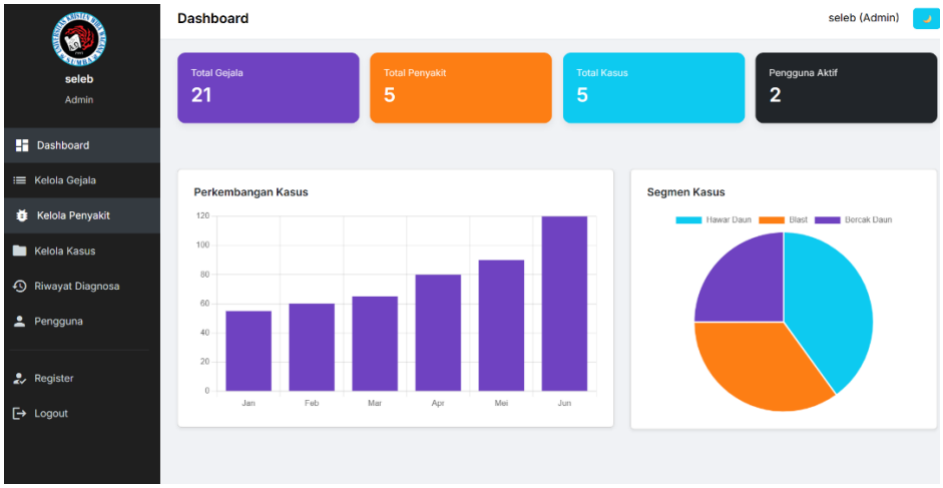

Fig. 6: Admin Dashboard view

In the admin dashboard image (specifically for the role of admin/system expert) will appear, This feature provides full control for admins to maintain the integrity and update of system data.

4.4. System Testing

At the testing stage, it is carried out using black-box testing. This test is very important because it is able to test whether the system is working according to its function and providing accurate results. The test is carried out on all key features such as login, symptom input, disease data management, and disease diagnosis process.

Here are the test results of the system features:

Black box testing is done to ensure that every function of the system works as expected without looking at the program code. Testing is carried out in the user section and the admin section.

Table. 1 : User Features

Yes	Tested Features	Test Description	Status
1	Login User	Users can log in with a valid username and password	Succeed
2	Home User	Displays a home page with a brief description of the system	Succeed
3	Diagnosis	Users can choose symptoms and get the results of the disease diagnosis	Succeed
4	Information	Displays disease list information and treatment solutions	Succeed
5	Contact	Displays system developer contacts and information	Succeed
6	Logout	Users can log out of the session and be redirected to the login page	Succeed

User function testing aims to ensure that all features accessed by ordinary users (farmers or users) run properly.

Table. 2: Admin features

Yes	Tested Features	Test Description	Status
1	Login Admin	Admins can log in to the dashboard page	Succeed
2	Dashboard	Displays statistics or amounts of symptom, disease, and user data	Succeed
3	Manage Symptoms	Admins can add, change, and delete symptom data	Succeed
4	Manage Disease	Admins can add, change, and delete disease data	Succeed
5	Manage Cases	Admins can add, change, and delete disease case data	Succeed
6	User List	Admins can see the entire list of registered users and accounts	Succeed
7	User Register by Admin	Admins can add new user accounts manually	Succeed
8	Logout Admin	Admins can log out of their account and return to the login page	Succeed

Testing the admin function (expert) is focused on specific features that can only be accessed by administrators or system experts.

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