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Online Expert Systems for Bamboo Identification Using Case Based Reasoning

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ABSTRACT

Bamboo is a typical plant that thrives in tropical countries like Indonesia. The diversity of bamboo species makes difficult to classified, then requiring the expertise from specialist who understands deeply about bamboo characteristics. The paper purpose to (1) adopts the bamboo expert knowledge into bamboo criteria of expertise; (2) implementing Case Based Reasoning method in online expert system for bamboo identification in Bengkulu Province; and (3) determined the identification accuracy of bamboo using expert systems. The system uses Case Based Reasoning with four main steps: retrieve, reuse, revise, and retain. Bamboo expert identify bamboo criteria into 6 morphology, 31 features, and 219 attributes as an input system. The results showed that the Case Based Reasoning method has high accuracy for identifying the bamboo species and can solve the problem of bamboo identification as a new case based on old case that stored in the base case.

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1. INTRODUCTION

Indonesia is a country with rich diversity of plants, including bamboo species. The large amount of bamboo in Indonesia makes bamboo identification become more difficult. Bamboo is one of tropics and subtropics plants, as a member in Spermatophyta division, angiospermae subdivision, Monocotyledonae class, Graminales ordo, graminiae family, bamusoideae sub family. According to Widjaja [1] types of bamboo that found in Indonesia is estimated around 159 species of a total of 1,250 species in the world. One of the bamboo cultivation locations is Bengkulu. Bengkulu Utara is one of the districts in Bengkulu province that have high potential for bamboo. Many bamboo species in Bengkulu were not well documented. Then, over time the bamboo species will become a distinct plant [2].

Bamboo belongs to the grasses family. This plant grows naturally in all continents except Europe and about 80% of these plants are in Southeast Asia. There are allegations that the spread of bamboo with the spread of humans. Uchimura, and Dransfield Research in 1980 revealed there may be 45-50 genus of bamboo which is divided into 700-750 species. Meanwhile, FAO in 1978 announced their 75 genera of bamboo with 1,250 species [3].

Bamboo is an easily planted and does not require special maintenance. Bamboo can live on dry land as well as on watered land. However, more bamboo grows in tropical highlands, including in Indonesia. Bamboo identification can be done by observing bamboo morphology [4], namely:

a) Shoots (buds), used to distinguish species based on the characteristic of bamboo shoots's color and stem's feathers.
b) Rod (reed), observation for stem height (m), segment length (cm), bamboo diameter (cm) and girth (mm).
c) Sheaths rods, a modified leaf stuck on each segment consisting of the leaf midrib reed, reed midrib ears, and ligula.
d) Branch, are in the books, observations were made of the size of branches and number of branches.
e) Leaves and leaf midrib, observations were made against internode shape of bamboo leaves, leaf length, leaf width, leaf midrib color, and shape of the ear leaf midrib.

An expert system is a computer system that designed to solve problems in specialized domain in a particular field that normally requires human expertise [5]. Expert systems has several advantages for bamboo identification, such as cheap, fast, have an expert capabilities and expertise into the system, and not damage the bamboo sample species that measured. Identification of bamboo species is difficult then requires special expertise. The method of Bamboo identification usually takes a long time, expensive, difficult, and require specific information from a bamboo expert. In this case, expert system can be used to identify the bamboo species. By transfering the bamboo expert knowledge to recognizing the bamboo characteristics such as roots, shoots, stems, stem trunk, branches and leaves, so that identification can be done without having to bring an expert directly.

Case Based Reasoning (CBR) methods use prior experience with similar case to understand and solve new problems. CBR collects previous cases that have similarity to the new problem and attempt solution to fit into the new case [6]. CBR problem solving is based on the previous experiences [7]. CBR has based case for diagnostic capability and provide information automatically based on previous knowledge that can be revised to conform with the latest problem then CBR knowledge will continue to grow [8]. The new CBR problem solving is done by searching for similar problems in the past and provide solutions based on the most similar problems that exist in the memory case. Problems used to solve problems stored in a case memory that can be revised to solve the future problems.

Researches related to expert systems have done with several research objects as follow. Mayadevi N, Vinodchanra SS, Ushakumari develop expert systems to simulate plant operator's actions and to give an overview of various expert system applications in power generation plants. The review shows that integration of expert system with modern method can improve system performance and problem solving capabilities [9].

Seyed Mojtaba S, Mehdi S, Fehime E. develop an expert system to help auditors in predicting and determining the different types of audit reports using artificial neural network and decision tree as an inference engine. This approach can improve the accuracy and ability to explain solutions for users [10].

Putra IKGD, and Prihatini PM develop fuzzy expert system for tropical infectious disease by certainty factor. Fuzzy system used to represent the vagueness of symptoms experienced by patients and certainty factor used to represents relationship between symptoms and disease. The result shows that this approach has similarity diagnosis with the expert at 93.99% [11].

This research develops an expert system with Case Based Reasoning (CBR) method to identify bamboo species. CBR method used to handle each case of bamboo characteristics and to save a new case in database for expert validation. The validation process carried out by bamboo expert because the characteristics were different with bamboo database. This expert system is expected to improve the identification and to increase the similarity percentage between system identification and expert identification.

2. CASE BASED REASONING (CBR)

Expert System is a program that acts like a human expert. Expert systems or knowledge-based system is the most widely application in helping to resolve problems in the real world [5]. An expert system consists of two main parts [12], namely: knowledge base and inference engine. Knowledge base contains insights that can solve the problem in particular field. Case Based Reasoning (CBR) is knowledge base that frequently used. CBR contains solutions that was achieved before, and will be used for the future problems [7]. This approach is used when a user has certain cases.

Knowledge based as inference engine have two approaches, namely forward chaining and backward chaining [13]. Forward chaining performs matching that starts from IF statement. The known facts use to test the truth hypothesis. While backward chaining performs matching that starting from THEN statements. Thus, the solution had to take a hypothesis, then looking for facts that exist in the knowledge base to test the hypothesis.

CBR is a system that uses a long experience to understand and resolve new problems [8]. CBR solved the problem by learning the pattern that happened before. When a new problem is similar to the previous problem then CBR perform the solutions extraction to search relevant problem with the new problems. Formally, the CBR has four main steps: retrieve, reuse, revise, and retain.

a) Retrieve
Retrieve referring back to the same case. System will retrieve the input cases that already exist in the database, some of cases in database can be the present case. Retrieve stages include problem identification, matching, and sorting problems.

b) Reuse
Reuse is re-using the information and knowledge from cases to solve the problem based on the most relevant similarities into a new case to produce a solution with adaptation to the new case. At this stage, reuse has new cases and old cases. The new case is identification from user that not been validated by experts, while the old case is identification from expert that has been stored in the database.

c) Revise
Revise is reviewing the suggested solution. This step did a comparison with the actual solution, and correcting errors from the confirmed solutions. Revise carried out on new cases that do not exist in the database to be stored into the new case table. Then, solution will be displayed some new cases and inserted into the cases table by experts.

d) Retain
Retain is learned case for the next troubleshooting. Retain process is done by storing the new case results into a database, either use to solve other cases or the case itself. Figure 1 shows the process of CBR starts from retrieve, reuse, revise, and retain.

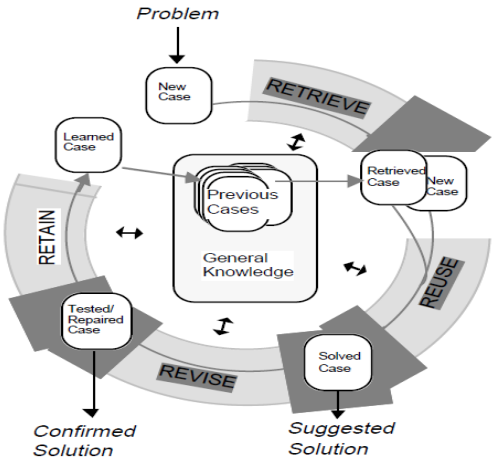


Figure 1. Case based reasoning cycle [8]

3. K-NEAREST NEIGHBOR (KNN)

K-Nearest Neighbor is an approach to looking for cases by calculating the affinity between the new cases with old cases. Calculations based on weight matching from the features. For example, if you want to identify a new species of bamboo that use solutions from earlier species of bamboo. To search what case will be used with calculated the proximity value between new species case and all species case. Case with the biggest proximity value will be taken as a solution for the bamboo identification.

KNN algorithm is a technique that often used to calculate the case similarity and to sort case from the highest similarity. This technique uses a similarity metric to determine the similarity between cases [8]. If the similarity degree between old case and new case was high then the case solution would be reused as a solution to new cases. The KNN formula is shown in the equation.

$$similarity\ (T,S) = \frac{(s_1 \times w_1) + (s_2 \times w_2) + \cdots + (s_n \times w_n)}{w_1 + w_2 + \cdots + w_n}$$

where:

T_n=new case

S_n=old case
s_n=similarity value, if 1 (same) and 0 (different)
w_n=*weight*

4. ONLINE EXPERT SYSTEM ALGORITHM FOR BAMBOO IDENTIFICATION

Dataset used as a knowledge base for the bamboo identification system in Bengkulu Utara consist of 11 species, namely: (1) Bambusa Vulgaris val.vulgaris; (2) Bambusa Multiplex; (3) Bambusa Vulgaris Striata; (4) Gigantochloa Robusta; (5) Gigantochloa Pseudoarundinacea; (6) Gigantochloa Schortechinii; (7) Gigantochloa Serik; (8) Schizostachyum Brachycladum; (9) Schizostachyum Lima; (10) Dendrocalamus Asper; (11) Gigantochloa Atter.

The characteristics of bamboo for online expert system for bamboo identification in Bengkulu Utara district, Bengkulu province are divided into 5 morphology, 29 characteristics, and 219 attributes. Bamboo morphology as input system includes stem density, stem, branch, sheath, leaves, and sprout. Bamboo characteristics is consist of low stem density, high stem density, stem height, segment length, stem diameter, stem thickness, stem color, stem surface, branch size, number of branches, presence of buds, ear shape, ear length, feather length, ligule edge, ligule length, leaves position, blade shape, sheath reduction, auricle shape, leaf length, leaf wide, ear length, feather length, ligule length, bud shape, bud colors, bud number, bud position, and bamboo sprout shape.

Expert system with CBR is a web-based online application which serves to identify the bamboo species based on the morphology characteristics and attributes from user input. It will be compared with bamboo data that stored in case memory. The similarity values of case are calculated and displayed by the highest level of similarity. This system can be accessed in www.bambubengkulu.com. The steps on CBR algorithm in online expert system for bamboo identification (Figure 2) is as follows:

1) Users input bamboo characteristics data on the expert system.
2) Expert system calculated the similarities between the new cases with the database cases using KNN.
3) System checked the users input, if the case is the same as database then continue to step (4). If the results are not equal then proceed to step (5).
4) If the result is same, system will display the solution from database.
5) If the result is not equal, system will display solutions for bamboo identification based on the closest distance with old case.
6) Expert validate the solution for bamboo identification by the shortest distance.
7) System checked whether case and solution validation will be saved or not. If the validation is saved it will be continued to step (9). If the validation is not saved it will be continued to step (8).
8) Based on the validation results, case and solution will be deleted from the database.
9) Based on the validation results, case and new solutions will be stored into the database and become the old case and the old solution.

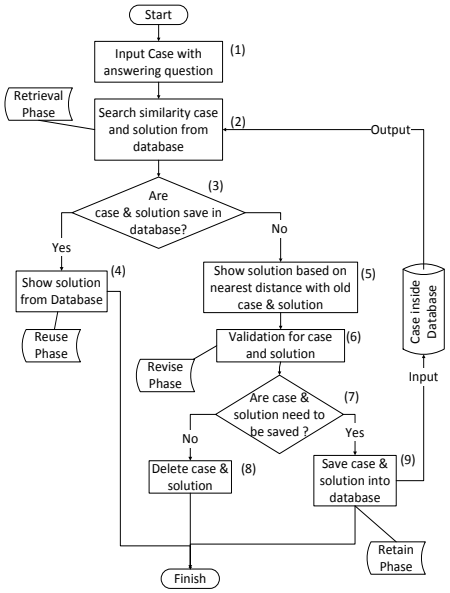


Figure 2. CBR algorithms in online expert system for bamboo identification

5. RESULT AND DISCUSSION

5.1. Implementation

Based on knowledge from morphological, characteristics, and attributes for bamboo in Bengkulu province. It can be made knowledge base with relationships about bamboo species features in Bengkulu Utara. Bamboo data set from expert became old cases that will be compared with new cases entered by the user. In the retrieval phase, user input morphological characteristics of bamboo by choosing from available option in the left pane, as in Figure 3.

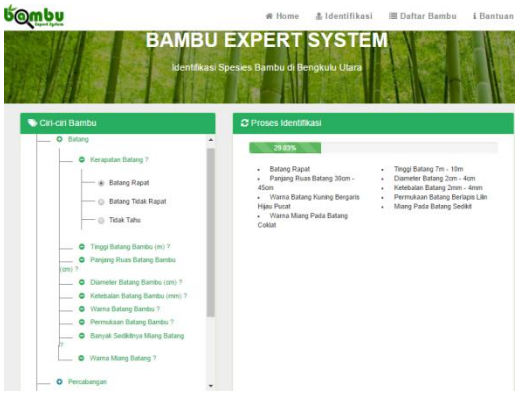


Figure 3. Interface for input bamboo characteristics

User chooses all the data characteristics until 100% then system automatically displays the bamboo identification Figure 4. In this reuse phase, the system provides information on the similarity level of bamboo from memory case with a new case that the user inputted. If there is no case in memory case that similar with user input, the system will record morphological characteristics of bamboo as a new case that requires validation by experts.

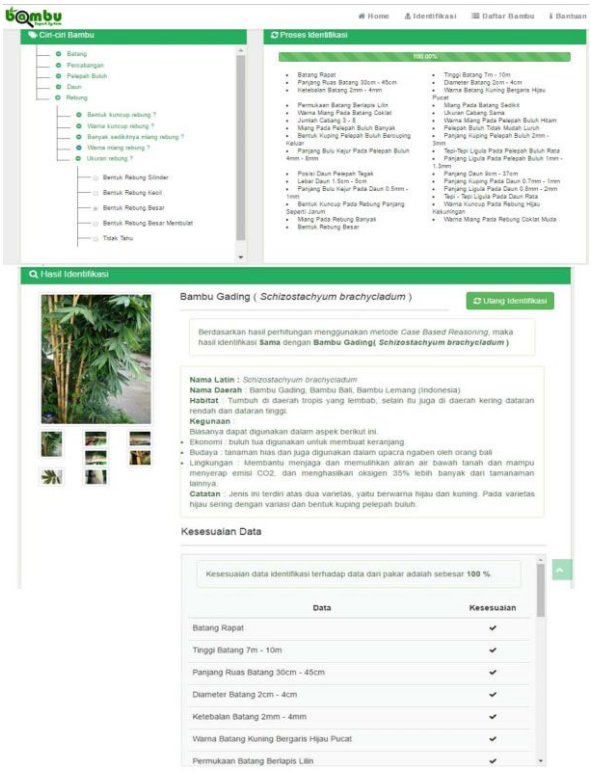
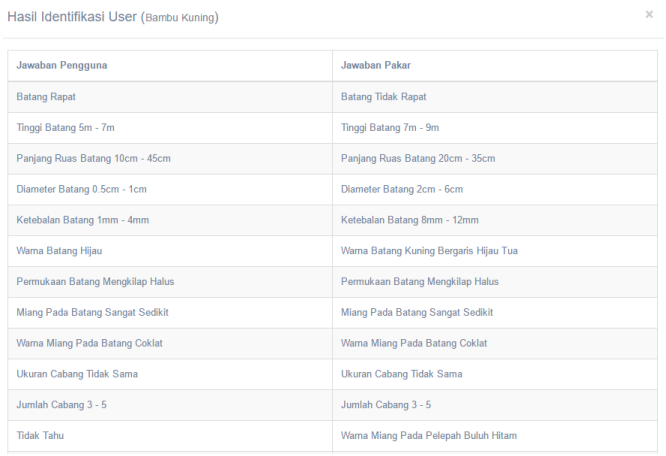


Figure 4. Interface for bamboo identification

In revise phase, bamboo expert can see a case list that entered by the user, as well as view detailed information on the new case to be revised. At Figure 4, a new case of bamboo can be validated or deleted. In figure 5 shows retain phase as knowledge management by experts. This phase compare user answers with expert answers for bamboo identification. Furthermore, the activities are carried out integrate new case in the memory case, and update the old case in case memory.


Hasil Identifikasi User (Bambu Kuning)

Jawaban Pengguna	Jawaban Pakar
Batang Rapat	Batang Tidak Rapat
Tinggi Batang 5m - 7m	Tinggi Batang 7m - 9m
Panjang Ruas Batang 10cm - 45cm	Panjang Ruas Batang 20cm - 35cm
Diameter Batang 0.5cm - 1cm	Diameter Batang 2cm - 6cm
Ketebalan Batang 1mm - 4mm	Ketebalan Batang 8mm - 12mm
Warna Batang Hijau	Warna Batang Kuning Bergaris Hijau Tua
Permukaan Batang Mengkilap Halus	Permukaan Batang Mengkilap Halus
Miang Pada Batang Sangat Sedikit	Miang Pada Batang Sangat Sedikit
Warna Miang Pada Batang Coklat	Warna Miang Pada Batang Coklat
Ukuran Cabang Tidak Sama	Ukuran Cabang Tidak Sama
Jumlah Cabang 3 - 5	Jumlah Cabang 3 - 5
Tidak Tahu	Warna Miang Pada Pelepah Buluh Hitam

Figure 5. Interface for knowledge management by experts

5.2. Discussion

Dataset testing is used to test whether system can identify bamboo species with morphology and attribute input correctly. Tests conducted to determine the expert system performance that has been created and measuring accuracy in bamboo identification. Accuracy can be calculated from the number of test scenarios diagnostic yield compared with the number of test cases. Solution was taken as the identification result which has the best similarity value. The solution is considered as a correct identification when appropriate to species morphology, and the false solution happened when bamboo identification does not match with species morphology.

System testing is also done by experimenting on the user input as a new case. If user have input different with old cases, it will be new case. Admin will validate whether that case can be prolonged or not. If not, the new case will be removed from the system. If the case validated, it will turn into an old case. Testing for online expert system with CBR method is carried out in three test scenarios (Figure 6), namely:

(1) Testing with 90-100% morphology attributes appropriate to the species characteristics in case memory
(2) Testing with only 70-80% morphology attributes appropriate for each species in case memory
(3) Testing with only 40-60% morphology attributes appropriate for each species in case memory

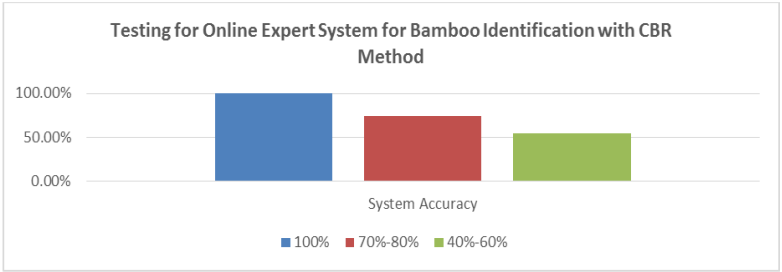


Figure 6. Testing for Online Expert System for bamboo identification with CBR method

In Figure 6, it can be shown that the first testing scenario has high accuracy rate about 100%. While the second scenario with 70% -80% input data similar to morphology attribute in case memory has average

of accuracy rate about 74.48%. But it requires validation by experts whether it could be an old case. The third scenario with 40-60% input data similar to morphology attribute in case memory gain the smallest accuracy of 54.79%.

This method can solve the problems with different the similarity level of morphology attribute ranging from 40% to 100% in memory case. This experiment results shows that online expert system with CBR method for bamboo identification have a good performance in providing identification solutions. The results indicate that the expert system with CBR have a great performance to identify bamboo species with accuracy rate 100% and be able to handle the identification from old case and new case that stored in the base case.

6. CONCLUSION

In this study we have developed an online expert system for bamboo identification with Case Based Reasoning (CBR) method. This web-based expert system has adopted a bamboo expert knowledge into 5 morphology, 29 characteristics, and 219 attributes as an input system. The usage of CBR is effective to identify the bamboo species in specific morphology attributes. It can be seen from high accuracy level for three testing scenario, the more morphology attribute entered into system can improve expert system performance. The more cases stored in case memory can improve identification accuracy significantly. This system can be accessed in www.bambubengkulu.com that facilitate user to identify bamboo species directly and quickly.

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