Automation Mangrove Identification with Case Based Reasoning Process

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Abstract—**Mangroves are ecosystems with unique functions in the environment. Because of its physical properties, mangroves are able to play a role as a wave retardant as well as retaining intrusion and abrasion of the sea. Mangroves themselves have various types of species that are spread throughout Indonesia and not yet widely known to people in general. In identifying the mangrove species itself cannot be done arbitrarily, it requires an expert who truly understands the mangrove species. This research was conducted with the aim of adopting the knowledge of mangrove experts to identify mangrove species into expert systems. The method used is case based reasoning method using the KNN algorithm which is used to calculate the similarity value between cases that will be applied to the expert system to identify mangrove species found in Taman Wisata Alam Pantai Panjang dan Pulau Baai Kota Bengkulu. This system is built using HTML, CSS, Javascript, Php, and Mysql programming languages and is designed using UML diagrams. The results of this study itself are, it has been successfully applied the case based reasoning method in the expert system to identify mangrove species found in Taman Wisata Alam Pantai Panjang dan Pulau Baai Kota Bengkulu..**

Index Terms—**Automation, Mangrove, case based reasoning, KNN, Bengkulu.**

Abstrak—**Mangrove merupakan ekosistem dengan fungsi yang unik dalam lingkungan hidup. Karena sifat fisiknya, mangrove mampu berperan sebagai penahan ombak serta penahan intrusi dan abrasi laut. Mangrove sendiri memiliki berbagai jenis spesies yang tersebar di seluruh Indonesia dan belum banyak diketahui orang pada umumnya. Dalam pengidentifikasian spesies mangrove itu sendiri tidak dapat dilakukan dengan sembarang, melainkan dibutuhkan seorang pakar yang benar – benar paham dengan spesies mangrove. Penelitian ini dilakukan dengan tujuan untuk mengadopsi pengetahuan pakar mangrove untuk melakukan identifikasi dari spesies mangrove ke dalam bentuk sistem pakar. Metode yang digunakan yaitu metode case based reasoning dengan menggunakan algoritma KNN yang dipakai untuk menghitung nilai similarity antar kasus yang akan diaplikasikan pada sistem pakar untuk mengidentifikasi spesies mangrove yang terdapat di Taman Wisata Alam Pantai Panjang dan Pulau Baai Kota Bengkulu. Sistem ini dibangun dengan menggunakan bahasa pemrograman HTML, CSS, Javascript Php, dan Mysql serta dirancang dengan menggunakan diagram UML. Hasil dari penelitian ini sendiri adalah, telah berhasil diaplikasikan nya metode case based reasoning dalam sistem pakar untuk mengidentifikasi spesies mangrove yang terdapat di Taman Wisata Alam Pantai Panjang dan Pulau Baai Kota Bengkulu.**

Kata Kunci—**Otomatisasi, mangrove, case based reasoning, KNN, Bengkulu.**

I. INTRODUCTION

Indonesia is a country that has the largest mangrove forests in the world and is spread across several islands such as Java, Sumatra, Kalimantan, Sulawesi, Papua and the Maluku Islands [1]–[4] . The area of mangrove forests in Indonesia in 1982 was about 4.25 million ha and in 1985 it was about 3.24 million ha. The results of the final survey in 1995 stated that the remaining area of mangrove forests in Indonesia was 2.06 million ha[4]–[6]. The mangrove forest ecosystem is an ecological system consisting of tropical coastal vegetation communities dominated by several types of mangrove trees that can grow and develop in muddy coastal tidal areas[3], [7]. Mangroves have various functions. Its physical function is to maintain coastal conditions in order to remain stable, protect coastal cliffs and river cliffs, prevent abrasion and seawater intrusion, as well as trap pollutants. The biological function of mangroves is as a habitat for fish, shrimp and crab seeds for living and foraging, as a source of diversity for aquatic and non-aquatic biota such as birds, snakes, monkeys, bats and orchids, as well as a source of germplasm. The economic function of mangroves is as a source of fuel (wood, charcoal), building materials (blocks, boards), as well as textile, food, and medicinal materials [4], [5].

The distribution of mangroves in Bengkulu Province is shrinking[8], [9] . The causes, ranging from land use change for settlements, ponds and fields, to mangrove encroachment itself. Based on the Book of Distribution of Critical Mangroves of Indonesia published by the Coordinating Ministry for Maritime Affairs and the Ministry of Environment and Forestry 2018, Bengkulu Province is one of the areas with alarming mangrove damage, both in conservation areas and outside. In 2002, in Bengkulu City there were 1,000 hectares of mangrove forest, which are spread across TWA Pantai Panjang and Baai Island, in the Sumber Jaya and Sepang Bay areas, Kandang Village, Kampung Melayu District. However, when it was collected again in 2007, it had decreased to 533 hectares[10], [11]. In 2011, monitoring was again carried out by this community. As a result, the mangrove condition is good, only about 193 hectares are recorded, which are in the conservation area. The case of mass mangrove destruction occurred at its peak when the clearing and stockpiling of 10 hectares of mangrove forest on Baai Island, Teluk Sepang Village, Kampung Melayu District, in August 2017[8], [9], [12]. Protection of the mangrove ecosystem needs to be done by establishing it as a protected area. The government needs to make regulations to save the mangrove ecosystem which plays

a role in coastal protection. One of the strategies is to form a mangrove protected forest area that cannot be disturbed. Furthermore, the reducing process itself can be caused by the limited knowledge owned by the people conflicted on the area. There are 11 species of mangroves in Pantai Panjang and Pulai Baai Nature Park. These species including *Acanthus ilicifolius L, Acrostichum aureum Linn, Avicennia marina (Forsk.) Vierh, Bruguiera gymnorrhiza (L.) Lamk, Bruguiera sexangula (Lour.) Poir, Ceriops tagal (Perr.) C.B.Rob, Lumnitzera littorea (Jack) Voigt, Xylocarpus granatum Koen, Rhizophora apiculata Bl, Sonneratia alba J.E. Smith, Sonneratia caseolaris (L.) Engl*[13]–[15].

This research shows the automation process of mangrove identification in mangrove over the area of TWA Pantai Panjang and Pulau Baai, Bengkulu. The method used in this research is the Case Based method Reasoning (CBR) [16]–[18], which in this method uses experience previously in a similar case to understand and solve new problems. CBR collects previous cases that are similar to the new problem and tries to modify the solution to fit the new case. The problem-solving technique in Case Based Reasoning is based on past experiences. The experiences that have occurred in the past are stored in a place called the base case. If there is a new case, then that case will be resolved by searching for cases stored in the base case which have similarities with the new case. If there is no similarity in the old case, the solution of the case is an analysis of the expert who approaches the case, which will then be saved as a new case or what is called retain [19], [20].

II. RESEARCH METHOD

Case-Based Reasoning (CBR) [21], [22] consists of four main steps:

1. Retrieve: which is to take back the same problem. In this step, the process of searching or calculating similar cases is carried out.
2. Reuse: namely reusing information and knowledge in the case to solve the problem based on the weight of the most relevant similarities into the new case so as to produce a solution where an adaptation is needed to the new case At this stage there are such things as new cases and old cases. New cases are the results of identification from users that have not been validated by experts, while old cases are the results of direct identification from experts that have been stored in the database. At this stage, the K-Nearest Neighbor algorithm is used to calculate the similarity value between cases and sort the cases with the highest similarity. The Nearest Neighbor Retrieval algorithm is an algorithm for classifying objects based on learning data that is closest to the object. The special case in which classification is predicted based on the closest learning data (in other words, k=1) is called the nearest neighbor algorithm.
3. Revise: namely reviewing the proposed solution. Revise is done for new cases that are not in the database which will be saved in the new cases table. From this table, several new cases will be displayed which will be entered into the cases table by the expert or admin.
4. Retain: which is deepening part of the previous experience to be used in solving the next problem. The retain process is done by saving the results of new cases into a database of cases so that they can be used as new cases, either using the help of other cases or the case itself.

Approach in retrieval based on surface features, the similarity of each case to the target problem is usually represented as a real number in (0.1), calculated according to a given measure of similarity. Usually the cases taken are the ones most similar to the target problem. Such an approach is often referred to as the K-Nearest Neighbors (K-NN) [23] approach or the case of closest neighbors. The CBR system can ensure that the case that is most similar to the target problem is to calculate the similarity of the target problem for each case in memory [18], [20], [24]. Cases are the primary knowledge element in CBR applications. Case describes an experience. Cases contain a collection of features and their values. The case structure has characteristics that can be grouped into the following three groups:

1. Descriptive Feature, which is the feature that is easiest to identify or classify cases. Generally in the form of name, identity number, description, explanation, and others.
2. Solution Feature, namely the features that show the answer. For example, in the case of a sick person, what medicine is given and at what dose, a case of repairing machines, replacing spare parts are needed.
3. Adjustment Features, which are characteristics that change or are dynamic in nature and greatly determine the solution of the case. Features are used to adapt old case solutions to suit new situation and problem conditions, for example, age and body weight determine the dosage of medication [25]–[27]

The testing process for this research was carried out on applications made using black box testing which includes alpha testing by observing the results of interface execution through test data and checking the functionality of the applications that have been made. Tests are carried out to test whether the student grade data evaluation system can perform a function according to predetermined scenarios. The steps in black box testing are as follows:

a. Alpha testing. Testing can be done by conducting operational testing by displaying each sub-function and running it.
b. Accuracy Test. Data accuracy will be applied by conducting a location survey to collect some mangrove data and comparing the data obtained in the field with expert data. Data testing from non-mangrove species was also carried out in this expert system.

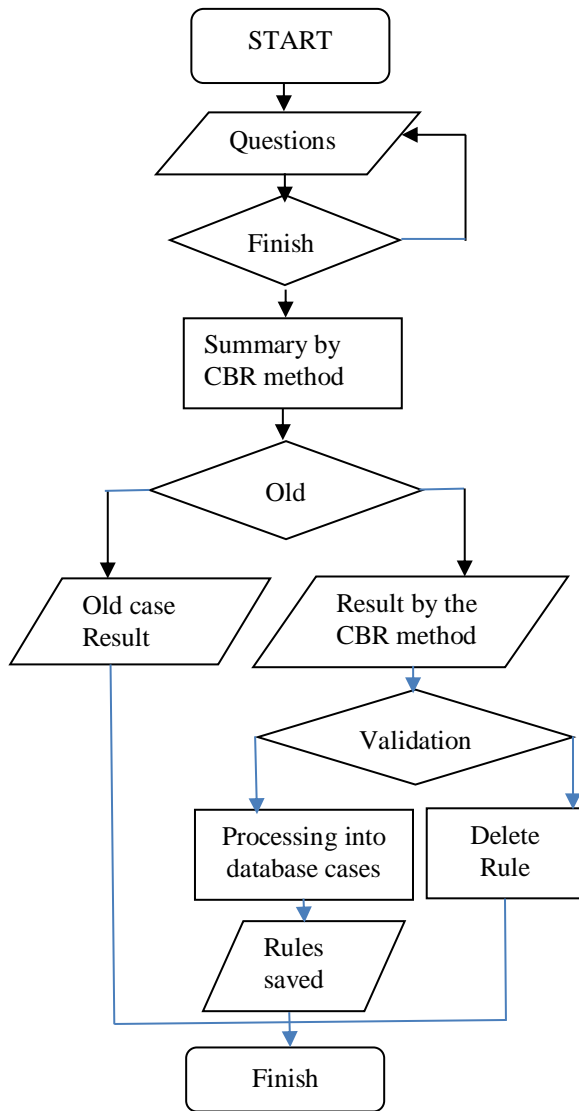The flowchart of the automation process would be described in Figure 1.

Fig. 1 System Flowchart

III. RESULT AND DISCUSSION

A. Calculation

Based on the features of each case, the data case structure can be divided into three feature groups as follows: (a). Descriptive Feature, this feature contains morphological data. Morphological data is data from the physical form of mangroves used in the identification process, where the data used are leaves, flowers, fruits, stems and roots; (b) Adjustment Feature, this feature contains data on the characteristics for each morphology in the descriptive feature, which distinguishes each morphology from one another, such as shape, colour, location, length, and width. (c) Solution Feature, in this feature there are criteria data, where the criteria data itself is the answer data of each feature contained in the adjustment features, such as how the leaves are shaped and how the stems are coloured.

To measure the distance between criteria, weights will be given to the criteria. Weighting is done based on the results of learning or observations on cases. The more influential a criterion is, the higher the weight, vice versa. The weight of this distance is given a range of values from 0 to 1 according to the influence of the criteria. Value 0 means if the criteria have no effect and vice versa value 1 if the criteria are very influential. In this system, the level of importance of the weight is taken from the form of the most prominent feature that can be used as a differentiator for each characteristic of the mangrove species. For each of these features, it will be seen for each criterion, which one has a greater number of criteria than each feature contained in each morphologies. The more criteria for each feature, the greater the weight value.

The distance is determined by a number between 0.01 and 0.09. From this number, the next three digit numbers will be followed, where the value of the next three digit numbers is determined from the characteristic criteria that are easiest to distinguish between each mangrove species. For example, on leaf colour characteristics with green characteristic criteria, the own weight value is 0.06822. Where 0.06 is the number of values determined from the effect of each criterion, and the next three digits, namely 822, are determined from the effect of the characteristic criteria for the differentiation of each mangrove species.

TABLE I
CRITERIA WEIGH

Criteria	Criteria Descriptions	Weight
Leaves Colour	Green	0.06822
	Yellowish Green	0.06666
	Green with Black dots	0.06465
	Shiny Green	0.06218
	Dark Green	0.06375
	Reddish Green	0.06768
Leaves Surface	Smooth	0.02870
	Rough	0.02685
Edge of Leaves	Jagged	0.02870
	Smooth	0.02685
Leaves Position	Opposite	0.02870
	Crosswise	0.02685
Leaves Shape	Long	0.02685
	Ellipse	0.02870
Leaves Point	Tapered and Sharp Tough	0.03885
	Tapered	0.03645
	Circle	0.03730
Flower Colours	Red	0.08325
	Light Red	0.08670
	Light Yellow	0.08164
	Pale Yellow	0.08172
	Brownish Green	0.08235
	White	0.08562
	Brownish White	0.08770
	Light Blue	0.08125
	Not Found	0.08243
Flower Position	Edge	0.03645
	Axilla	0.03730
	Not Found	0.03885
Flower Formation	fascicle	0.06218
	Solitaire	0.06768
	Group Solitaire	0.06666
	Grouped	0.06822
	Random Cluster	0.06375
	Not found	0.06465
Fruit Colour	Green	0.08770
	Bright Green	0.08562
	Yellowish Green	0.8235
	Brownish Green	0.08243
	Purplish Green	0.08325
	Reddish Green	0.08172
	Dark Purplish Green	0.08164
	Brown	0.08670
	Not Found	0.08125
Fruit Surface	Smooth	0.05860
	Rough	0.05781
	Downy	0.05425

	Nodules	0.05670
	Not Found	0.05235
Fruit Shape	Ellipse	0.04870
	Circle	0.04565
	Circle with Sharp Point	0.04430
	Not Found	0.04560
Trunk Shape	Circle	0.01875
Trunk Surface	Rough	0.07285
	Smooth	0.07520
	Sleek	0.07338
	Sleek with broken pieces	0.07484
	Wrinkled	0.07130
	Rough Gaps	0.07475
	With Scales	0.07614
Spiked	Yes	0.02870
	No	0.02685
Brach	Yes	0.02685
	No	0.02870
Trunk Colour	Green	0.09370
	Brown	0.09682
	Light Brown	0.09473
	Yellowish Brown	0.09140
	Blackish Brown	0.09235
	Brownish Black	0.09344
	Grey	0.09135
	Brownish Grey	0.09125
	Blackish Grey	0.09555
	Dark Grey	0.09780
Root Shape	Tap Root	0.07130
	Fibrous Roots	0.07285
	Respiratory Root	0.07614
	Knee Root	0.07520
	Tunjang Root	0.07475
	Board Root	0.07484
	Aerial Root	0.07338
Root Colour	Yellowish White	0.05670
	Brown	0.05781
	Dark Brown	0.05425
	Yellowish Brown	0.05860
	Dark Grey	0.05235

Fig.2 is an example of an analysis of the results of identification with several features in Table 1., where the characteristics used in the examples are the characteristics of the leaves.
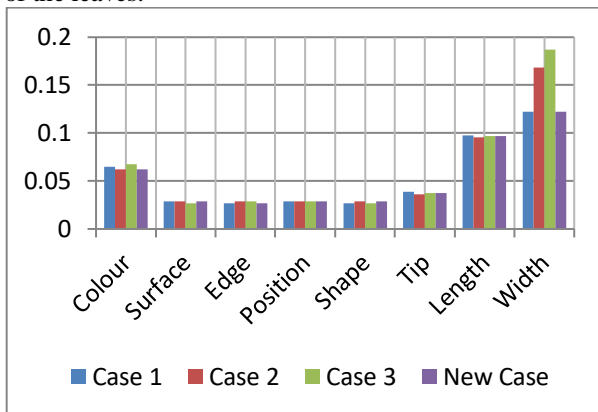

Fig. 2. Similarity Calculation

From the above calculations, it can be seen that the similarity of new cases to each old case can be obtained the closest similarity, Case 1, where the similarity level is 48.3%.

B. System Implementation

The rules of the algorithm were implemented into the system with internet based to help the identification process. The system is implemented using the PHP programming language and using the Codeigniter framework. The first interface would be the page of admin to login into the system. The login menu is provided for the administrator to manage the rules and mangrove data for another user.
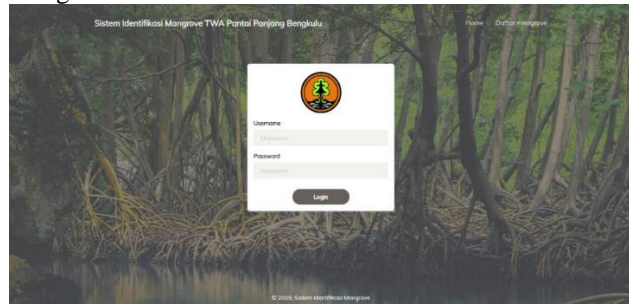

Fig. 3. Admin Page

After the login page in Fig.3. , the next implementation is the dashboard system where the management of the web were visualized on the system.
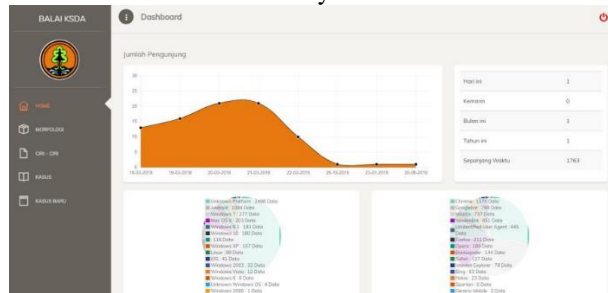

Fig. 4. Dashboard System

On the dashboard page in Fig. 4. , there are 5 main menus on the left side with its description:

a. The home page on this system is the first page. The home page contains an overview of automation system for identifying mangrove species diversity, then a button to start identifying and viewing a list of mangroves.

b. The morphology page is a management page for morphological data. On this page, the admin can take actions in the form of adding, changing and deleting morphological data from each mangrove species contained in the database. Morphological data itself is characteristic data of each species, such as data on leaves, flowers, fruit, stems and roots.

c. The features page is a management page for traits data. On this page, the admin can take actions in the form of adding, changing and deleting data on the characteristics of each mangrove species contained in the database. Data on the characteristics themselves are question data of each morphology of each mangrove species, such as leaves, flowers, fruit, stems and roots.

d. The case page is a management page for case data. On this page, the admin can take actions in the form of adding, modifying and deleting case data from each mangrove species contained in the database. The case data itself is data from each mangrove species, where the case data itself is a comparison of the input that will be input by the user. The data itself is in the form of detailed data from each mangrove species, such as the morphological case attributes of each mangrove species.

e. The new case page is a management page for new case data. On this page, the admin can take actions to verify the data entered by the user, whether the data

can be classified as a new case or not. On this page the admin can also see comparison data between answers from users and answers that have been entered by experts.

The identification page is a page that is used to carry out the identification process, in which there are forms that can be filled in by the user in carrying out the identification process. In this identification process, there are five processes carried out, namely to select the characteristics of the leaves, flowers, fruits, stems and roots. It is describe on Fig. 5.
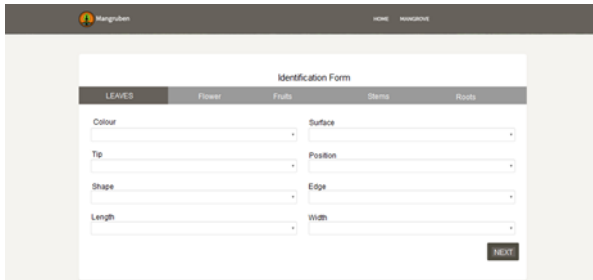

Fig. 5. Identification Process Page

The identification results page is a page where the results of the identification process will be displayed. On this page, the name of the mangrove that is closest to the features entered by the previous user will be displayed, and there is also a comparison of the suitability of the answers entered by the user, and the answers previously entered by the admin. Within each of these mangrove species there are more details about each mangrove species itself. In the details of the mangrove species themselves, there is a detailed description of each species, as well as photos of the species.

IV. SYSTEM TESTING

Black box is a test that is carried out to observe the results of interface execution through test data and check the functionality of the system that has been created. Black box testing is a test data design method based on software specifications. The test data is generated, executed in the software and then the output from the software is tested whether it is as expected or not. The following is a case for testing software that has been built using the black box method.

TABLE 2
BLACK BOX TESTING

No	Activity	Realisation	Result
Main Page			
1	Home	Showing home page	[√] Succeed [ ] Not Succeed
2	Mangrove List	Showing mangrove list page	[√] Succeed [ ] Not Succeed
3	Mangrove Identification	Showing Mangrove Identification page	[√] Succeed [ ] Not Succeed
4	Contact Page	Showing Contact page	[√] Succeed [ ] Not Succeed
Mangrove List			
1	Mangrove Species	Showing the details of mangrove species	[√] Succeed [ ] Not Succeed
2	Click on Mangrove Image	Showing the Mangrove Picture	[√] Succeed [ ] Not Succeed
3	Click Close Button	Return to previous page	[√] Succeed [ ] Not Succeed
Identification			
1.	Click Return Button	Return to home page	[√] Succeed [ ] Not Succeed
2.	Click Next without complete form	Show incomplete notification	[√] Succeed [ ] Not Succeed
3	Click next with partial input	Show incomplete notification	[√] Succeed [ ] Not Succeed
4	Complete all the form and click next button	Continue to identification process	[√] Succeed [ ] Not Succeed
5.	Complete all of characteristic form	Show the result of identification	[√] Succeed [ ] Not Succeed
6.	Complete partial input of characteristic	Show incomplete notification	[√] Succeed [ ] Not Succeed
7.	Click on Mangrove picture	Show the details of mangrove identification	[√] Succeed [ ] Not Succeed
Login			
1.	Click Login without filling the bar	Showing the notification of wrong username or password	[√] Succeed [ ] Not Succeed
2.	Click login with partial completion	Showing the notification of wrong username or password	[√] Succeed [ ] Not Succeed
3.	Complete username and password	Go to admin dashboard	[√] Succeed [ ] Not Succeed
Morphology			
1	Click add morphology	Show add morphology page	[√] Succeed [ ] Not Succeed
2	Fill on add morphology form and send	Show successful process	[√] Succeed [ ] Not Succeed
3	Click on Close button	Return to morphology page	[√] Succeed [ ] Not Succeed
4	Fill the Search and press enter	Showing the result of search case	[√] Succeed [ ] Not Succeed
5	Click on Edit button	Show edit page	[√] Succeed [ ] Not Succeed
6	Click on Delete Button	Show notification that the data already deleted	[√] Succeed [ ] Not Succeed
Characteristic			
1	Click on Characteristic button	Showing characteristic form	[√] Succeed [ ] Not Succeed
2	Fill on add characteristic form and send	Showing successful process	[√] Succeed [ ] Not Succeed
3	Click on Close button	Return to previous page	[√] Succeed [ ] Not Succeed
4	Fill the Search and press enter	Show the result page	[√] Succeed [ ] Not Succeed
5	Click on Management Data button	Show data management page	[√] Succeed [ ] Not Succeed
6	Click on add data	Show the add data page	[√] Succeed [ ] Not Succeed
7	Fill on add data form and send	Showing successful process	[√] Succeed [ ] Not Succeed
8	Click on Close button	Return to previous page	[√] Succeed [ ] Not Succeed
9	Fill the Search and press enter	Show the result page	[√] Succeed [ ] Not Succeed
10	Click on Edit button	Show edit page	[√] Succeed [ ] Not Succeed
11	Click on Delete Button	Show notification that the data already deleted	[√] Succeed [ ] Not Succeed
Case			
1	Click on add cases	Show form add case	[√] Succeed [ ] Not Succeed

No			
2	Fill add case and send	Showing successful process	[√] Succeed [ ] Not Succeed
3	Click on Close Button	Showing previous page	[√] Succeed [ ] Not Succeed
4	Fill the Search and press enter	Show the result page	[√] Succeed [ ] Not Succeed
5	Click on details cases button	Showing the details of the cases	[√] Succeed [ ] Not Succeed
6	Click of the case figure	Show the detail figure	[√] Succeed [ ] Not Succeed
7	Click on add figure and send	Showing successful process	[√] Succeed [ ] Not Succeed
8	Click on Close Button on figure	Showing data fill page	[√] Succeed [ ] Not Succeed
9	Click on Case Attribute button	Showing attribute case page	[√] Succeed [ ] Not Succeed
10	Click on add attribute case	Showing form for adding new item	[√] Succeed [ ] Not Succeed
11	Click on submit button	Showing successful process	[√] Succeed [ ] Not Succeed
12	Fill the Search and press enter	Show the result page	[√] Succeed [ ] Not Succeed
13	Click on Edit button	Show edit page	[√] Succeed [ ] Not Succeed
14	Click on Delete Button	Show notification that the data already deleted	[√] Succeed [ ] Not Succeed
New Cases			
1	Click on Show Data Button	Showing the answer comparison from the user and the expert	[√] Succeed [ ] Not Succeed
2	Click on Validation Button	Showing successful process	[√] Succeed [ ] Not Succeed
3	Click on Delete Button	Show notification that the data already deleted	[√] Succeed [ ] Not Succeed
Log Out			
1	Click on Log Out Button	Return to login page	[√] Succeed [ ] Not Succeed
Total Scenario		49	
Successful Scenario		49	
System functionality		100%	

Apart from black box testing, this application were tested into 100 mangroves plants over the area, the result of the testing are describe in table 3.

TABLE 3
ACCURACY TEST

No	Palatation	Identification Result
Mangrove		
1	Rhizophora apiculata Bl.	100 %
2	Lumnitzera littorea (Jack) Voigt	90,88 %
3	Avicennia marina (Forsk.) Vierh.	92,31 %
4	Acrostichum aureum Linn.	92,39 %
5	Acanthus ilicifolius L.	84,9 %
6	Sonneratia alba J.E. Smith	100 %
Average		93%
Non-Mangrove		
1	Coconut	58,02 %
2	Mango	45,19 %
3	Guava	55,94 %
4	Lime	52,17 %
5	Star fruit	48,12 %
Average		51.89%

From the testing result we can see that the average showed the average of 93% successful result for mangrove and the value of average 51.89% for non-mangrove plants.

IV. CONCLUSION

An automation system for mangrove detection was successfully built by applying the Case Based Reasoning method and the K-Nearest Neighbor algorithm. This system was implemented on the Pantai Panjang and Pulau Baai Nature Tourism Area with a Web-based system. The system has been tested with a data testing process that is carried out to obtain the percentage of test results with the highest (100%) and lowest (84.9%) results, with the average value of 93%. The data that is tested is expert data and field data. Another test was carried out with data that was not a mangove species, the percentage of testing was the highest (58.02%) and the lowest (45.19%), with an average value of 51.89%.

REFERENCES

[1] V. Robertua, "The Reconstruction of Indonesia's Mangrove Diplomacy," *J. Glob. Strateg.*, vol. 13, no. 2, 2019, doi: 10.20473/jgs.13.2.2019.171-183.

[2] D. Sunyowati, L. Hastuti, and F. B. Butar, "The Regulation of Sustainable Mangroves and Coastal Zones Management in Indonesia," *J. Civ. Leg. Sci.*, vol. 06, no. 01, 2017, doi: 10.4172/2169-0170.1000220.

[3] S. Pagiola, "Land use change in Indonesia," *Backgr. Pap. Prep. Environ. Dep. World Bank, Washington, DC*, no. June 2000, 2000, [Online]. Available: http://129.3.20.41/eps/othr/papers/0405/0405007.pdf.

[4] A. Rahardian, L. B. Prasetyo, Y. Setiawan, and K. Wikantika, "Tinjauan historis data dan informasi luas mangrove Indonesia," *Media Konserv.*, vol. 24, no. 2, 2019.

[5] "Degradasi Hutan Mangrove Di Indonesia *," *J. Lingkung. dan Pembang.*, vol. 1, no. 3, 2015.

[6] "MANAGEMENT OF MANGROVE ECOSYSTEM IN INDONESIA," *J. Nat. Resour. Environ. Manag.*, vol. 1, no. 2, 2011, doi: 10.19081/jpsl.2011.1.2.152.

[7] A. Rizal, "Economic Value Estimation of Mangrove Ecosystems in Indonesia," *Biodivers. Int. J.*, vol. 2, no. 1, 2018, doi: 10.15406/bij.2018.02.00051.

[8] S. Indarti, "Coastal conservation and capacity empowerment of community based disaster risk reduction in Bengkulu province," *Adv. Sci. Lett.*, vol. 23, no. 3, 2017, doi: 10.1166/asl.2017.8667.

[9] F. Febriansyah, D. Hartono, B. F. S. Negara, P. P. Renta, and Y. P. Sari, "Struktur Komunitas Hutan Mangrove di Pulau Baai Kota Bengkulu," *J. ENGGANO*, vol. 3, no. 1, 2018, doi: 10.31186/jenggano.3.1.112-128.

[10] G. Senoaji and M. F. Hidayat, "Peranan ekosistem mangrove di pesisir kota Bengkulu dalam mitigasi pemanasan global melalui penyimpanan karbon," *J. Mns. dan Lingkung.*, vol. 23, no. 3, 2016.

[11] O. Oktamalia, E. Apriyanto, and D. Hartono, "Potensi Kepiting Bakau (Scylla Spp) Pada Ekosistem Mangrove Di Kota Bengkulu," *Nat. J. Penelit. Pengelolaan Sumber Daya Alam dan Lingkung.*, vol. 7, no. 1, 2019, doi: 10.31186/naturalis.7.1.9253.

[12] D. A. Miteva, B. C. Murray, and S. K. Pattanayak, "Do protected areas reduce blue carbon emissions? A quasi-experimental evaluation of mangroves in Indonesia," *Ecol. Econ.*, vol. 119, 2015, doi: 10.1016/j.ecolecon.2015.08.005.

[13] A. Malik, R. Fensholt, and O. Mertz, "Mangrove exploitation effects on biodiversity and ecosystem services," *Biodivers. Conserv.*, vol. 24, no. 14, 2015, doi: 10.1007/s10531-015-1015-4.

[14] N. Duya and R. Noveria, "Jenis-Jenis Crustacea Di Cagar Alam Teluk Klowe Pulau Enggano Kabupaten Bengkulu Utara," *Konserv. Hayati*, vol. 15, no. 1, 2019, doi: 10.33369/hayati.v1i1.10943.

[15] A. N. Renggani, P. F. Guo, W. Wu, and T. R. Pavase, "A comparative study on mangrove forests between Indonesia and China," *Indian J. Geo-Marine Sci.*, vol. 47, no. 10, 2018

[16] H. Rantanen and M. Kahila, "The SoftGIS approach to local knowledge," *J. Environ. Manage.*, vol. 90, no. 6, pp. 1981–1990, 2009, doi: 10.1016/j.jenvman.2007.08.025.

[17] J. Lu, D. Bai, N. Zhang, T. Yu, and X. Zhang, "Fuzzy case-based reasoning system," *Appl. Sci.*, vol. 6, no. 7, 2016, doi: 10.3390/app6070189.

[18] J. A. Recio-García, P. A. González-Calero, and B. Díaz-Agudo, "Jcolibri2: A framework for building Case-based reasoning systems," *Sci. Comput. Program.*, vol. 79, 2014, doi: 10.1016/j.scico.2012.04.002.

[19] J. L. Kolodner, "An introduction to case-based reasoning," *Artif. Intell. Rev.*, vol. 6, no. 1, 1992, doi: 10.1007/BF00155578.

[20] O. N. Oyelade and A. E. Ezugwu, "A case-based reasoning framework for early detection and diagnosis of novel coronavirus," *Informatics Med. Unlocked*, vol. 20, 2020, doi: 10.1016/j.imu.2020.100395.

[21] N. Löw, J. Hesser, and M. Blessing, "Multiple retrieval case-based reasoning for incomplete datasets," *J. Biomed. Inform.*, vol. 92, 2019, doi: 10.1016/j.jbi.2019.103127.

[22] T. P. D. Homem, P. E. Santos, A. H. Reali Costa, R. A. da Costa Bianchi, and R. Lopez de Mantaras, "Qualitative case-based reasoning and learning," *Artif. Intell.*, vol. 283, 2020, doi: 10.1016/j.artint.2020.103258.

[23] G. Rawashdeh, R. Bin Mamat, Z. B. A. Bakar, and N. H. A. Rahim, "Comparative between optimization feature selection by using classifiers algorithms on spam email," *Int. J. Electr. Comput. Eng.*, vol. 9, no. 6, 2019, doi: 10.11591/ijece.v9i6.pp5479-5485.

[24] J. B. Lamy, B. Sekar, G. Guezennec, J. Bouaud, and B. Séroussi, "Explainable artificial intelligence for breast cancer: A visual case-based reasoning approach," *Artif. Intell. Med.*, vol. 94, 2019, doi: 10.1016/j.artmed.2019.01.001.

[25] C. Sannier, R. E. McRoberts, L. V. Fichet, and E. M. K. Makaga, "Using the regression estimator with landsat data to estimate proportion forest cover and net proportion deforestation in gabon," *Remote Sens. Environ.*, vol. 151, pp. 138–148, 2014, doi: 10.1016/j.rse.2013.09.015.

[26] Naser Khani, Khalil Md Nor, Hossein Hakimpoor, Mojgan Bahrami, and Shahram Salavati, "IS/IT Capability and Strategic Information System Planning (SISP) Success," *Int. J. Manag. Inf. Technol.*, vol. 3, no. 3, pp. 28–37, 2011, doi: 10.5121/ijmit.2011.3303.

[27] P. M. Mather and M. Koch, "Classification," in *Computer Processing of Remotely-Sensed Images*, John Wiley & Sons, Ltd, 2011, pp. 229–284.