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Android based rice pest detection system using learning vector quantization method

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Abstract. In Indonesia, rice was still an essential commodity. Aside from being a staple food producer of rice, as well as a primary source of livelihood for farmers. The problem often experienced by farmers was the threat of pest attack and cause massive losses; it could even lead to crop failures and harm the farmers. During this time to suppress the attacks of pest, farmers give pesticides which if it handles inappropriate would interfere with health. The best solution was to make detection system of pest attacks so could minimise the pest aggression. The limited knowledge and skills of farmers in the detection of rice crops made farmers prefer to spray pesticides. To facilitate farmers in detecting pest attacks, developed Android-based applications that were simple and easy to use device directly in the field using smartphone devices and Learning Vector Quantization (LVQ) Method. Farmers could use the application by taking pictures of rice plants that allegedly exposed to attacks with smartphones. The app would recommend alternative solutions to pest-infected plants without the use of pesticides.

Keywords: Farmer, increase productivity, minimise pesticide, pest control, smartphone.

1.Introduction

Indonesia should be able to help the country foreign exchange income and improve the people economy from agriculture. But in fact, in 2016 the number of farmers were decreased and caused in reduced food production availability production. Based on National Statistic Survey Agency in 2013, the number of farmers has dropped to 26.13×10^6 ; the previous 10 yr amounted to 31.17×10^6 [1]. One of the factors causing the declining number of farmers is the difficulty of agricultural management, especially rice crops.

Madiun Regency is one of the areas of East Java Province Which some of the inhabitants work as farmers. The problems faced by farmers are due to pest attacks. By 2017, the Agriculture and Fishery Service of Madiun Regency has recorded 223 ha of paddy fields affecting the decrease of rice production. This is apparent in yields of only 2.5 t to 3 t should be able to harvest 6 t of rice, According to Head of Food Crops, Madiun Regency Department of Agriculture and Fisheries (*Disperta*), the stricken pest area such as Sawahan [2].





Figure 1. Failed rice crop

Figure 1 shows one example of the rice crop that was attacked by pests at Madiun Regency. The existence of a pest attack causes many farmers suffered losses because the harvest was less than the maximum so that many farmers who switch to other livelihoods. If many farmers are changing professions; it makes the price of rice can soar because of the rice production from the country were slight. Though Indonesia was an agrarian country which rich in natural resources, which should be able to manage the owned wealth, the threat of rice pest attack can create a cultural tradition of farming in Indonesia especially rural areas can be lost. This condition does not rule out the possibility for the government to import rice. Based on the problem of pest attacks, especially on rice crops, the government should participate in handling problems experienced by farmers. By appealing to farmers to early identify the pest attacks.

Indonesian farmers are threatened by rice plant pests, one area of Madiun Regency that has been attacked by pests that is Sawahan District. As a result of pest attacks on rice plants have an impact on the decrease in productivity and income of the farmers. Currently, farmers always late to know the pest attack. Commonly the pest attacks identified by the farmers after the plant is severely damaged or almost dead. Pest attacks on rice plants are rapidly spreading so the damage is widespread. Farmers handle only by spraying pesticides.

The problem faced by partners in this research is the lack of knowledge regarding the identification of rice pest attack and unresponsive in early pest identifying. In identifying the pests, partners are always waiting for information from the agricultural extension workers, so pest handling is often too late. Besides, partners rely more on handling pests by using pesticides are quick and easy. What can be done to overcome these problems is to identify the pest attack early, so that pest attacks do not spread to all rice crops. By using android apps to identify the pest, it could be more shortly.

The development of mobile application in agriculture area already done by many researchers, previous research like Mobile based expert system application for improving the productivity of crops in agriculture for Tamilnadu, India [3]. In that research developed a mobile-based expert system that could use for controlling the disease by giving proper management strategies to the farmer so that the farmer could expand the production. On other research also developed an expert system to identify pest and disease of rice plant using HTML 5. The system gave questions to the user about the condition of the rice plants, and then the system could provide a conclusion about the condition [4].

In this research would develop a mobile application that could take a picture from the mobile phone and then analyse the result. On the previous study, the plant disease could detect by taking a picture of the leaf then application doing the process by image processing method to know what disease happened on the plant [5].

2. Research method

The first step taken in this research is the field study for knowledge acquisition process related to data about pest of rice crops including image data of rice plants that affected by pest and the image of healthy rice plants. In addition to data acquisition related to rice pest attack also conducted data acquisition associated with the way of handling rice pest by using a biological agent. After the data acquisition process was complete, then develop the system or application of Android-based rice pest detection system. The system is built using an Artificial Neural Network method, in learning algorithm there is 2 method that usually used, it is Back Propagation and Learning Vector Quantization (LVQ). Back Propagation showed in previous research where combine with Adaptive Learning Rate [6]. LVQ is one of the artificial neural network algorithms that conduct training to gain knowledge weight. Stages of LVQ algorithm calculation is as follows [7]:

Initialize the initial weights and learning rate (α)

As long as the condition is false, then do:

- a. For each training input vector x
- b. Find j so $\|x - W_j\|$ have the minimum value
- c. Fix w_j with:
 - If $T = C_j$ Then

$$W_j(\text{New}) = W_j(\text{Old}) + \alpha(x - W_j(\text{Old})) \quad (1)$$

- If $T \neq C_j$ Then

$$W_j(\text{New}) = W_j(\text{Old}) - \alpha(x - W_j(\text{Old})) \quad (2)$$

- d. Minus α Value

For system recognition can use the calculation of vector values [8]:

Enter the tested data

Find j so that $\|x - W_j\|$ is minimum

j is the class for x

In the previous research activities that have been developed, one of them is an Early Warning System by utilising Information Technology [9]. In the study built a mobile-based early warning system with SMS Alert, where the system will send auto SMS based on prediction calculations of a possible emergence of pests. Related to the system development early warning with the LVQ method has also been done by [10], wherein the research has been built a system that can make predictions of the 11th class students determination. In the previous study developed a system of pre-harvest detection of rice plants with leaf colour parameters calculated by using LVQ method, and from the research obtained an accuracy of 55 % [11]. And on other previous research also using LVQ method to classified Road Damage based on image [12].

Based on these studies it is entirely possible to develop an Android-based rice pest detection system using LVQ method, where the initial data input used as parameter learning is a collection of images of rice plants that affected by various pests of rice plants. And in this research activities will be made an application/system first used as a pest detection tool.

The main data used in this research is image data, where the image data processed using LVQ method to get the value. Image data processing were used in many research, on previous research image segmentation were used for Brain MRI Survey [13]. Image processing also used for pattern recognition where the accuracy about 98 % for precision value [14]

The stage of system development used in this research was apart in four stages:

- i. System Analysis and Design
- ii. System Creation
- iii. System Implementation
- iv. System Testing

And after the system development is done, then for field implementation done in this research were apart in four stages:

- i. Socialization of pest attacks early response
- ii. Socialization of Android-based rice pest attacks detection system
- iii. Training of Android-based rice pest attacks detection system
- iv. Mentoring the utilisation of Android-based rice pest detection system
- v. Monitoring the usage of the Android-based rice pest detection system.

3.Result and discussion

The results and discussions were related to the system design, analysis, and results of this research. The system developed is the flow of the running system in this research. The developed system can do rice pest attack detection. The flowchart of the system training stage can be seen in figure 2.

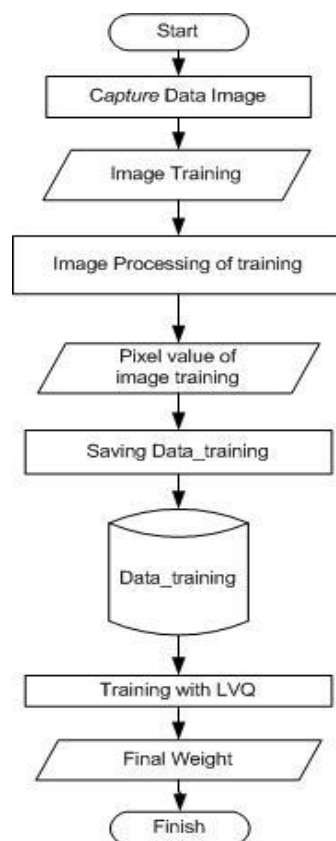


Figure 2. Example of an unacceptable low-resolution image

In figure 2 has presented the stages of system training. The system can perform detection of rice plant pests. The algorithm used by the system is one of the Neural Network methods, it is Learning Vector Quantization (LVQ). It can do the detection; the system must be trained first to get the reference weight. Because to get the detection result, it will be calculated by using distance calculation

concerning the final weight. The final weights are obtained from weight training using pixel values from healthy rice plant images and rice plants that have been attacked by pests.

For the system training phase, the image was read by its pixel value. The pixel value of the image was stored into the database which is then performed for the system training. For the system training, 50 data were collected consisting of 25 data from healthy rice plant image, and 25 data from rice crop image that had been attacked by the pest. The pixel value that has been read convert to grayscale process to unify the value of RGB pixels into a set of grey pixel values. Calculations of the grayscale process can be seen in the following calculations.

A pixel of one of the data has an RGB value is

R = 169, G = 142, B = 133

To do a grayscale calculation using the formula [3].

$$grayscale = \frac{(Red * 299 + Green * 587 + Blue * 144)}{1000} \quad (3)$$

$$grayscale = \frac{(169 * 299 + 142 * 587 + 133 * 144)}{1000} \quad (4)$$

$$grayscale = 149.047$$

The pixel value already stored in the database, then the training is done using the LVQ algorithm. For system calculations using the LVQ method begin by setting the initial weight (W), maximum Iteration, minimum Error, and learning rate (α). In this study, the initial weight was taken from each data type, it is data of healthy rice plants and data of rice plants attacked by pests. For maximum iteration used ten iterations, with the learning rate (α) of 0.05, and a minimum error of 10^{-6} . Data selected as initial weight is first and second data.

$$Weight1 = 149.047; 146.014; 148.998; 142.475; \dots; 139.073 \quad (5)$$

$$Weight2 = 82.601; 81.117; 80.889; 79.313; \dots; 79.279 \quad (6)$$

Weight number 1 is one of the images of rice plants attacked by pests, while weight number 2 is an image of healthy rice plants. In the first iteration, the first data will be compared with weights number 1 and weight number 2.

$$Data1 = 146.976; 147.487; 152.292; 144.894; \dots; 139.073 \quad (7)$$

$$Weight1 = \sqrt{(146.976 - 149.047)^2 + \dots + (139.073 - 139.073)^2} = 10.126 \quad (8)$$

$$Weight2 = \sqrt{(146.976 - 82.601)^2 + \dots + (139.073 - 79.279)^2} = 453.819 \quad (9)$$

Based on these calculations, the first data has the smallest distance to the weight number 1. Next, update the weight of the new number 1 weight.

$$w1.1(new) = 149.047 + 0.05 * (146.976 - 149.047) = 148.943 \quad (10)$$

$$w1.2(new) = 146.014 + 0.05 * (147.487 - 146.014) = 146.088 \quad (11)$$

To

$$w1.100(new) = 139.073 + 0.05 * (139.073 - 139.073) = 139.073 \quad (12)$$

From weight update to weight number 1, it get new weight value.

$$\text{Weight1} = 148.943; 146.088; 149.163; \dots; 139.073 \quad (13)$$

$$\text{Weight2} = 82.601; 81.117; 80.889; \dots; 79.279 \quad (14)$$

Before entering the calculation on the second iteration will be updated learning rate (α) first.

$$\alpha = 0.1 * 0.05 = 0.005 \quad (15)$$

Calculations of up to 10 iterations will be performed as such the previous calculations. From the calculation of 10 iterations, it get the last weight.

$$\text{Weight1} = 147.953; 145.078; 148.143; \dots; 135.072 \quad (16)$$

$$\text{Weight2} = 83.611; 80.107; 78.860; \dots; 79.251 \quad (17)$$

Recognition stage in this research is used in the image detection of the rice plant condition, to know healthy rice (not exposed to pest attack) or sick rice (exposed to pest attack). For the recognition phase of system testing can be seen in figure 3.

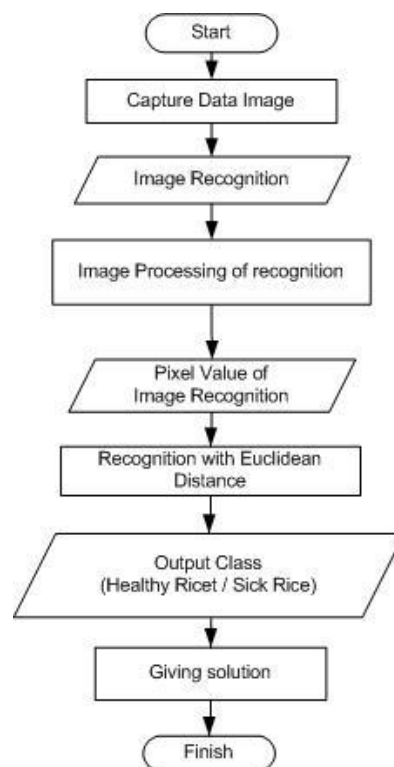


Figure 3. System recognition

The calculation used for the recognition is Euclidean Distance.

$$\text{DataTesting1} = 81.567; 79.101; 79.887; 79.313; \dots; 79.279 \quad (18)$$

$$\begin{aligned}
 \text{Weight1} &= \sqrt{(81.567 - 147.953)^2 + \dots + (79.279 - 135.072)^2} \\
 &= 448.793 \\
 \text{Weight2} &= \sqrt{(81.567 - 83.611)^2 + \dots + (79.279 - 79.251)^2} \\
 &= 2.495
 \end{aligned}
 \tag{19}$$

Based on the calculation of the recognition stage, the smallest distance to the weight number 2. So it can be concluded the first data testing is a picture of healthy rice plants. The system has been tested on four types of smartphones, such as Samsung Galaxy Core Duos, Lenovo A6000 Plus, Huawei Y3, and Xiaomi Redmi 4 Prime. For smartphone specifications used can be seen in table 1.

Table 1. Smartphone specifications for system recognition

No	Smartphone brand	Camera resolution	Operating System (OS)
1	Samsung Galaxy Core Duos	5 MP (2592x1944 pixels)	Android OS v4.1.2 (Jelly Bean)
2	Lenovo A6000 Plus	8 MP (3264x2448)	Android OS v4.4.4 (KitKat)
3	Huawei Y3 (2017)	8 MP (f/2.0)	Android OS v6.0.1 (Marshmallow)
4	Xiaomi Redmi 4 Prime	13 MP (f/2.2)	Android OS v6.0.1 (Marshmallow)

System recognition is carried out with four smartphones as in table 1. Recognition is divided into two types, namely recognition using training data and using testing data. The percentage of test results with training data and test results with testing data can be seen in figure 4.

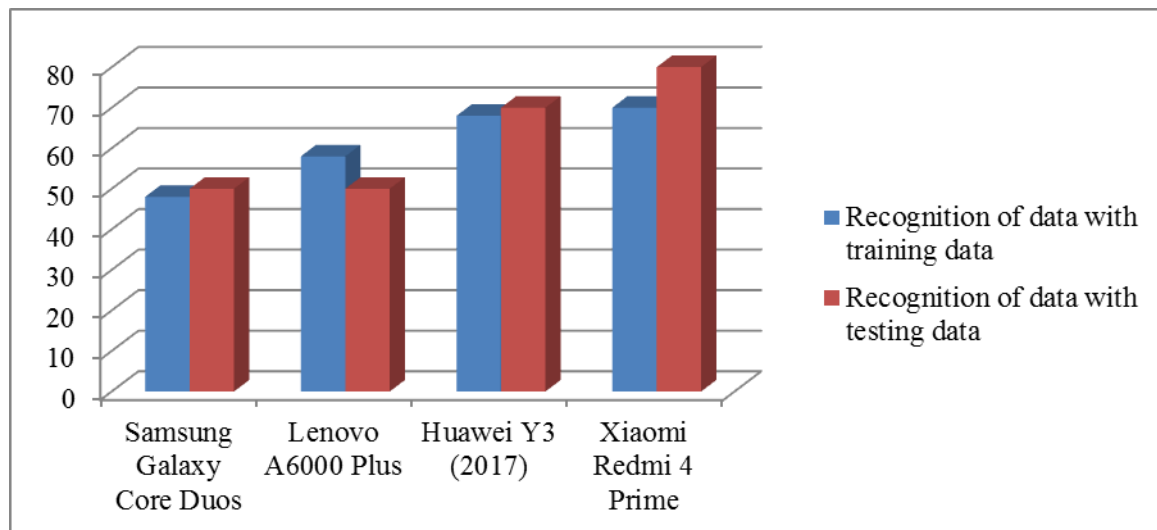


Figure 4. Percentage of recognition results

Based on figure 4, the percentage of the recognition results has been shown, where the highest percentage of results is Xiaomi Redmi 4 Prime with a percentage value of 70 % using training data for system testing, and 80 % using testing data. Percentage results are generated from the calculation of accuracy.

$$\text{Accuracy} = \frac{\text{Data True}}{\text{All Data Testing}} * 100 \% \quad (20)$$

$$\text{Accuracy With Training Data} = \frac{(4+4)}{10} * 100 \% = 80 \% \quad (21)$$

$$\text{Accuracy With Testing Data} = \frac{(20+15)}{50} * 100 \% = 70 \% \quad (22)$$

With the formula accuracy is done to calculate accuracy testing on Huawei Y3 has a percentage of results with a percentage value of 68 % using training data for system recognition, and 70 % using testing data. For recognition on Lenovo A6000 Plus, it has results with a percentage value of 58 % using training data for system testing, and 50 % using testing data. Tests were also conducted on the Samsung Galaxy Core Duos, the percentage of results obtained was 48 % using training data for system testing, and 50 % using testing data. The details of the recognition results can be seen in table 2 for detailed test results with training data. For details of the test results using testing data can be seen in table 3.

Table 2. Results of recognition of data with training data

No	Smartphone brand	Healthy rice data testing		Sick rice data testing	
		Recognized healthy rice	Recognized sick rice	Recognized healthy rice	Recognized sick rice
1	Samsung Galaxy Core Duos	20	5	21	4
2	Lenovo A6000 Plus	15	10	11	14
3	Huawei Y3 (2017)	18	7	9	16
4	Xiaomi Redmi 4 Prime	20	5	10	15

Table 3. Results of recognition of data with testing data

No	Smartphone brand	Healthy rice data testing		Sick rice data testing	
		Recognized healthy rice	Recognized sick rice	Recognized healthy rice	Recognized sick rice
1	Samsung Galaxy Core Duos	5	0	5	0
2	Lenovo A6000 Plus	3	2	3	2
3	Huawei Y3 (2017)	4	1	2	3
4	Xiaomi Redmi 4 Prime	4	1	1	4

Implementation of recognition stage in the detection of rice pest attack applied to the android based system. At the recognition stage, it is starting from taking the pictures first. The image is done with digital image processing to read the pixel value. After getting the pixel value, then the pixel value is compared with the final weight of the training result by using the Euclidean Distance formula. From the calculation of distance calculation using Euclidean Distance obtained the selected class output.

Where the output class there are two possibilities of healthy rice and sick rice. Healthy rice is data included in the type of rice that is free from pest attacks. For the unhealthy rice, the class is the type of image that is included in the rice affected by the pest attack. The image of the Android-based rice pest detection system in figure 5.

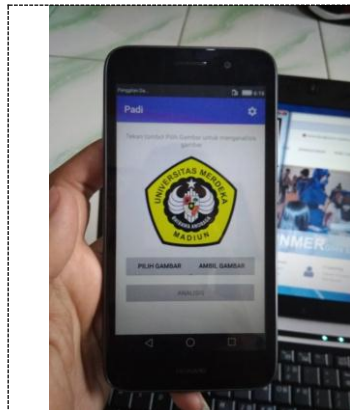


Figure 5. Android-based rice pest detection system using LVQ method

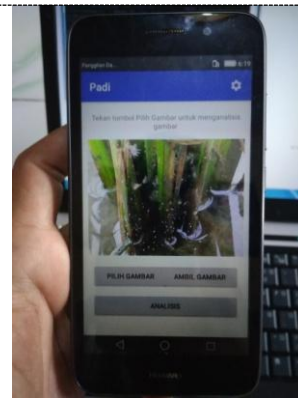


Figure 6. Choosing a data page

In figure 5 has presented the main of the Android-based Detection System. The system has three buttons that are images capture, select images, and analysis. Before performing the analysis or detection, the user must take a picture first. The system also provides the facility of image to choose buttons for images to be detected already in the smartphone gallery. The following display data after shooting can be seen in figure 6.

In figure 6 has been shown a selected rice plant data. Images can be taken directly or can be retrieved from the mobile gallery. After the picture is taken, the next stage is detection. Detection can be done by switching the analysis button. From the results of the detection will be obtained the image results include data of healthy rice plants or data of rice plants affected by pest attacks. If the data tested is the data of rice plants affected by the pest attack, then the system will show the following analysis results with the advice of handling to overcome the pest attack. For the view of the detection results can be seen in figure 7.

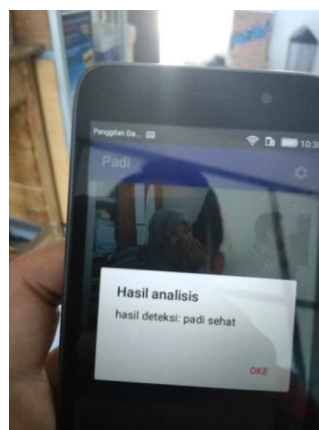


Figure 7. The detection result (analysis result)

4. Conclusions

The Android-based detection system of rice pest attacks using LVQ method is an intelligent system that utilises information technology to solve agricultural problems. The system was divided into two stages; it is training and testing. The data used for the training consist of 50 image data, consisting of 25 images of healthy rice and 25 images of rice that have been up to pests. In the training process, the system uses ten iterations, with a learning rate of 0.05 and a minimum error of 10⁻⁶. Before the training finished, first image pixel read using a grayscale method. Then the pixel value is stored in the database, which finishes the training process. The final weight of the training result used for the introduction process, and the Recognition process used to get the test result using the Euclidean Distance method. Data used for recognition ten image test data and 50 image data that have been used for training. Percentage of accuracy from the results of the recognition, Xiaomi Redmi 4 Prime has the highest accuracy value of 80 % from the recognition of testing data, and 70 % from the recognition of training data. Of the 10 testing data, eight data were identified correctly. While from 50 training data recognize to the system, obtained 35 data can be identified.

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