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ARTIFICIAL NEURAL NETWORK TO MEASURE PHOSPHORUS AMOUNT IN AGRICULTURAL SOILS

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ABSTRACT

This research investigates alternative way to measure one of important elements, phosphorus, in agricultural soils. In many agricultural lands, the farmers' behavior is just using their experience and invalid information when take fertilizer in their soil. This condition not only scarifies the soil fertility and harm microorganism but also waste the farmer's money. This study develops equipment using camera, computer and Artificial Neural Network (ANN) as algorithm. The result show that proposed method can do measure the phosphorus amount well.

Keywords: ANN, agriculture, soils, camera, phosphorus.

1 INTRODUCTION

The Soil holds important role for the plant growth. It has main function as place to growth, providing water and providing air to root breath. There are three main factors deciding the quality of fertility in agricultural soil. They are Biology, physic and chemistry factors. In real world, they influence one to another and must be equilibrium [1]. If the plants can get the nutrition directly from the soil, they will grow well and result good crop.

Today, the nutrition for the plants provided by the agricultural soil is not enough. Since the industrial Green Revolution of the 20th century, chemically synthesized inorganic fertilizers were widely used in agricultural plant. It replaces organic fertilizer due to fulfill plant nutrition fast. Lately, it has been realized that the utilization of the chemically synthesized inorganic fertilizers causes decreasing of microorganisms in the soil and affect the decreasing of the soil fertility.

In Indonesia, a country with wide agriculture land, the utilization of the chemically synthesized inorganic fertilizers has started since early 70-es. About twenty years later, early 90s, the crop has not satisfied anymore.

The condition of soil is very important information for the farmer before they cultivate the plant. The information will be useful to decide what the elements being needed are and how many is. This procedure is not work well due to difficulties to conduct it. The farmers, who leave far from the center of research or university, do the fertilizing based on experience and lack of information. This condition causes disadvantage for the farmers; wasting fertilizer and money.

In this research, we use artificial neural network (ANN) to predict one of important elements, phosphorus (P), deciding the quality of soil's fertility. There have been researches in agricultural field involving soft computing intelligence techniques. He et al. [2] use ANN to estimate monthly total nitrogen concentration in streams. They investigate the relationship among the land use, fertilizer, and hydrometerological conditions in 59 river basins over Japan and then applied to estimate the monthly river total nitrogen concentration (TNC). Anctill et al. [3] use ANN to simulate daily nitrate-nitrogen and suspended sediment fluxes from a small agricultural catchment (Melarches), 70 km east of Paris, France. They investigate the soil erosion and biochemical applications associated to human activities such as intensive agriculture. Lek et al. [4] used ANN to predict phosphorus concentration and phosphorus load from watershed characteristics. They investigate relationship between land use and the concentration and export of total phosphorus and of orthophosphate by watersheds. Salehi et al. [5] used ANN to predict of annual nitrate-N ($N0_3$-N)) losses into drain flow at Eugene F. Whelan Experimental Farm (Agriculture Canada, Woodslee, Ontario, Canada). They used daily measurements of nitrate-N taken from eight different soil conservation treatments during 1992-1994.

In this research, we use ANN to predict phosphorus amount in agricultural soils. The result of this research is aim to make portable instrument (included ANN inside) which can be used in many place easily. The instrument is helpful tool to give farmer information about soil condition. The information is very important because farmer can give appropriate treatment to their agricultural land.

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2 MODEL, ANALYSIS, DESIGN, AND IMPLEMENTATION

2.1 Proposed method

In this research, we investigated ANN application to decide phosphorus amount in agricultural soil. It is aimed to simplify procedure to check condition of the agricultural soil before farmers give treatment for its fertility.

The general procedures in many research center or university are shown in fig.1. This procedure is very difficult to do because of accessibility reason. In Indonesia which has wide agricultural land in thousand kilometers from research centre, it is a difficult thing to do the standard procedure. The reason for this problem caused by expensive and non-portable tool, spectrophotometer. The proposed method, shown in fig.2, is aimed to create a tool simplifying this problem. With this tool, non agricultural scientist can do the procedure easily. They just operate the computer and find the condition of their agricultural soil fast.

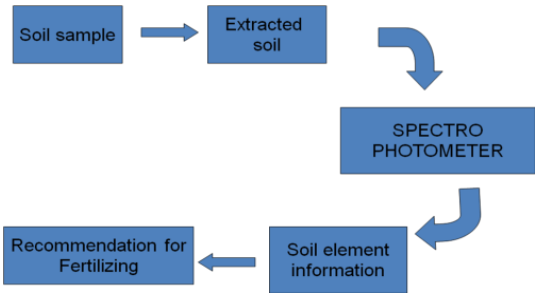

Fig.1. Official procedure to find information of soil condition

Detail of general process in this research is described in fig.2. The input is extraction of phosphorus solution appearing different color for different value. Camera will capture the solution and the results are then processed by ANN to find the level of phosphorus in the soil's extraction.

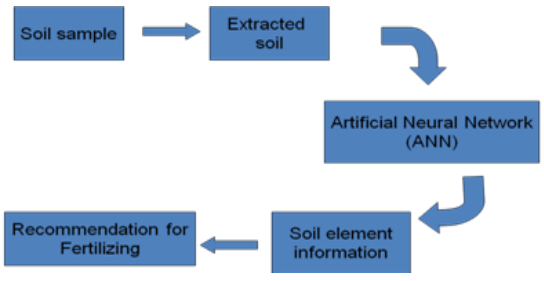

Fig.2. Diagram of proposed method

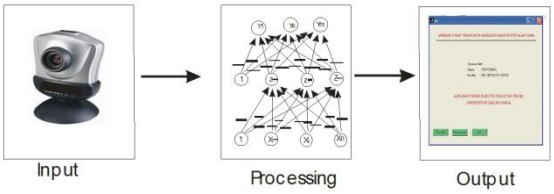

Fig.3. Detail of General Process in this research

Detail of the processes is also shown in fig.6. In this research, we used MATLAB 6.3 to do the process. The image is captured through video streaming process. It is aimed to avoid distortion of the image caused by camera calibration. The image consisting of three main colors, red, green, blue, will be used as input of ANN.

2.2 Camera's lighting standard

In image processing, lighting holds important role to decide quality of resulted image. In this research we used certain conditioning to make standard lighting in capturing the image, fixed in one box design (see fig.4 and fig.5). This fixed box is assumed in same condition when camera captures the image for both data training and real measuring image.

The example of the captured image is shown in fig.5. The captured image shows that camera can distinguish different color well.

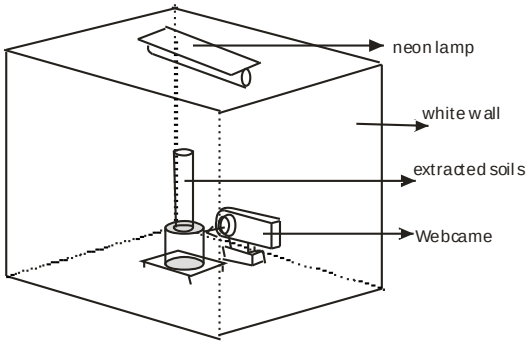

Fig.4 Fixed Box for lighting standard

2.3 Artificial Neural Network (ANN)

The genetic algorithm is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems [6]. In this research, ANN will be used to mimic the pattern of phosphorus color which has relationship with its level. We used back propagation algorithm to train the network and used several methods with its combinations in hidden layer to find minimum error. The methods and layers will be compared to

unknown data to analyze whether the ANN can introduce the unknown data or not.

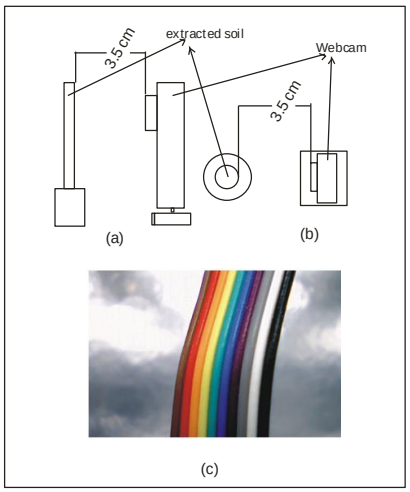

Fig.5. Dimension of box and the captured image a). side view, b). top view, c) . captured image

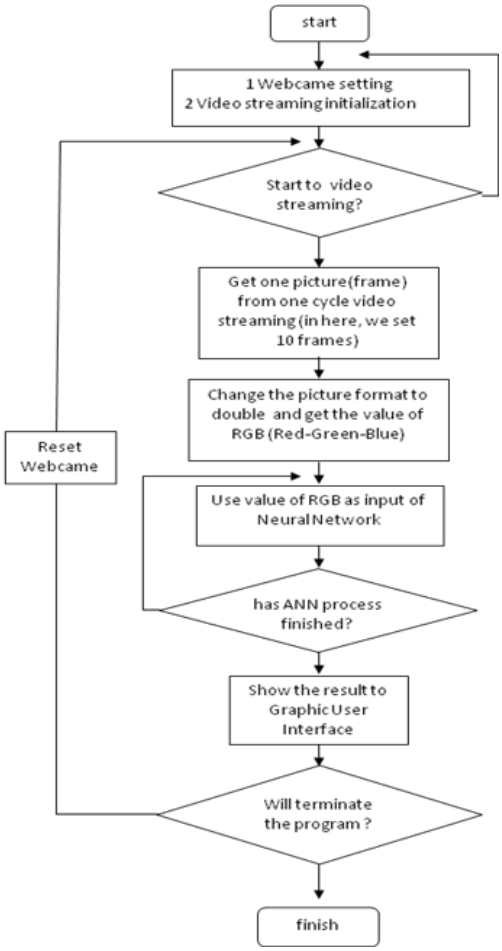

Fig.6. Flowchart of proposed method

3 RESULT AND DISCUSSION

Table.1 shows the value of color component and its level. In this research, extract process will produce color which has relationship with phosphorus amount. The higher level of phosphorus the darker the color. This data will be used as training data to build ANN structure with value of each RGB as its input. In this study, the training data is ten samples and the examiner data is five samples.

Tabel 1. Phosphorus level, captured image and RGB value

ppm	R	G	B	color
0	0.5176	0.4941	0.4941	
0.2	0.4784	0.4667	0.4941	
0.4	0.4471	0.4431	0.4627	
0.8	0.4157	0.4157	0.4549	
1	0.4118	0.4196	0.4667	
1.4	0.3529	0.3608	0.4196	
2	0.3294	0.3490	0.4353	
3	0.2392	0.3020	0.4039	
4.5	0.1412	0.2039	0.3373	
5	0.1412	0.1882	0.3529	
6	0.0902	0.1490	0.3176	
7	0.0627	0.1176	0.3020	
8	0.0314	0.0980	0.3020	
9	0	0.0784	0.2863	
10	0.0078	0.0510	0.2706	

The result of training data is in table.2. It shows that ‘trainlm’ (levenberg-marquart) method can reach smallest error, about 10^{-27}- $10^{-28,}$ that means it can introduce the data pattern with very small error.

Table 2. Training method and the results

Algorithm	MSE	Epoch	result
traingd	1e-03	1500	No-conv
traingda	1e-03	1500	No-conv
trainrp	1e-05	1500	No-conv
traincgf	1e-05	1500	No-conv
traincgp	1e-05	1500	No-conv
traincgb	1e-05	1500	No-conv
trainbfg	1e-06	1500	No-conv
trainlm	1e-28	74	convergent

From the convergent method, we use several combinations of hidden layer to find which the best formation being able to introduce new data or testing data. The results of checking the hidden layer combination are shown from table 3 to table 6. Value of error is found by equation 1.

$$\% \text{ Error} = \frac{|\text{Neural Network prediction} - \text{new data (testing data)}|}{\text{new data (testing data)}} \times 100\ \% \quad \ldots(1)$$

Table 3. Neural Network with formation 3-4-4-3-1

Testing data (ppm)	ANN prediction (ppm)	% Error
0.6	0.6357	1.3
3.5	3.5929	2.6543
5.5	5.5311	0.5655
6.5	6.5287	0.4415
1.8	1.4953	16.9278

Table 4. Neural Network with formation 3-5-4-3-1

Testing data (ppm)	ANN prediction (ppm)	% Error
0.6	0.6078	1.3
3.5	4.1382	18.2343
5.5	5.7654	4.8255
6.5	6.5074	0.1138
1.8	1.6699	7.2278

Table 5. Neural Network with formation 3-5-4-2-1

Testing data (ppm)	ANN prediction (ppm)	% Error
0.6	0.6865	14.4167
3.5	1.4946	16.9667
5.5	3.7787	7.9629
6.5	5.5422	0.7673
1.8	6.5328	0.5046

Table 6. Neural Network with formation 3-5-4-4-3-1

Testing data (ppm)	ANN prediction (ppm)	% Error
0.6	0.7007	16.7833
3.5	3.6100	3.1429
5.5	5.2784	4.0291
6.5	6.2652	3.6123
1.8	1.4530	19.2778

Table 7. Comparison among different layer formations and average error

Layer formation & Neuron amount	% Error
3-4-4-3-1	8
3-5-4-3-1	8.142
3-5-4-2-1	9
3-5-4-4-3-1	8.46

From table 7, we can see that ANN with structure 3-4-4-3-1 can introduce the new data and has smallest minimum error. This structure is become chosen structure of ANN in proposed method. The weights of neural network are then applied in MATLAB program merged with camera instruction.

After finding the best structure of ANN, the chosen ANN is then compared to spectrophotometer reading. The comparison result is shown in fig.8. From fig 8, we can see that the ANN can get more accurate reading than spectrophotometer. This result shows that the proposed method can be used to replace spectrophotometer to analyze agricultural soil condition particularly in far place from research center.

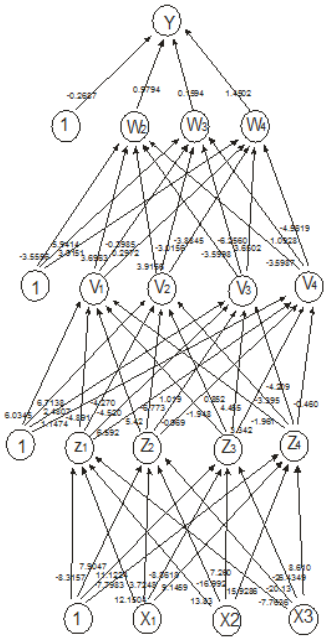

Fig.7. Structure of chosen formation with its weights

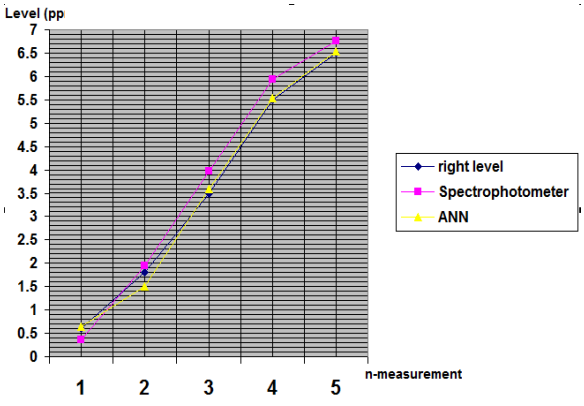

Fig.8. Comparison between ANN and Spectrophotometer reading

4 CONCLUSION

From the result of analysis, we can conclude that the proposed method can introduce pattern of image representing phosphorus level in agricultural soil well. When compared to spectrophotometer reading, the result shows the proposed method can read more accurate. It is mean that the result of this research can be used to analyze the agricultural soil before farmer give something treatment to it. The advantage of this tool is portable equipment where it can be used in remote area or agricultural land which's far away from research centre.

To the future research, the researchers need to investigate the influence of lighting in relation to captured image. The lighting will strongly influence the quality of image, it is "The better the image the more accurate information we get".

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