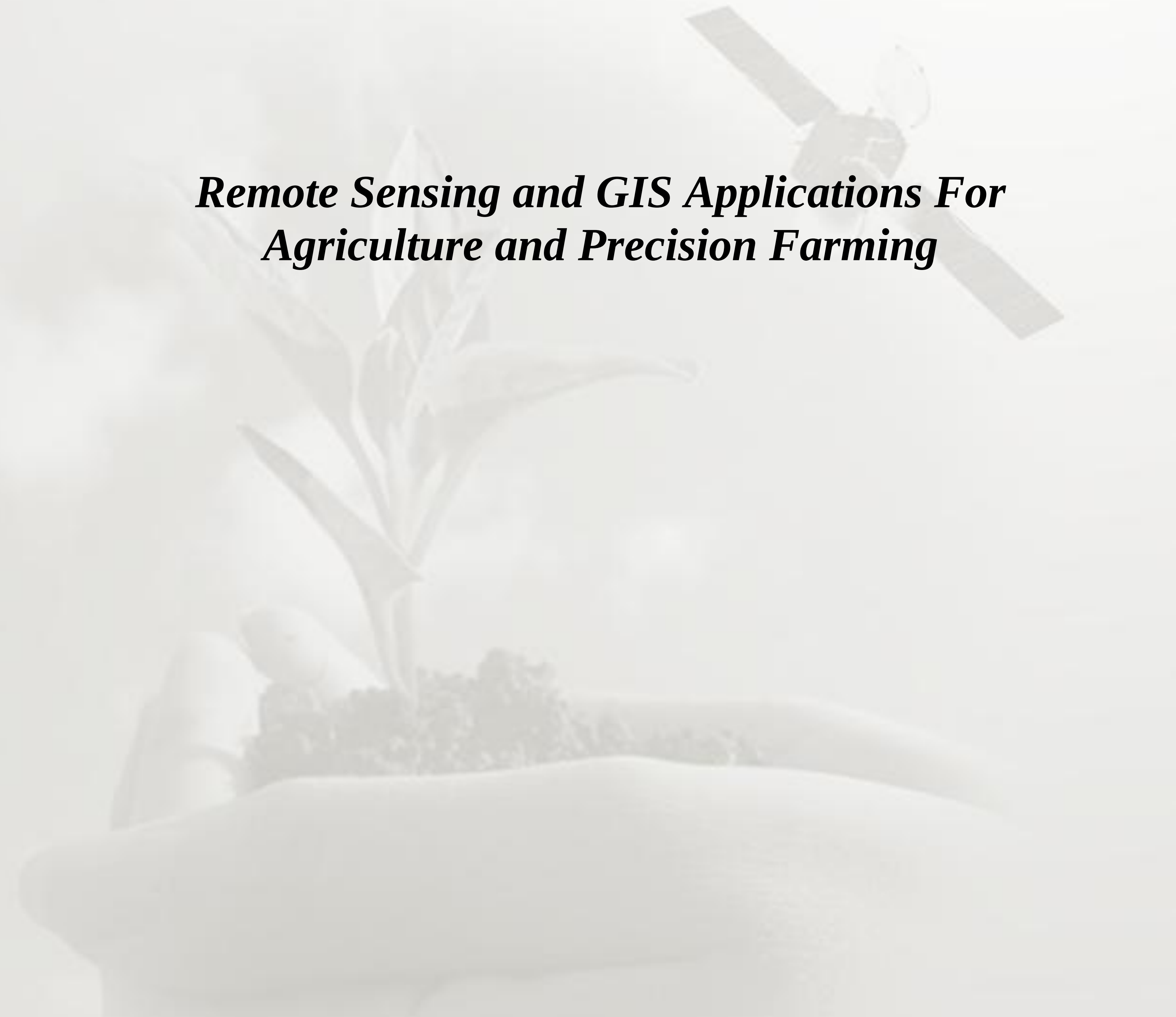
Remote Sensing and GIS Applications For Agriculture and Precision Farming



The Use of Hand Phone Camera to Determine Paddy Leaf Color Level as a Reference for Fertilizing Dosage

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***Abstract* — This research aimed at attempting to use hand phone cameras to determine paddy leaf color level instead of using leaf color chart. Five brands of popular hand phones were used to capture the image of paddy leaves which were previously measured with the standard IRRI's leaf color chart. The leaves were placed on the palm skin and on a white paper under two lighting conditions: under body shadow (around 100 lumens) and under open sunlight (around 850 lumens). The images were then processed to extract the RGB color components of both background image and the leaf image. Eighteen color components were used as the classifier. With those eighteen variables, the k-nearest neighborhood (k-NN) pattern recognition method was applied to develop the prediction tool. Almost clear distinct different of color characteristics was found between background images and leaf images, but on the other hand, the color characteristics of each level of paddy leaf color level were not distinctively different. With the k-NN prediction method it was found that the best accuracy was showed by capturing sample images on palm skin under body shadow (66%) and followed capturing sample images on white paper under open sunlight (68%). The low accuracy is probably caused by the ambiguity of leaf samples colors.**

Keywords : leaf color chart, fertilizing dosage, nutrient management, precision fariming, hand phone camera, k-NN classifier

I. INTRODUCTION

Indonesian government is currently promoting to decrease the use of inorganic fertilizer as the raw materials for producing the fertilizer tends to become scarce. The first effort is to avoid excessive use of inorganic fertilizer and the second by replacing part of it with organic fertilizer. For efficient use of fertilizer, Indonesian MOA has introduced leaf color chart to determine the color level of paddy leaf, and finally determine the proper fertilizing dosage. This method has been proposed by [1], in Indonesia the standard 4 levels leaf color chart introduced by IRRI is used. The problem is that the chart is not easily adopted by farmers due to its limited availability and lack of socialization.

With hand phone technology on farmer's hands currently, and with its data processing and data transfer capability, there are a wide possibilities to utilize hand phones for agricultural purposes. Several utilization have been proposed, such as by [2] using the hand phone to send and request agricultural product prices, and such a purpose has also been developed by Indonesian MOA.

With its built in camera, there is possibility to use hand phones to capture and process images of plants or agricultural products, as those done previously with digital cameras or photo sensors. Related to determining fertilizing dosage, hand phones could be use to determine the color level of paddy leaf instead of using leaf color chart. There is a major problem in using the camera for the purpose, that is lighting conditions. As the camera will be used in the field, lighting condition will be vary, making the color will be not consistent. Although the camera is set automatic, both for the aperture and shutter speed, there is no guarantee that a certain leaf color level will produce a constant color in the image.

This research aimed at attempting to use hand phone cameras to determine paddy leaf color level instead of using leaf color chart. The study is focused on the consistency of the color characteristics between the leaf samples and their images.

II. MATERIALS AND METHODS

This research was done in local farmer's rice fields surrounding the Bogor Agricultural University, Bogor, Indonesia within the time span from June to August 2010. Five persons were involved in the research representing varying characteristics of local farmers indicated by varying in their skin colors. As for the camera, five brands of popularly used hand phone were used to take photos of paddy leaves. Lighting environment were selected at two levels, around 80 lumens (under body shadow) and around 850 lumens (under open sunlight).

There were 4 levels of paddy leaf colors were taken as the samples, which were previously measured with the standard IRRI's leaf color chart. Each sample were captured 4 times with each camera: 1) on the palm skin under body shadow, 2) on the palm skin under sunlight, 3) on a white paper placed on the palm under body shadow, 4) on a white paper placed on the palm under sunlight, as shown in Figure 1.

The placement of sample, and the image frame is set in a such condition that only the leaf sample and the palm are in the frame. With that setting, the white balance set automatically by the camera will be affected only by the color of background and the leaf sample.

a) on the palm skin background b) on a white paper background

Figure 1. Sample of images taken with hand phones

Each photo was then processed with Visual Basic™ 6.0 to extract the color characteristics of leaf images and background images (palm skin or white paper). Color characteristics were expressed in RGB color system. Eighteen color variables were extracted for both background and for the leaf images: Minimum R , Maximum R, Average R, Minimum G , Maximum G, Average G, Minimum B , Maximum B, Average B. With those total 18 variables, the k-NN (k-nearest neighborhood) pattern recognition method were used to classify the photos into 4 leaf color levels.

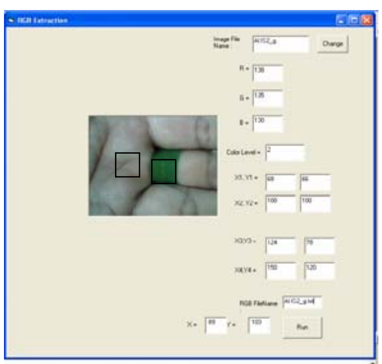


Figure 2. Color components extraction

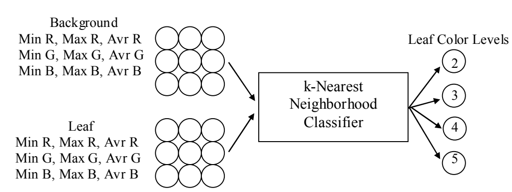


Figure 3. Input and output of the leaf color level prediction method

III. RESULTS AND DISCUSSIONS

a. Image quality

Leaf samples were placed at about 15 cm distance in front of the hand phone. This is done in order to fit the image frame. The paddy leaf part is placed at the center of the frame. Two hand phone brands (D and E) allows frame zooming so that the sample can be placed in longer distance. With the distance about 15 cm, several images were not in sharp focus, but there is a quiet distinct difference colors between the background and the leaf. As for the image file size, each hand phone has its own image size setting.

The number of total snapshoot was 320, 308 photos could be processed, while 12 failed due to unsuccessfully saved or inappropriate framing.

b. Image Characteristics

For the coming figures and discussions, the following notations are used.

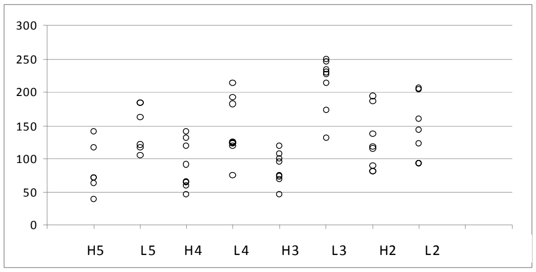
H : hand background (skin or white paper)
L : leaf samples
S : under body shadow lighting condition
B : under open bright sunlight lighting condition
A, B, C, D, E : hand phone brand
2, 3, 4, 5 : leaf color levels

The first concern about the image is that the color difference between the leaf and the background. As the leaf image is dominantly filled by green color, the G color component was used to distinguish the leaf from the background. It was found that the range of minimum and maximum value for G components are almost clearly different in paper background as shown in Figure 4c, 4d and Figure 5c, 5d. In palm skin background, the different was not clearly shown from the entire minimum and maximum range, but from each pair of data there is a regular pattern, where leaf image always has higher R values then the background. Among brands of hand phone, as shown in Figure 5, different brand showed relatively different range of G values, both for the backgrounds and for the leaf samples. Hand phone C and D showed narrow ranges.

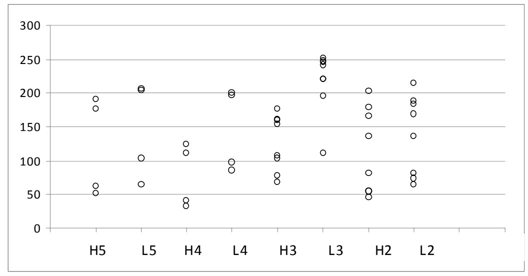
The second concern, or the main concern, is the different color characteristic between one color level with other color level. This difference will give the accuracy of leaf color level prediction. As shown in Figure 4, focusing on L5, L4, L3, and L2 indicating leaf color level 5, 4, 3, and 3, the difference of G component is not clearly shown. Logically, increasing leaf color level will imply in the increasing value of G component. But this doesn't happen consistently, including that on Figure 4a, L5 showing lower G component then L4 and L3. Automatic white balance setting done by the camera should not change that far as the lighting condition is the same. The possible cause is that the G component is not the only change caused by the change in leaf color level. The changes probably also happen to other color components, including the color components of the background.

Another possible reason is the leaf samples themselves. As well experienced in using the standard 4 levels leaf color chart, there is an ambiguity in determining the proper color level. The reason is that the color of the leaf often far from fitting any of the color in the chart.

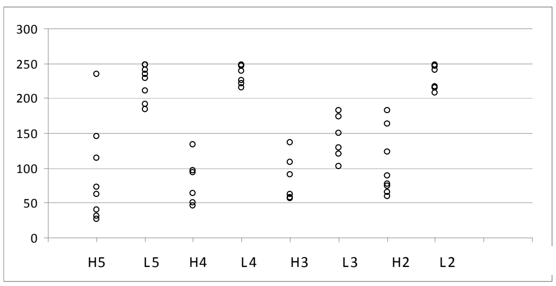
Relying on the previous reason, where G may not the only effect caused by the change in color level, the k-NN classifier method was applied with complete R, G, B color components, both for the background and leaf image as well.



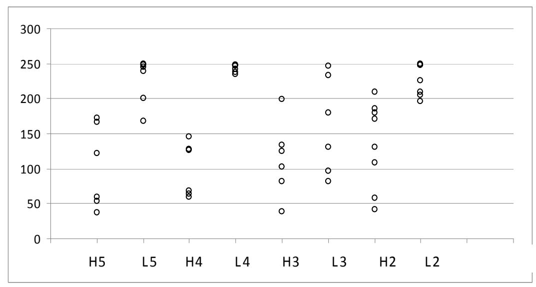
a) Skin background under body shadow



b) Skin background under open sunlight

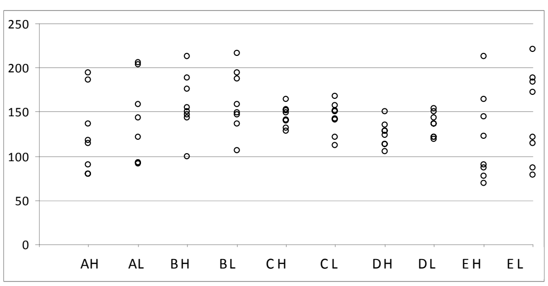


c) Paper background under body shadow

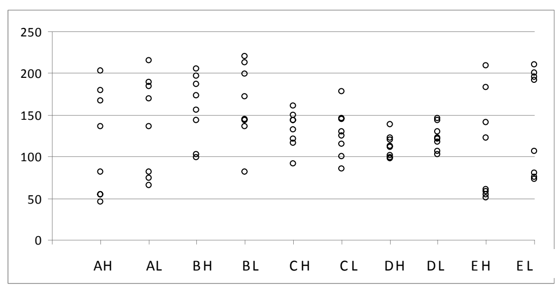


d) Paper background under open sunlight

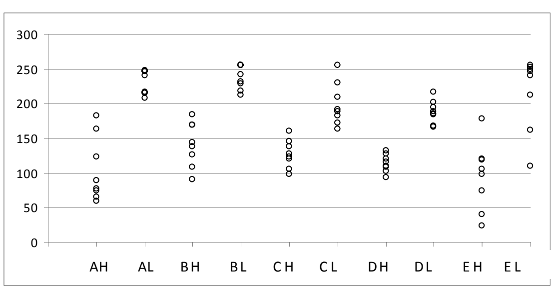
Figure 4. Range of G values for images taken with hand phone A



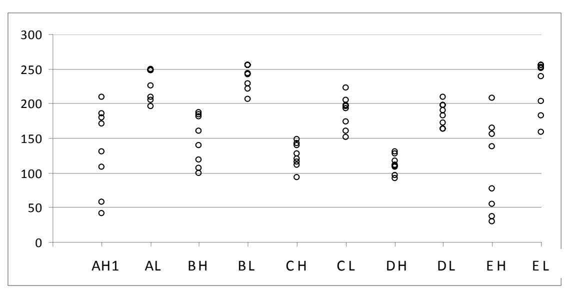
a) Skin background under body shadow



b) Skin background under open sunlight



c) Paper background under body shadow



d) Paper background under open sunlight

Figure 5. Range of G values for leaf color level 2

The k-NN has been trained with 308 images, and then used to classify other data. Under the four kinds of background and lighting condition, the best accuracy achieved by the k-NN classifier is shown in Table I. The best accuracy is shown by capturing samples on palm skin under body shadow condition. This means that the varying skin colors can be accommodated by the automatic white balance setting of the camera.

TABLE I. PREDICTION ACCURACY OF VARYING BACKGROUNDS AND LIGHTING CONDITIONS

Leaf Color Levels	Accuracy under different background and lighting condition				Average
	Skin shadowed	***Skin under sunlight***	***Paper shadowed***	***Paper under sunlight***	
2	0.75	0.80	0.85	0.80	0.80
3	0.45	0.35	0.21	0.53	0.39
4	0.67	0.61	0.21	0.58	0.52
5	0.78	0.55	0.25	0.63	0.55
Average	0.66	0.58	0.38	0.63	0.56

Further more can be seen, color level 3 always shows the worst accuracy. This is probably caused by the ambiguity of the color level, so that it often recognized as other color levels. As shown in Table II, color level 3 is often recognized as color level 4. But again, other unknown reason arises, where at the same time, color level 3 is also recognized as color level 2. Referring to the characteristic of k-NN method, the error could happen at color level 2 during the training, so that the color level 3 falls into the wrong color level 2.

TABLE II. PREDICTION ACCURACY OF THE BEST CAPTURING METHOD

Leaf Color Levels	Number of samples	Number of color levels predicted				Accuracy
		2	***3***	***4***	***5***	
2	20	15	2	3	0	0.75
3	20	3	9	5	3	0.45
4	18	0	2	12	4	0.67
5	18	0	2	2	14	0.78

Experiments on the k-NN parameters showed similar results. Table III shows that the increasing value of parameter k gives less prediction accuracy. This indicates that big number of data are similar each other between the four leaf color levels, or on the other words, big number of the data are similar, can not be classified into a specific color level.

Up to this point, the cause of those similarities is not exactly known. Further study should be done to answer the question. The doubt about the ambiguity of leaf samples can be overcome by simulating the prediction using the color levels from the leaf color chart itself. With its exact colors, if the problem persists, the cause must be in the cameras automatic setting. If this happens, it must be admitted that automatic digital cameras, as those belonging to hand phones, are not suitable for leaf color level prediction under uncontrollable field light condition.

TABLE III. PREDICTION ACCURACY UNDER SEVERAL VALUES OF PARAMETER K

Leaf Color Levels	Accuracy under the number of comparing neighborhood – k			
	1	***3***	***5***	***10***
2	0.75	0.80	0.73	0.80
3	0.45	0.25	0.35	0.20
4	0.67	0.44	0.39	0.06
5	0.78	0.50	0.33	0.39
Average	0.66	0.50	0.44	0.36

IV. CONCLUSIONS AND SUGGESTIONS

Color characteristics of leaf samples and the background are consistently different, but not among the leaf color levels. Big number of data in the k-NN training step are similar each other among leaf color levels. This makes the prediction accuracy low.

So far, it was found that the best capturing method is placing leaf sample on the palm skin under body shadow lighting with average accuracy 66%, followed by placing leaf sample on a white paper under open sunlight with average accuracy 63%. It indicates that varying skin color as the background can be accommodated by the automatic white balance setting of the camera.

In order to reveal the cause of color characteristic similarities among leaf color levels, it is suggested to assure the color level targets by treating the colors in the leaf color chart as the samples. With these results, further study can be arrange with improvements in taking leaf samples and proper capturing methods.

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