RICE CROP HEIGHT MONITORING USING FIELD SERVER AND DIGITAL IMAGE ANALYSIS

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Abstract: Rice crop height is an important agronomic trait linked with plant type and yield potential. To obtain rice plant height in remote site, a digital image processing system based on field server has been developed. A digital camera is used to acquire photos on the rice crop field. Rice crop height can be measured indirectly by measuring marker bar height. The images compose of rice plant and marker bar which is used as a reference height. Feature extraction module can be used to extract more different features between the marker bar and rice crop field for supported segmentation. Image segmentation is applied to separate objects and boundaries for the marker bar and the others. The marker bar is detected and compared with initial marker bar for measuring rice crop height. In our experiment, the field server with a digital camera is monitored at a rice crop field in Supanburi Province, Thailand, during growing season in 2012. The experimental results showed that the proposed method measures rice crop height effectively.

INTRODUCTION

Field server has been developed (Fukatsu and Hirafuji, 2005; Fukatsu et al, 2006; Fukatsu etc al, 2008) for monitoring environment parameters. Field server provides various sensors, cameras, communication and control units. The field server technology is useful to monitor environments or activities through sensors and cameras. Users can collect data such as rain, humidity, wind, temperature, soil moisture etc. to support planning and management. This technology can transfer data and it may be controlled remotely through a computer via internet-based system.

Rice Plant Height is one's important information for monitoring rice crop growth. When rice grows, its stalk becomes higher. Rice height thus collected data can be used to analysis rice type classification, yield estimation and harvest planning, etc.

For tree height measurement, the tree height is most important measuring factors in forest resource. It indicates the productivity, standing volume and volume growth rate. The tree height measurement techniques and tools have been presented (Changgui and etc, 2006; Changgui and etc, 2007; Qingwang and etc, 2008; Zhongke and etc, 2007; Han, 2011) and other works such as those based on surveying (Zhongke and etc, 2007), (Yunwei and etc, 2007; Qing and etc, 2005). However, tree and rice height measurement are clearly different methods. Since tree height can be directly measured by measuring its trunk. While rice height is hard to directly measure because its stalk is quite small.

This paper presents a measuring method of rice crop height based on digital image processing techniques. A digital camera in field server provides photos of the rice crop field. In the photos, rice crop height can be indirectly measured by measuring marker bar height. The benefits of the method are: reducing manual works, less cost, fast computing and real time assessment.

MODEL

Field server is installed for monitoring rice crop field. As sensor of field server, a digital camera is used as the sensor to provide photos of rice crop field. The height of rice crop can be measured form the photos. Since rice height is hard to directly measure because its stalk is quite small and there are so many rice plants in any particular field. Rice crop height can be indirectly measured by measuring marker bar height. The images compose of rice plants and the marker bar. The marker is focused and detected for measuring while the other things such as rice field, soil, cloud, and sky are defined as background. The proposed method gives an average height of rice crop in the field. Figure 1 shows Field server at a rice crop field in Supanburi province, Thailand. The product image of this field server is also shown in figure 2.

Figure 1: The field server at a rice crop field in Supanburi province, Thailand

Figure 2: Photo showing rice crop height monitoring at a rice crop field in Supanburi province, Thailand

IMAGE PROCESSING

The field server provides the images of rice plant, marker bar and the others. The marker is detected for indirect measuring of rice crop height. For digital image processing techniques, feature selection method is used to remove redundant features. Feature extraction module extracts more differential features between the marker bar and the others. Image segmentation is applied to separate the marker bar and the others. The marker bar is detected and compared with initial marker bar for measuring rice crop height. The flowchart of this method is shown in Figure 3 and the detail is described in four topics of feature selection, feature extraction, image segmentation and measuring (Gonzales and Woods, 2008).

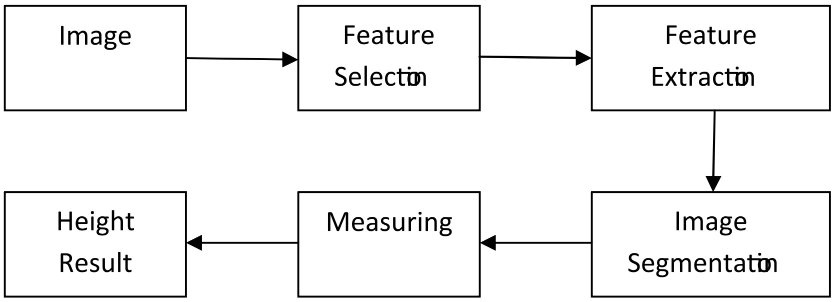

Figure 3: The flowchart of rice crop height measurement

A. Feature selection

For the color model, a digital camera provides images, namely, in RGB color model. The color value of each pixel is composed of three components of Red, Green and Blue. The marker bar is designed as white and red alternating color, which is easy to inspect by human evaluation. However, the alternating color is harder to detect in computation analysis than unique color. Since homogeneous values in the whole object is easy to separate from the other objects. Red band is selected to be the feature in the analysis since values of white and red color of the marker bar in Red band has positive direction that both values are high while the values in green and blue band are negative direction (Red color is low value and white color is high value in both of green and blue bands).

B. Feature extraction

The spatial filter is used to extract the feature between marker bar and non-marker bar. Laplacian filter (Reuter and others, 2009) is applied in extracting edge and directional filter (Lindeberg, 1998) is often used in directional edge detection. Since the marker bar locates the following in 90 degree of x-axis or y-axis (Vertical direction), the kernel filter in spatial filtering is designed that direction is shifted 90 degree of marker bar direction as direction in 0 degree of x-axis (Horizontal direction) for extracting the long edges in y-axis between the marker bar and others. The kernel is designed to be similar to Laplacian and directional kernels but the values and size of the kernel is modified for appropriate feature of the marker bar for easy separation of the marker bar and others.

C. Image segmentation

Image segmentation is applied to separate the marker bar and others. Thresholding (Sezgin and Sankur, 2004) which is the simplest method of image segmentation is selected for creating binary image. This method enables the filtered image to turn into a binary image by clippling threshold. The resultant binary image is separated into two types; (1) masked marker bar (2) unmasked marker bar. Threshold value is assigned from testing in our experiment.

D. Measuring

In the resultant binary image, there are masked marker bar and unmasked marker bar. Considering masked marker bar, marker bar has character of long length masked marker bar in y-axis while character of noises or other things are of short length. Thereby longest length masked marker bar in y-axis is used as detected marker bar. Initial marker bar is initially measured of its length by human evaluation in initial step. The rice crop height is the height of the hidden marker bar when comparing between detected and initial marker bar. The proposed method provides an average height result of the rice crop in this filed.

In real practice, the top of marker bar in our experiment nearly hits the sky. In red band, the value of marker bar both of red and white are close to the value of the sky (all are high). Marker bar and the sky are closely homogenous area. The filter cannot extract the edges and image segmentation cannot separate the objects. So the area that marker bar is near the sky is cut off and residue marker bar is taken as reference marker bar.

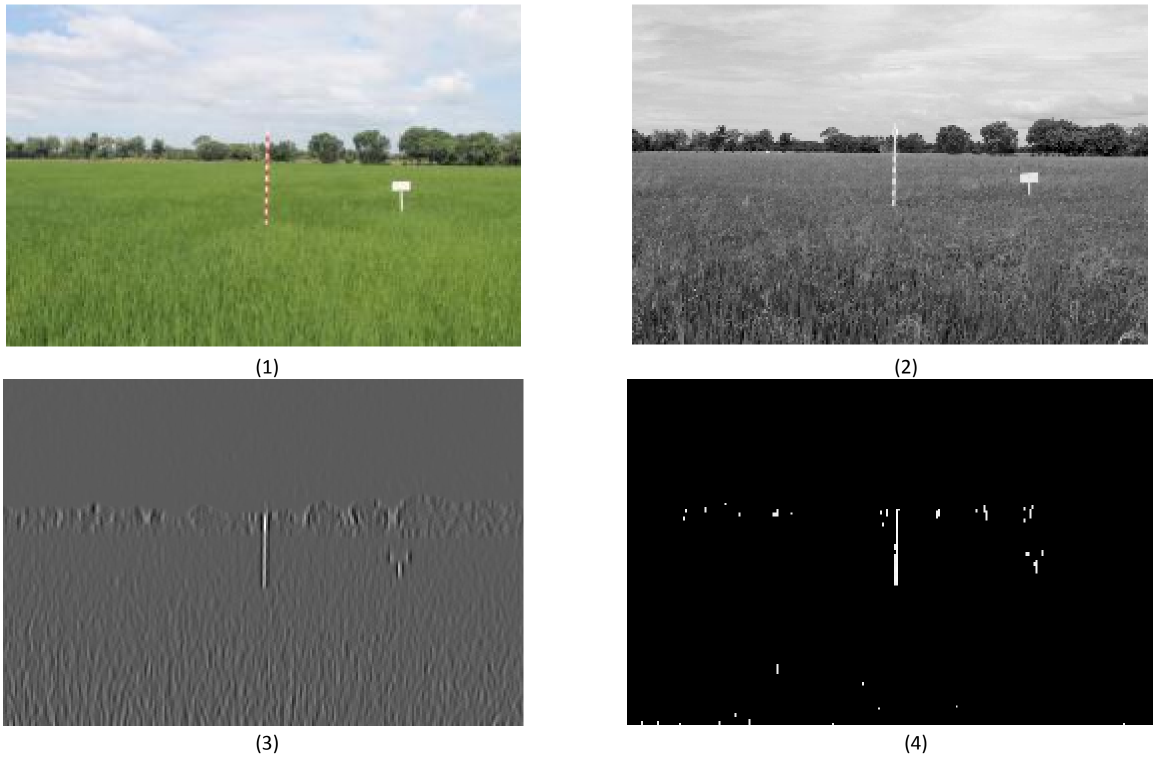

Figure 4: (1) RGB Image (2) Red band Image (3) Filtered red band Image (4) Binary image

EXPERIMENT AND RESULT

Field server is set up at a rice crop field in Supanburi province, one of the important rice plantation areas in Thailand. The images acquired from digital camera of this field server are daily recorded. Ten images were selected to test our proposed method using the tested data acquired in July, 2012.

The rice crop height can be reliably measured by human evaluation of the image. Therefore, the results of this method is set as the reference and compared with the results of our proposed method. Relative error index is selected to verify accuracy of our experimental result. The experimental result is shown in Table 1.

Table 1: Comparison between results of proposed method and reference results

Date of Image	Reference result	Proposed result	Relative error
2012/07/01	58.0 cm.	56.7 cm.	2.3 %
2012/07/04	58.0 cm.	56.7 cm.	2.3 %
2012/07/07	60.0 cm.	60.6 cm.	1.00 %
2012/07/10	61.0 cm.	56.7 cm.	7.1 %
2012/07/13	67.0 cm.	64.5 cm.	3.7 %
2012/07/16	68.0 cm.	61.9 cm.	8.9 %
2012/07/20	95.0 cm.	92.0 cm.	3.2 %
2012/07/23	98.0 cm.	98.5 cm.	0.5 %
2012/07/26	100.0 cm.	99.8 cm.	0.2 %
2012/07/29	96.0 cm.	97.2 cm.	1.3 %

Table 1 shows that the proposed results are close to the reference results. The average relative error is about 3.0 % with the minimum at 0.2 % and the maximum at 8.9 %.

CONCLUSION

This paper presents a method for measurement of rice crop height using filed server and image processing technique. In our experiment, the proposed method can measure rice crop height effectively. This method can be adapted for the feature of the marker bar which depends on designation. The advantages of the method are four fold: replacing human evaluation, less cost, speedy operation and real time system. However, the error will rise with the movement of the rice stalk, photography shift, and insufficient perspective view. Moreover, if the background such as rice, soil, cloud, and sky is rather complex, the resulting accuracy may be lowered. Also the environment parameters, such as lighting condition, weather, etc. especially rain, may seriously impact on the result.

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