Method of vegetation spectrum measurement using multi spectrum camera

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ABSTRACT: In this paper, a method of vegetation spectrum measurement using multi spectrum camera was studied. Each pixel in taken images using multi spectrum camera have spectrum data, the relationship between spectrum data and distribution, structure, etc. are directly turned out. In other words, detailed spectrum data information of object including spatial distribution can be obtained from those images. However, the camera has some problems for applying field measurement and data analysis. In this study, those problems are solved.

KEY WORDS: Multi spectrum camera, Observation, Vegetation, Spectrum.

1. Introduction

For research vegetations by remote sensing, it is important to investigate spectrum of ground vegetation covered surface. Normally, the targets of ground measurement have some element such as vegetation itself, soil, shadow, etc. The spatial distribution and position if these elements are affected to average spectral response in sensor's filed of view. In the case of using generally spectrometers, although it is possible to take average spectrum in filed of its view, it is impossible to take elements spectrum in that. To solve this problem, a method has been developed in previous research. It use some pictures which taken by digital camera and estimate elements spectrum from coverage ratio of elements in pictures and average spectrum in filed of spectrometer's view. Since the method supposes as each element in the picture has same spectral reflectance factor, it is impossible to take structure and condition of vegetations for it. In this paper, method of vegetation spectrum measurement using multi spectrum camera is described.

Fig.1 Multi spectrum camera (MS3100)

Table.1 Wavelength and correspondence colour

Channel	Wavelength (colour)
Channel-1	785 – 855 (NIR)
Channel-2	640 – 680 (Red)
Channel-3	550 – 590 (Green)

Multi-band images taken from multi spectrum camera are able to solve these problems. The spectrum data which are taken from the camera is only digital counts which are taken from CCD. These digital counts must be transformed into reflectance factor. When they are transformed, there are some problems.

- On ground truth measurement, Brightness changes during observation by sun position.
- CCD and camera lens has some errors.

In this study, these problems are solved.

2. Objective

- Development of the method for finding reflectance factor which is not able to be measured by the camera
- Correction of camera lens and CCD errors
- Development of the method for acquiring effective spectrum data information taken by the camera at ground truth

3. Calculation of reflectance factor

Our study group uses a spectrometer which has 2 ports (sample port, and reference port). In generally observations, the spectrometer is taken synchronous sample and reference from the ports. If brightness is changed by moving sun position, the spectrometer enables us to be taken reflectance factor by this synchronized observe. Reflectance factor is obtained using them by next equation.

$$R = s / r \quad (1)$$

Where R is reflectance factor, s is sample value, r is reference value.(s and r don't include dark current offset)

However, it is impossible to acquire from multi spectral camera which has only one lens. That is to say, only this camera can't be taken reflectance factor in being changed brightness by san position.

Therefore we have proposed a method as follows. In this method, general spectrometer is used for taking the white reference. During the measurement of vegetation target using multi spectral camera, white reference is continuously measured by general spectrometer. Firstly a white reference is taken from synchronous a spectrometer and the camera, and ratio of theirs values are calculated. The ratio is correcting coefficient between value of the spectrometer and the camera. It is shown by below equation.

$$k = r_s / r_c \qquad (2)$$

Where k is correcting coefficient, r_s is reference value of the spectrometer, r_c is reference value of the camera.

Secondly the spectrometer is continued to take reference while the multi spectral camera is taken sample, ratio of sample values of the camera and reference of the spectrometer calculated. After observation, reflectance factor is acquired from multiplying the ratio and correcting coefficient. Below equation is calculation by this method.

$$R = k * s_c / r_s' \qquad (3)$$

s_c is sample value of the camera, r_s' is reference value of the spectrometer at the time of the camera taken sample.

This method enables us to acquire reflectance factor from multi spectrum camera in being changed brightness by san position.

4. Correction of errors

Even if white reference is taken as an image from multi spectral camera, values of each pixels in the image isn't constant. The reason is camera lens and CCD of the camera has some error. Especially, limb darkening, sensitivity difference of individual CCD element, and random noise on CCD is seriously problem at the time of observation. In this study, these problems are solved. To begin by stating conclusion, to use the method which is discussed in previous chapter solve some problem. In this chapter, method for correcting these errors is discussed.

1) Limb darkening

Generally lens system has limb darkening. This effect is that fringes of image are darker than center. In ideal lens system, it is known that defuse ratio of brightness closely resemble $\cos^4\theta$. In this way, if even intensity of light enters into ideal lens system and output value of center (incidence angle is 0) is A, output value of a point where incidence angle is θ is A $\cos^4\theta$. Now, to discuss simply, sample and reference value is supposed to individual constant value and reflectance factor is found using Eq.(1). That is shown by below equation.

$$R = s' \cos^4\theta / r' \cos^4\theta = s' / r' \qquad (4)$$

Where s' is sample value on a point, r' is reference value on a point.

From this, Limb darkening of lens isn't effective by division.

2) Sensitivity difference of individual CCD element

Each elements of CCD have independent sensitivity. There are even outputs in the image ever if CCD elements aren't acquired incidence ray; this is noise of dark current. By the way, output of CCD is in proportion to quantity of incidence ray. Actuary, CCD output is conformed in proportion to quantity of incidence ray. From these, Opto-electric conversion curve of CCD element closely resemble next equation.

$$i = \gamma E + n \qquad (5)$$

where i is output value, γ is Opto-electric conversion coefficient, E is quantity of incidence ray, n is value of dark current.

From Eq.(1) and (5), reflectance factor is found using output subtracted with dark current. It is below equation.

$$R = s / r = (i_s - n) / (i_r - n) = \gamma E_s / \gamma E_r = E_s / E_r \qquad (6)$$

Namely, sensitivity difference of individual CCD element isn't also affected finding reflectance factor by division in the equation.

3) Random noise of CCD

In addition to noise of dark current, CCD has random noise. This noise doesn't rely on sensitivity difference of

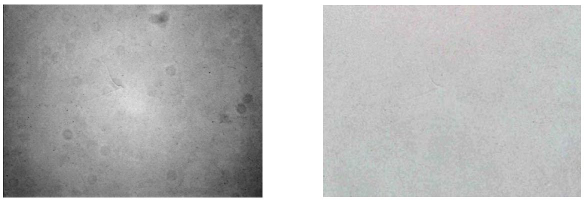

Fig.2 Comparison of result of finding reflectance factor

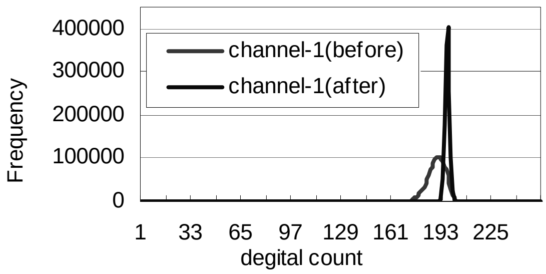

Fig.3 Comparison of histogram between before finding reflectance factor and after

individual CCD element, and it is very high frequency noise. From the characteristic, median filtering processing is used for noise reduced.

4) Result of these correcting

Correcting result shown in Fig.2. And Fig.3 is shown changing histogram of channel-1.From these, error and dispersion of histogram became reduce; it has been possible to correct.

5. Experiment

For checking of these methods, some sample was taken by the camera and a spectrometer. Samples were made like Fig.4 Data of the camera and data of the spectrometer are compared about these samples. Fig.5 is image of sample which is taken from each cannel of the camera. Fig.6 is NDVI image which is made from channel-1 (NIR) and channel-2 (RED). NDVI image is calculated from below equation.

$$NDVI = NIR - RED / NIR + RED \qquad (7)$$

From Fig.6, NDVI values of vegetation are higher than other part. Fig.7 is comparative value of the camera and the spectrometer, yet value of camera is average of all of pixel in image. In Fig.7, there are some errors. These errors generated from difference of their filed of view and filter response function of the camera approximated with rectangle.

6. Conclusion

In this paper, below item was discribed.

-Errors of Lens and CCD were corrected, and method of calculation of reflectance factor in changing brightness was proposed.

- From experience, correction of Image of reflectance factor from camera and reflectance factor from spectrometer was shown

- Each pixel in Image which have reflectance factor show structure, condition of vegetations, and element.

Hereafter, the method will be used checking BRF information of vegetation with other observation.

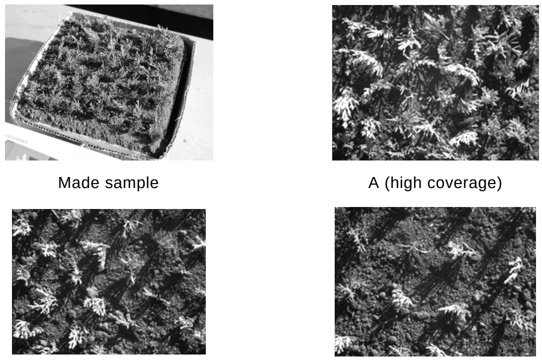

Fig.4 Made and taken samples

Fig.5 Taken sample by each channel about sample A

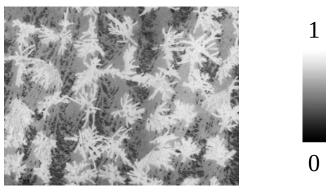

Fig.6 NDVI image of sample A

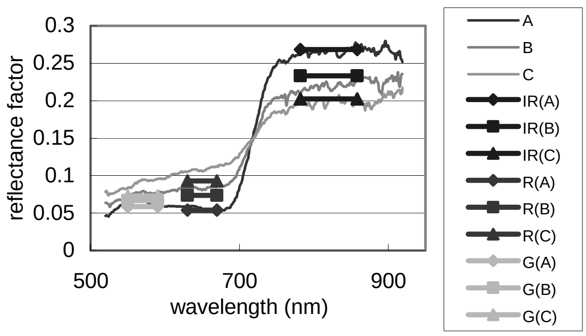

Fig.7 Comparative the camera and the spectrometer (Value of camera is average of all of pixel in image)