Analysis of reflectance panel with different altitude, orientation, sensor angle and weather condition

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***Abstract*—Radiometric sensor response of a commercial low budget UAV is important for spectral information obtainment.In case of agriculture field the crop growth analysis are highly relied on the capability of sensor to capture the spectral information.Calibration method is necessary to obtain the maximum potential image from the sensor.This study is based on the finding does the change in height,orientation of sensor,sensor viewing angle,Different weather condition does it anyhow changes the minimum and maximum that is obtained in 8bit image which ranges from 0 to 255 value.The height play's key role in change of digital number which is evident by this study.**

Keywords: Digital Number, sensor, UAV, camera calibration.

I. Introduction

The evolution and application of the UAV(Unmanned aerial vehicle) has been rapidly increasing over all domain.In which agriculture an important domain that needs a lot of technological implementation to increase the productivity and also reduce the work force which is the main advantage for farmers. The UAV is used to capture high resolution images of a particular part of the field which is data rich that helps to study a lot of things about the field and also about the plant.

With help of artificial intelligence the drones are intelligent to fly through the mission which is easy for the farmer to operate according to the needs. There are different varieties of drone in the market such as multirotor, fixed wing, single rotor which are used diversely over different applications. The drones which are used for UAV applications[1] are fitted with camera sensors like multispectral, thermal, RGB and LIDAR. With the images that are captured from different sensors they are used to analyse some indexes like NDVI(Normalised difference vegetation index),NDGI(Normalised Difference vegetation index) etc[1][2].

In this experiment we use consumer drones and this study tells about the ability of the drone how much they can help for precision farming[2]. work is based on how to calibrate the camera sensor and to tell that the commercial drone images can help for analysis. In high-end drones they will have two or more cameras built in the drone for different uses like for getting multi spectral images and also for other processes.

II. Related Works

UAV camera are capable of capturing high resolution images that may be used for analysis the application of UAV is widely spreading over many area which it makes impossible task possible in optimized way.To use the drone camera to maximum potential it need's calibration to be done before the capturing of images.To get closely same level of image for all over the mission it's important to calibrate the sensor.In high end drone the calibration process is developed by the manufacturer itself with the high quality calibration panel.The high end panel are special proprietary panel that are used for calibration of camera sensor[4].

[3]This article is aimed at developing the calibration model for UAV based NIR and visible camera. They have conducted the twelve different flight with different altitude and illuminating condition. Experiment were conducted only on sunny condition not in cloudy condition. It cover all the season (summer,winter,autumn,spring) at midday and flight altitude were around 100, 200, 400, 700 and 1000m.They used six tarpaulins of different shade (red, green, blue, yellow, dark grey, light grey). To get the ground truth they had laboratory setup and for the reflectance panel they used proprietary panel by labsphere and collected with Fieldspec 3 Jr. spectrometer. Two identical camera made by Fujifilm S200EXR without the NIR filter that can capture both visible and NIR image. The accuracy of the generated model is accessed by RMSE By using the DN's before calibration and after calibration of each calibration target of each spectral band among all flight conditions compared through coefficient on variation and check the ability in reduction of variation with respect to flight altitude and flight condition. validation of generated model is performed by correlation between predicted and actual reflectance measured in the field. The Digital number from UAV showed average variation from 14 to 17For visible band model were developed with R^2 0.94 to 0.97 for red band, 0.98 to 0.99 for green and 0.94 to 0.98 for blue band. [5]They used different flight altitude, Flight condition With linear regression method for calibrating images acquired from particular camera (Mini MCA 6 sensor). Images are captured in Different flight altitude , Different weather condition. They were able to achieve result for 6 band like R^2 0.95,0.93,0.95,0.97,1.0,1.0. Some of cost effective method for calibration by using low cost panel were used for the calibration [6] With help of ethylene - vinyl acetate (EVA) grayscale reflectance panel is it sufficient for calibrating small UAV. Conducted on three different illumination conditions with comparing the commercial panel and low cost panel.Altitude : 30 m ,Month : November,Climate condition: Clear, Clear, Cloudy.They mainly focused on comparing the difference and how well the low grade drone work comparatively to the high end drone.

III. Dataset Description

In our work the dataset was collected from low cost commercial UAV - Dji Spark and the images are taken at four different height ranging from 5m to 20m which were taken in two different flight condition sunny and cloudy condition,And there are two different image captured in single height which are set with Auto ,preset white balance.For this mission the 21 panel are placed in huge 'x' form with different pattern.sample image is shown as follows:

Fig. 1: Example image which is taken at 20m with two different whitebalance setting and facing north direction in sunny condition

IV. Methodology

A. Panel material

Material for panel is very important for our study as per the role of the panel it should work by giving minimum and maximum value which are 0 and 255 that represent black and white respectively.Material for the first experiment was conducted using Black and white chart paper which was easily available in the market. The images were taken with phone camera and processed with Fiji software to check the R, G, B value how the chart paper performs for the next step. Then the experiment was conducted with drone by placing the chart in center of the rooftop and each images are taken by varying different height level by setting min and max altitude of 2m to 20m (6.5ft to 65ft). But the result was not promising with the black panel material which showed there is about (74 values) missing over the black panel which digitally 8 bit black should be 0 and white to be 255. So this was the first struggle faced over the first experiment and also by varying altitude the black value was significantly not to the level of expectation. By this experiment the white panel did it's job very well by giving value about 255 over all height.And the white chart is fixed for the white panel. Then also this experiment was conducted at the midday around 1pm which gives an another open question on the position of the sun. On with experiment 2 fabric material was replaced for black panel for this i have used the black quilt which gave comparatively better with reference [7].

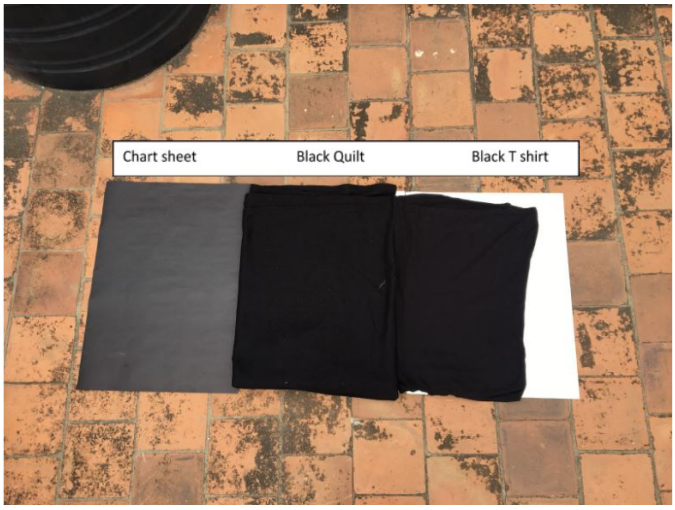

Fig. 2: Material selection

TABLE I: Black panel material and mean value)

Material	R	G	B
Chart Paper	81.920	80.397	81.045
Quilt	27.048	24.629	26.295
T-shirt	31.471	26.915	30.118
Black towel	**28.217**	**27.870**	**30.126**

From above tabulation we can see that fabric material works well in this quilt performs better than other material but chosen the black towel because their price in market quilt is costlier than towel.

B. Data-collection processes

After the material selection the panel are placed in open field without any interference in the surrounding.Then each panel is placed with different pattern as shown in figure[1].Then the UAV are placed at four different height form 5m to 2m with increase in interval of 5m.Then at each different height the photo are taken in four different direction at particular height with two different setting such as Auto white-balance and preset such as Sunny or cloudy.Then two different mission were taken at two different flight condition such as sunny and cloudy condition.So each height will have 8 different images with different direction, Flight condition, angle, white-balance.

V. Experimental Results

As per our objective we have to find does any of the factor such as Drone orientation, Height, Direction, Angle, White balance setting, Flight condition play's major role in obtaining Digital number from the sensor. So the basic idea is to follow a calibration method that might be used for particular type of camera sensor during the missionary flight at different environment which comprise all the varying factor's mentioned above. The reference have worked on with the height, condition but they all used high cost drone but they didn't work on with other factor that is implemented in this work. The panel are numbered and kept constant all over the experiment for the identification With the [4] the mean value

of panel 11 which is used for the first level of analysis which show's whether the digital number vary with respect to the change in altitude.The value are plotted for the three mode and tried to fit the regression line to see how well you can be able to predict the value.The graph is shown as follows.

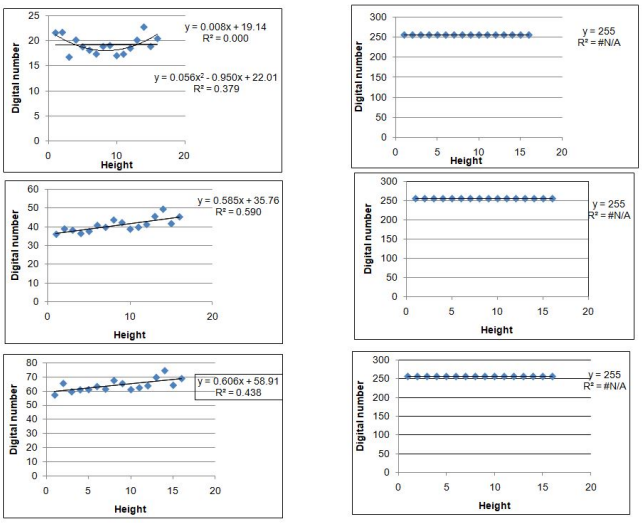

Fig. 3: Sunny condition, Auto white balance, panel11

In the above figure 3. it shows that maximum value does it job well and the panel is working good.But in case of black the red shows some draft and increase but with polynomial fitting with order 2 it was able to achieve $R^2 0.379$ for red band but for all other band it fits with linear trend which were $R^2 0.59$ and $R^2 0.438$ the white is flat where $R^2 0$

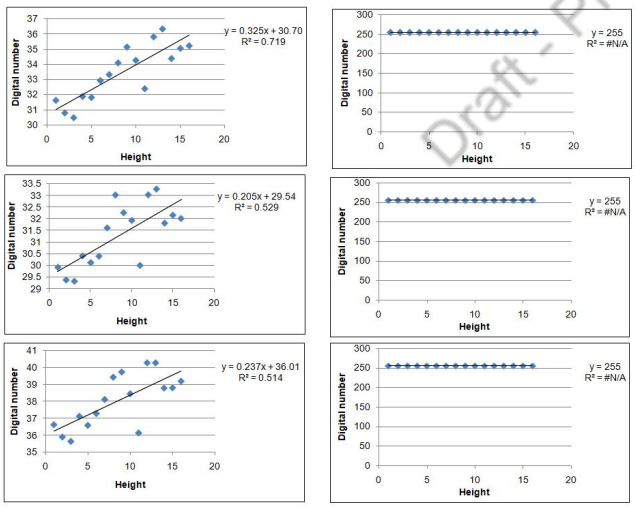

Fig. 4: Sunny condition, Sunny preset white balance setting, panel11

By this figure 4. it shows that now Red value is not drafting as seen in figure 3.In this Red value fits the linear regression model which is significantly better with the preset white balance and achieved $R^2 0.719$, $R^2 0.529$, $R^2 0.514$ respectively R,G,B, here white is same as previous case.

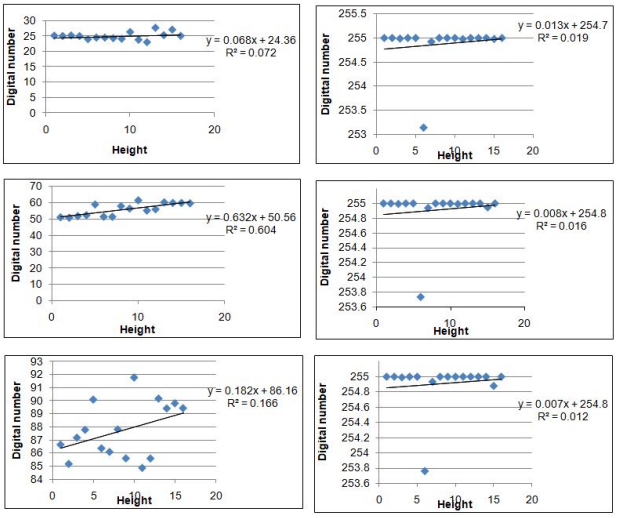

Fig. 5: Cloudy condition, Auto preset white balance setting, panel11

Above result are taken entirely different day which was cloudy in condition and the plot shows the value are not increasing with increase in altitude for Red band, Green stay's at range of 50-70 and in case of blue it is clearly showing some scatter and gives with respective $R^2 value$.Also in this maximum panel have some draft of single value at altitude around initially.

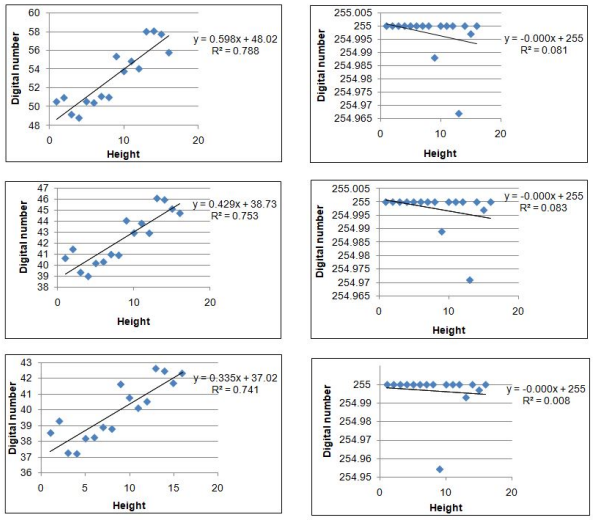

Fig. 6: Cloudy condition, cloudy preset white balance setting, panel11

Same data is captured with cloudy preset auto balance which shows there is linear way of increase with respect to varying altitude for three band in case of white it shows trend is weakly fitted and R^2 value are shown respectively.

VI. Discussion

These method were identified after 4 experiment which starts from material selection to first level analysis there are some limitation in these kind of commercial drone where battery drain is one of the considerable limitation where drain in battery may leads to capture data in different condition so there may be entirely new environmental condition in intermediate time for the next capture.

VII. Conclusion and Future work

UAV are the future tool to optimize the work flow in different application especially in agriculture for precision farming.The initial analysis of this study shows that there is significant effect with respect to digital number by varying the altitude of the drone and there are some noticeable draft in the plot which may be caused by environmental disturbance which creates a new open question why Red band faces draft. The analysis also only made with single panel that is center panel which there are still 20 other panel to analyse to see that whether any factor such as UAV direction, Sensor angle, Height, White balance setting,Flight condition affect the Digital number obtained by the camera sensor.After finding the optimal method to fly this particular drone moving on to the future work to find optimal number of images required to create a Mosaic with best calibrated input image with best minimal and maximum value.

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