THE STUDY ON THE METHODS TO CALIBRATE DRONE AND SATELLITE DATA FOR DISASTER MANAGEMENT

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ABSTRACT: In the event of a large-scale disaster, drones and satellite data are effective tools for understanding the extent of damage over a wide area, and it is very important to use them in an integrated manner. However, due to differences in observation wavelength bands and the influence of the atmosphere, images from drones and satellites may look different even if they were observed on the same date and time, so data calibration is necessary for integrated use. Conventional calibration methods require data that were taken by drone and satellite on the same day and time, but it is difficult to collect a sufficient amount of data. In this research, we attempted to calibrate data from DJI's P4 Multispectral drone and Planet Lab's optical PlanetScope satellites which were acquired between August 2020 and November 2021. Multiple boards with varying colors were used as the ground control point, the reflectance data of these 12 color boards were measured by spectroradiometer and drone on the same day. The correlation coefficients were found using both of these data and were applied for the calibration of drone data. On the other hand, for satellite data calibration, we used the time-series data of grasslands and soil in the research area, captured by the drone and satellite at different dates and times. By approximating the curves from the satellite time series data, we calculated the satellite data corresponding to the drone's acquisition date. This approach enabled us to calibrate the satellite data in a similar manner as the drone data. The results were promising, as 242 out of 421 drone data (57.5%) for multispectral drone data calibration and 150 out of 243 satellite data (61.7%) for optical satellite data calibration showed good effectiveness. These findings could contribute in making training data sets for deep learning or machine learning algorithms facilitating integrated utilization of multispectral drone and optical satellite data for disaster management scenarios.

1. INTRODUCTION

Satellite and drone data are one of effective observation tools to quickly understand the extent of damages caused by large-scale natural disasters. The single satellite can observe wide-area over the damaged area with one observation, and satellite constellation can frequently provide disaster information. The drone can acquire very high-resolution images, and these are very useful for understanding detailed damaged situation. It is very important to use them in an integrated manner.

However, due to differences in observation wavelength bands and the influence of the atmosphere, images from drones and satellites may look different even if they were observed on the same date and time, so data calibration is necessary for integrated utilization. Conventional calibration methods require data that were taken by drone and satellite on the same day and time, however it is difficult to collect a sufficient amount of data.

From that background, we attempted to calibrate data from DJI's P4 Multispectral drone and Planet Lab's optical PlanetScope satellites which were acquired on the different day between August 2020 and November 2021 in this study.

2. MATERIALS AND METHODOLOGY

Figure 1 shows the data processing flow from data collecting to accuracy assessment for the calibration of drone data and satellite data.

2.1 Data Collecting

The data from DJI's P4 Multispectral drone, Planet Lab's optical PlanetScope satellites and ASD's HandHeld2 spectroradiometer which were acquired between August 2020 and November 2021. The field surveys such a drone flights and spectrum measurements in order to collect the reflectance data were carried out once a month. The reflectance data from multiple boards with 12 colors and ground surface such as vegetation and bare land area were measured using spectroradiometer and drone, and each measurement locations also were located and recorded as reference points in the drone and satellite images by using GNSS logger. In total, the 16 times flights data by drone and 759 locations data by spectroradiometer were acquired, and these data were used for drone data calibration and satellite data calibration. Table 1 shows the used data list in this study.

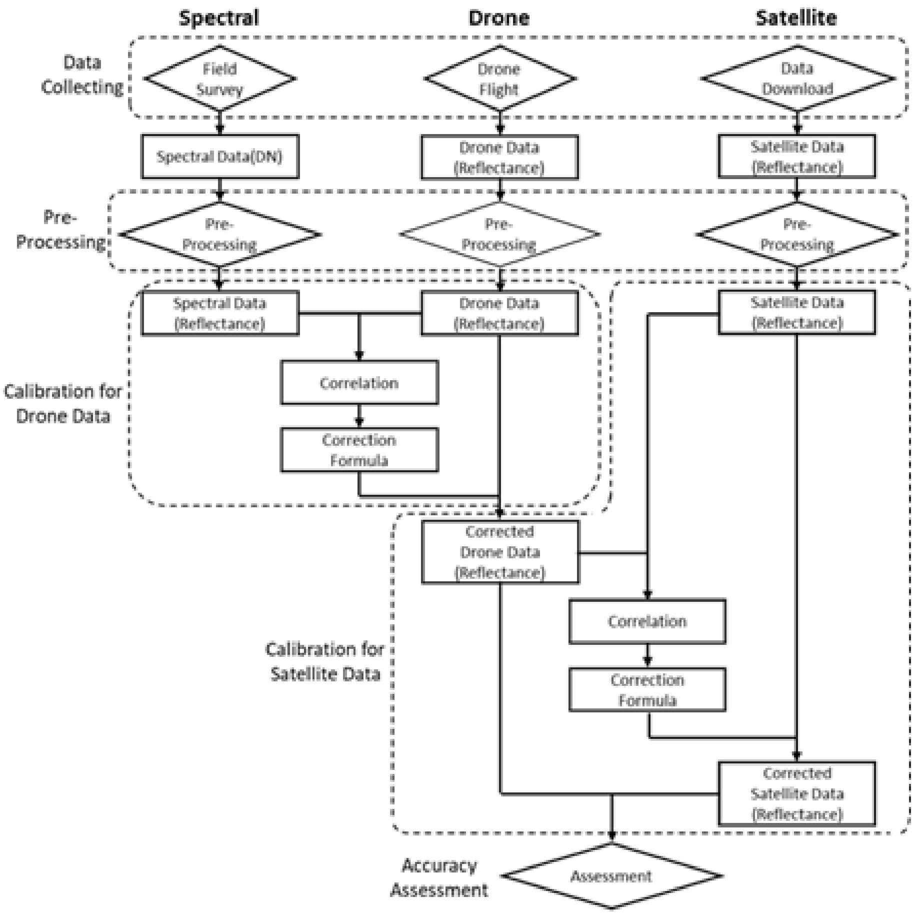

Figure 1. The Flowchart of Cross-Calibration for Drone Data and Satellite Data

Table 1. The Used Data List of Cross-Calibration for Drone Data and Satellite Data

Data	Acquired Date
PlanetScope	9/8, 10/14, 11/19 in 2020 1/20, 2/10, 3/15, 4/21, 5/28, 7/29, 9/24, 11/7, 11/19, 11/28, 12/9 in 2021.
P4 Multispectral	8/24, 9/23, 10/13, 10/28, 11/17, 11/27, 12/7 in 2020. 1/19, 2/10, 2/25, 3/17, 4/21, 5/28, 6/24, 7/29, 8/31 in 2021.
HandHeld2	8/24, 9/23, 10/13, 10/28, 11/17, 11/27, 12/7 in 2020. 1/19, 2/10, 2/25, 3/17, 4/21, 5/28, 6/24, 7/29, 8/31 in 2021.

2.2 Pre-Processing

The digital number of spectroradiometer data, drone data and satellite data were converted to reflectance by using View Spec Pro, Pix4D Mapper and original program developed by authors, and ortho mosaic images also were produced from drone data.

2.3 Calibration for Drone Data

The drone data were calibrated based on spectroradiometer data. The regression lines of each band were acquired by comparison of reflectance between spectroradiometer data and drone data that were measured color boards. Then, the drone data were calibrated based on the equation of them.

2.4 Calibration for Satellite Data

The satellite data were calibrated based on calibrated drone data. First, the resolution of drone data was resized to 3.7 [m/pixel] same as satellite data. Next, the Normalized Difference Vegetation Index (NDVI) were calculated by calibrated drone data and satellite data. Then, the three-dimensional regression curve were acquired by the NDVI time-series data at each measurement locations, and satellite NDVI data on the same day as drone observation date were calculated based on the equation of them. Finally, the regression line was acquired by comparison of NDVI between calibrated drone data and satellite data, the satellite data were calibrated based on the equation of it.

2.5 Accuracy Assessment

The calibration results were assessed based on the number of data, that were decreased the differences of value between base data and calibrated data.

3. RESULTS AND DISCUSSIONS

3.1 Calibration for Drone Data

Equation 1 shows the reflectance correlations between spectroradiometer data and drone data, that was acquired by 158 data used for drone data calibration.

$$Ref_{CaliD} = 0.9336 * Ref_{OriD} + 0.0690 \tag{1}$$

where Ref_{CaliD} = calibrated drone reflectance [-]
Ref_{OriD} = original drone reflectance [-]

Figure 2 shows the comparison of NIR band reflectance between spectroradiometer data and drone data, the left figure shows before calibration and the right figure shows after calibration. This calibration allowed the differences of reflectance between spectroradiometer data and drone data to be decreased, as 242 out of 421 drone data (57.5%) for multispectral drone data calibration showed good effectiveness.

Table 2 shows the calibration results for all bands data. With blue band, red band and rededge band, these calibrations couldn't shows good effectiveness. Because these issues were caused by the differences of reflectance between color boards data used for acquiring the calibration equation and ground surface used for assessing the calibration results. Figure 3 shows the comparison of reflectance between spectroradiometer data and drone data that used for calibration and validation. The color boards reflectance data used for calibration shows a value between 0 to 0.7, on the other hand, the ground surface reflectance data used for validation shows a value between 0 to 0.4, so the color boards reflectance value range is wider. As a result of revalidations that used only over 0.4 reflectance value data, the approximately 70 % data showed good effectiveness for blue band, red band and rededge band data calibration.

From these results, the calibration accuracy should be considered using additional data sets that shows high reflectance value as a future task.

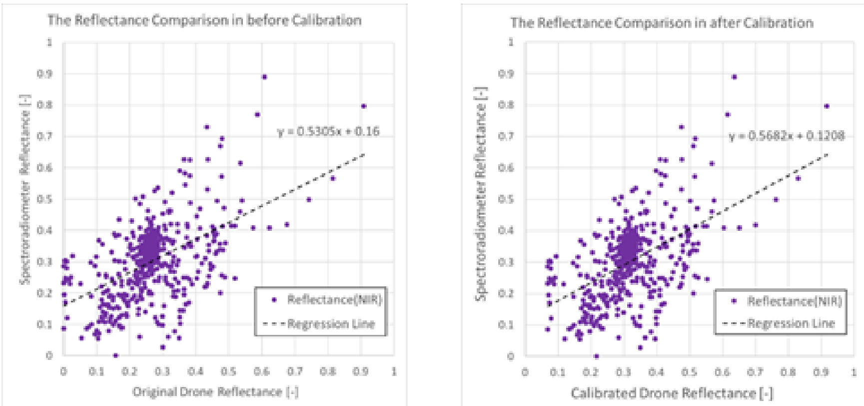

Figure 2. The Comparison of Reflectance between Before and After Calibration

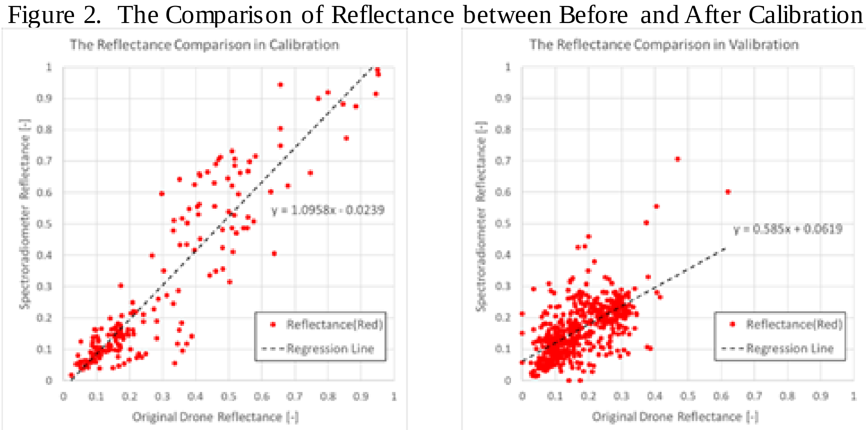

Figure 3. The Comparison of Reflectance between for the Calibration and for the Validation

3.2 Calibration for Satellite Data

Equation 2 shows the NDVI correlations between calibrated drone data and satellite data, that was acquired by 413 data used for satellite data calibration.

$$NDVI_{CaliS} = 1.0035 * NDVI_{OriS} - 0.0370 \quad (2)$$

where $NDVI_{CaliS}$ = calibrated satellite NDVI [-]
$NDVI_{OriS}$ = original satellite NDVI [-]

Figure 4 shows the NDVI time series comparison of calibrated drone data and satellite data between before and after calibration, and the dashed lines are three-dimensional regression lines, green means calibrated drone data, blue means original satellite data and red means calibrated satellite data. This calibration allowed the differences of NDVI between calibrated drone data and satellite data to be decreased, as 150 out of 243 drone data (61.7%) for optical satellite data calibration showed good effectiveness.

Figure 5 shows the comparison of calibrated drone NDVI image and satellite NDVI images between before and after calibration. This calibration allowed the appearance of satellite NDVI image to be similar to calibrated drone NDVI image, and showed good effectiveness for the cross-calibration between multispectral drone data and optical satellite data.

From these results, this study method could contribute in making training data sets for deep learning and also machine learning algorithms facilitating integrated utilization of multispectral drone and optical satellite data for disaster management scenarios.

Table 2. The Calibration Results of Blue, Green, Red, RedEdge and NIR Band

Band	Total Number of Used Data	Number of Good Results
Blue	504	152
Green	500	285
Red	492	171
RedEdge	488	235
NIR	421	242

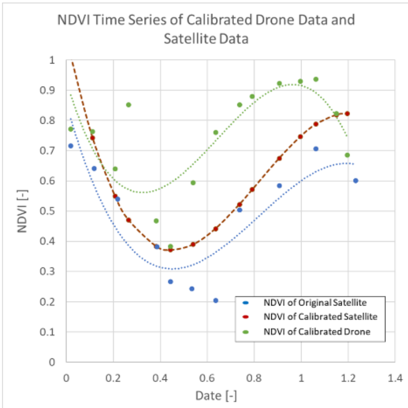

Figure 4. The Comparison of NDVI between Calibrated Drone data and Satellite Data

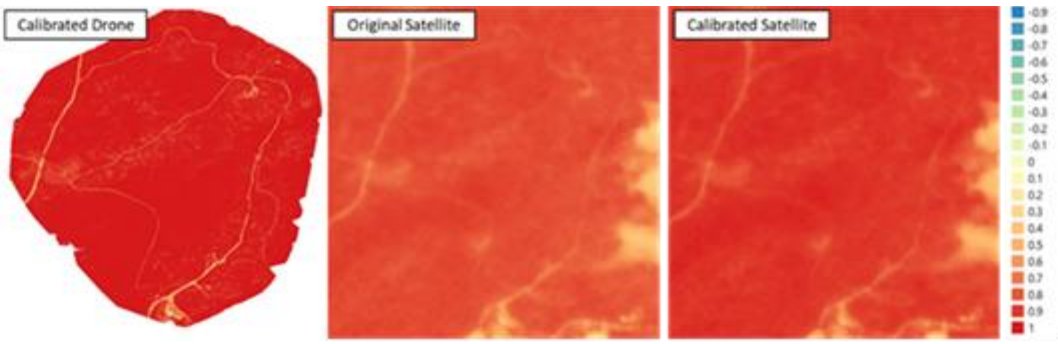

Figure 5. The NDVI Image Comparison between Before and After Calibration

4. CONCLUSION

In this study, we attempted to calibrate data from DJI's P4 Multispectral drone and Planet Lab's optical PlanetScope satellites which were acquired between August 2020 and November 2021 for integrated utilization of them. As a result, this study method showed good effectiveness as 242 out of 421 drone data (57.5%) for multispectral drone data calibration, and as 150 out of 243 satellite data (61.7%) for optical satellite data calibration. Furthermore, this method allowed the satellite NDVI image to be similar to calibrated drone NDVI image, and showed good effectiveness for the cross-calibration between multispectral drone data and optical satellite data. This study results could contribute in making training data sets for deep learning and also machine learning algorithms facilitating integrated utilization of multispectral drone and optical satellite data for disaster management scenarios.