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Airborne hyperspectral data over Chikusei

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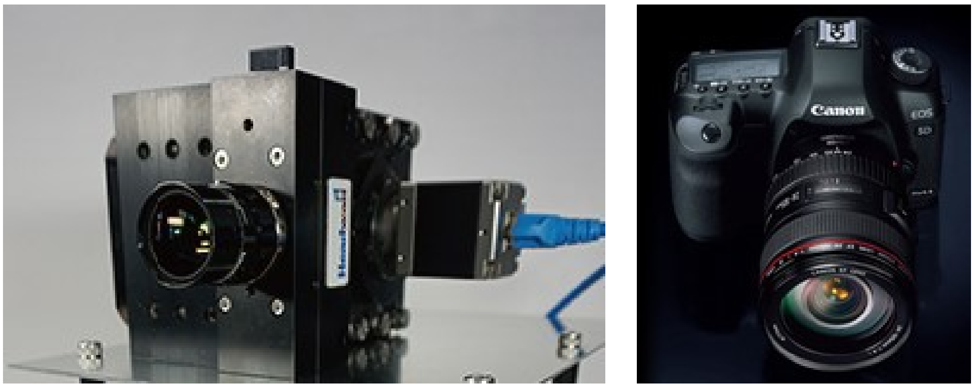
ABSTRACT

Airborne hyperspectral datasets were acquired by Hyperspec-VNIR-C (Headwall Photonics Inc.) over agricultural and urban areas in Chikusei, Ibaraki, Japan, on July 29, 2014, as one of the flight campaigns supported by KAKENHI 24360347. This technical report summarizes the experiment. The hyperspectral data and ground truth were made available to the scientific community.

1 EXPERIMENTAL SETUP

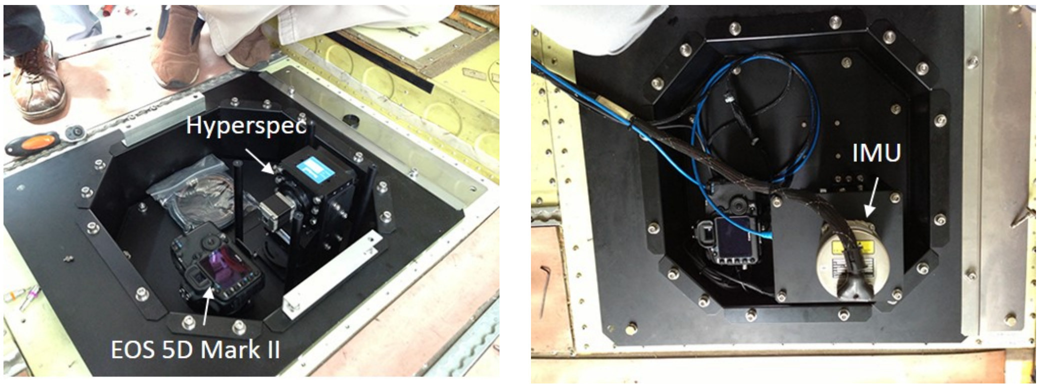
Headwall Hyperspec-VNIR-C imaging sensor and Canon EOS 5D Mark II [see Figure 1.1] were used for flight campaigns supported by a project named "Multidimensional superresolution of remote sensing data via information fusion" (KAKENHI 24360347) to obtain hyperspectral and color images from the same platform. The two sensors were mounted on the same platform together with GPS/IMU, as shown in Figure 1.2. The main specifications of the two imaging sensors are summarized in Table 1.1.

Hyperspec-VNIR-C comprises a Headwall's original spectrograph and a CCD camera of PCO pixelfly qe. The pixelfly qe detector has a size of 1024 × 1392 pixels in spectral and cross-track directions. The Hyperspec sensor covers the wavelength range from 363 nm to 1018 nm with a spectral resolution of 1.29 nm. The frame rate is originally 12 fps and can be improved to 23 fps with a w/ 2x vert. binning mode, which records each frame with a 512 × 696 pixel size. To improve an along-track GSD, we used the binning mode and set the frame rate to 23 fps. The along-track GSD is 2.66 m when a ground speed is 220 km/h. The cross-track



(a) (b)

Figure 1.1: (a) Hyperspec-VNIR-C (Headwall Photonics Inc.) and (b) EOS 5D Mark II (Canon Inc.).



(a) (b)

Figure 1.2: Layout of (a) Hyperspec-VNIR-C, EOS 5D Mark II, and (b) IMU.

GSD is 0.97 with the binning mode. In this case, the pixel aspect ration is approximately 11:4 (along-track:cross-track).

2 Data acquisition

Airborne hyperspectral datasets were taken by the Hyperspec-VNIR-C imaging sensor over agricultural and urban areas in Chikusei, Ibaraki, Japan, on July 29, 2014, between the times 9:56 to 10:53 UTC+9. The flightlines recorded by GPS are shown in Figure 2.1. There are thirteen flightlines parallel to the north-south direction and one flightline parallel to the east-west direction. The thirteen flightlines in the north-south direction were overlapped by approximately 35 % of each swath to reduce BRDF effects in the mosaic data. The average ground speed was 119 kt (220 km/h) and the average height of the sensor above ground was

Table 1.1: Specifications of Hyperspec-VNIR-C and EOS 5D Mark II with 900 m flight height and 220 km/h flight speed. $(\cdot)$ indicates specifications with binning.

Sensor	Hyperspec	EOS 5D Mark II
Size of detector	1024 × 1392	3744 × 5616
Size of pixel (μm)	6.45	6.4
Focal length (mm)	12	35
FOV (degree)	41.0	54.4
Frame rate	12 (23)	–
Cross-track GSD (m)	0.48 (0.97)	0.16
Along-track GSD (m)	5.09 (2.66)	0.16
Swath	673	924

approximately 900 m. Therefore, the along-track and cross-track GSDs were 2.66 m and 0.97 m, respectively. EOS 5D Mark II sequentially acquired high-resolution color images every 2.2 sec together with the hyperspectral data.

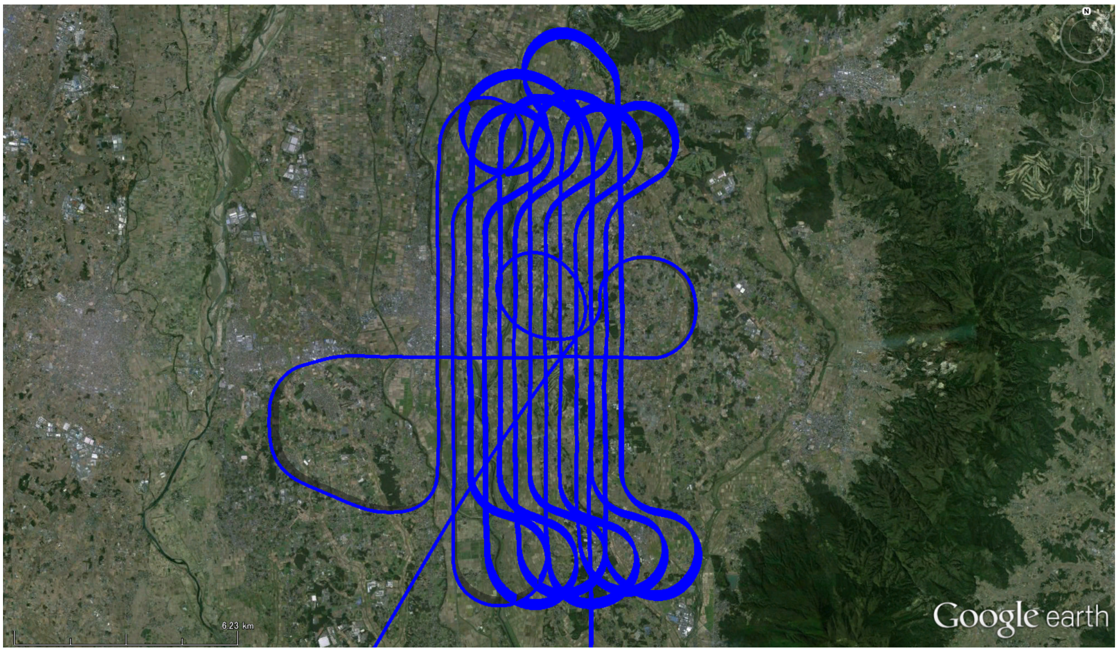


Figure 2.1: Flightlines in Google Earth.

3 Data processing

The Hyperspec sensor recorded 512 bands in 12-bit DN values. Spectral binning was performed and the number of bands was reduced to 128 to increase signal-to-noise ratios. The DN datasets were converted to reflectance by a series of data correction and mosaicked to obtain one entire image. The data correction procedure comprises radiometric correction, geometric correction, atmospheric correction, and BRDF correction. The correction procedure was performed on each flightline image.

- Radiometric correction: Gains and offset radiometric calibration coefficients were measured for 512 bands by a set of precise laboratory experiments. The at-sensor radiance datasets were retrieved from the DN datasets using the calibration parameters.
- Geometric correction: The position and orientation data of the sensor was recorded for each frame by GPS/IMU. The at-sensor radiance datasets were geometrically corrected and rectified to the UTM 54N projection with a grid of 2.5 m.
- Atmospheric correction: We used the ATCOR-4 program [1], version 6.3, for atmospheric correction. The used atmospheric type was a mid-latitude summer atmosphere with a rural aerosol model.
- BRDF correction: BRDF correction was performed by the ATCOR-4 program.

We used thirteen north-to-south flightlines to make the mosaic data. The mosaiced entire scene consists of 2517 × 2335 pixels. The central point of the scene is located at coordinates: 36.294946°N, 140.008380°E. The color composite mosaic image is shown in Figure 3.1(a). All the flightlines were mosaicked based on smoothly weighted averaging in overlapped areas so that edges of flightlines can be seamless. Finally, we applied spectral polishing to the mosaic data using the ATCOR-4 program to mitigate spectral spikes due to non-optimal atmospheric correction.

4 GROUND TRUTH DATA

Ground truth of 19 classes was collected via a field survey and visual inspection using the high-resolution color images obtained by EOS 5D Mark II. The 19 classes comprise water, three types of bare soil, seven types of vegetation, and eight types of man-made objects. The ground truth is shown in Figure 3.1(b) and the names and numbers of ground truth pixels are listed in Table 4.1. A classification map obtained by Rotation Forest [2] using the ground truth is demonstrated in Figure 3.1(c). The hyperspectral data and ground truth were made available to the scientific community in the ENVI and MATLAB formats at http://park.itc.u-tokyo.ac.jp/sal/hyperdata.

REFERENCES

[1] R. Richter and D. Schläpfer, “Atmospheric / topographic correction for airborne imager: ATCOR-4 User Guide,” DLR IB 565-02/16, Wessling, Germany, 2016.

[2] J. Xia, P. Du, X. He, and J. Chanussot, “Hyperspectral remote sensing image classification based on rotation forest,” *IEEE Geoscience and Remote Sensing Letters*, vol. 11, no. 1, pp. 239–243, 2014.

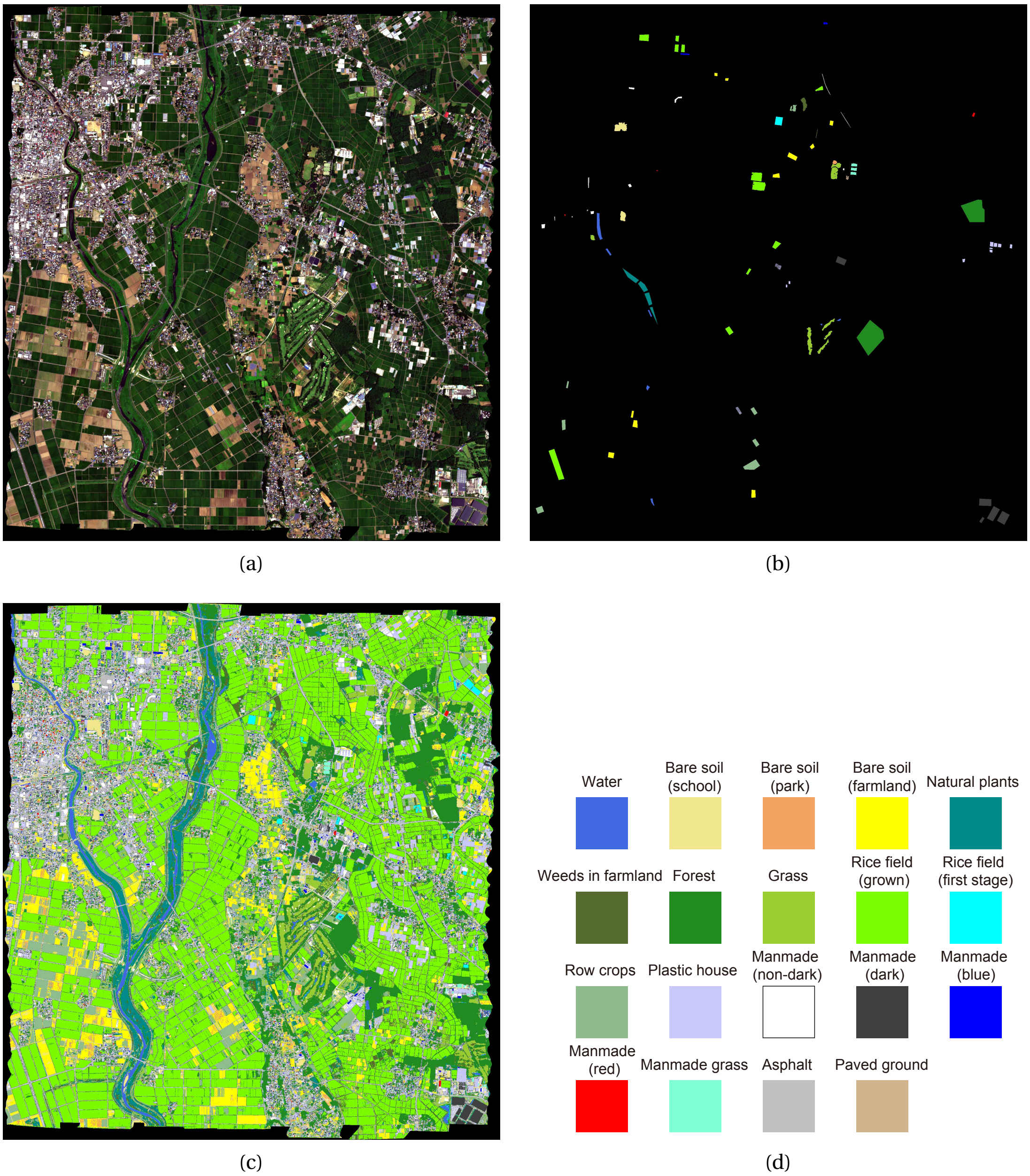


Figure 3.1: (a) Color composite image, (b) ground truth, (c) Rotation Forest classification map, and (d) legend of 19 classes.

Table 4.1: Name and number of samples in ground truth

No.	Name	Pixels
1	Water	2845
2	Bare soil (school)	2859
3	Bare soil (park)	286
4	Bare soil (farmland)	4852
5	Natural plants	4297
6	Weeds in farmland	1108
7	Forest	20516
8	Grass	6515
9	Rice field (grown)	13369
10	Rice field (first stage)	1268
11	Row crops	5961
12	Plastic house	2193
13	Manmade (non-dark)	1220
14	Manmade (dark)	7664
15	Manmade (blue)	431
16	Manmade (red)	222
17	Manmade grass	1040
18	Asphalt	801
19	Paved ground	145