Remote Sensing with Multiple Types of Photographs

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ABSTRACT: Recently, UAV (Unmanned Aerial Vehicle) technology are developed rapidly. UAV allows engineers to do remote sensing at low cost rather than satellite images or aerial photos. The expansion of business for UAV is expected. However, UAV do not enable researchers to take photos in local areas, not the global area. Then the authors covered areas without pictures by UAV using aerial photograph from aircrafts. The objectives on this study were: to identify possibilities for remote sensing with three types of photography (aerial photographs, panoramic photographs and UAV photographs) and to monitor vegetation covers. The data were processed through five main steps:(1) The authors obtained aerial photographs in research sites from Geographical Survey Institute, (2) took pictures with digital camera in 360 degrees in research sites, (3) flew UAV with two filters: IR72 and IR90 twice more in research sites, (4) constructed a 3D model in research sites with PhotoScan, and (5) analyzed vegetation covers with GIS.

1. INTRODUCTION

The modern remote sensing was developed. In 1858, Tournachon, who was a balloonist took photographs in Paris from his balloon. In World War I, aerial photograph technology was the most advanced for military purpose. In the latter half of the twentieth century, it was possible to use remote sensing all over the world with satellites. Therefore, new aeronautical technology, UAV would develop remote sensing.

Also the authors made a 3D model from UAV photogrammetry with PhotoScan, Professional. PhotoScan is a software that creates a 3D model with high resolution. In general, UAV has a wide-angle lens. A wide-angle lens makes lens distortion; however, PhotoScan corrects automatically the distortion with a correction algorithm. Moreover, PhotoScan allowed to export orthogonal photos including GPS (Global positioning system) coordinates and DEM (Digital elevation model) and also to calculate NDVI and another normalized vegetation index, NDWI.

Incidentally, the authors utilized data obtained from remote sensing as broadband data for GIS (Geographic Information System). Orthogonal photos were analyzed with ArcGIS for terrain analysis.

2. METHODS

2.1 Photographing methods with UAV

The authors utilized Phantom 4.0 Professional in this research. First, UAV was flown in the survey field. Next, a filter, IR72 was set for UAV camera was flown to calculate NDVI. The authors flew UAV with a filter. Finally, a list of bands in this study is shown in Table 1.

Table 1　List of bands

Band	Wave length(nm)	Electric Magnetic Wave
1	450-520	Blue
2	520-600	Green
3	630-690	Red
4	760-900	Near Infrared
5	900-	Short Infrared

2.2 Photograph methods with digital camera

The authors utilized digital camera: Nikon D5500 in this research. The photographs were processed through three main steps:(1) The authors locked digital camera on a tripod, (2) took a picture with no filter, and (3) used a filter, IR72 to calculate NDVI.

2.3 3D modeling with PhotoScan

The authors constructed a high-density cloud from UAV photogrammetry and GPS (Global Positioning System) coordinates with Agisoft, PhotoScan Professional. Furthermore, constructing meshes and textures made a 3D model. Also lens distortion was corrected with the correction algorithm of lens distortion in PhotoScan. In the same way, 3D models were made from aerial photographs.

2.4 Methods for orthogonal photos with PhotoScan

Orthogonal photos were made from a 3D model with Agisoft, PhotoScan Professional. Furthermore, orthogonal photos with 3D data were made by exporting in TIFF file format.

2.5 Calculation of NDVI with Photoshop

NDVI was calculated with Adobe, Photoshop CS6 by subtracting orthogonal photos in Band 3 from orthogonal photos in Band 4 at the same position. NDVI is shown as next.

$$\text{NDVI} = \frac{Band4 - Band3}{Band4 + Band3} \tag{1}$$

2.6 Methods for calculating a catchment area

Surfaces were smoothed from DEM (Digital Elevation Model) in a 3D model with ESRI, ArcGIS. Furthermore, flow direction raster and cumulative-flow-rate value raster were made from DEM (Digital Elevation Model). Finally, catchments were calculated with flow-direction raster and cumulative flow-rate-value raster with ArcGIS

2.6 Methods for detecting land-use maps.

Band 3 distributions were calculated in the survey field with PhotoScan. Band 3 distribution enabled authors to detect land-use maps because vegetation area absorbed Band 3.

3. RESULTS AND DISCUSSION

Experiments were carried out for remote sensing with UAV at a location: Onigi village in Nagasaki prefecture. The purpose of study was to make an orthogonal photo and DEM, to calculate NDVI and a catchment area, and to detect land-use maps.

3.1 Results and discussion for Onigi Village

On 30 July 2016, the aerial photos were taken with Phantom 4.0 at Onigi village, Hasami town in Nagasaki prefecture. The objectives of this field work were to make a 3D model and orthogonal photos, to estimate NDVI, to calculate catchments, and to detect land-use maps.

Fig. 1   Orthogonal images with aerial photos at Onigi village

Fig. 1 shows an orthogonal image with aerial photos at Onigi village. The orthogonal photo enabled to know a wide investigation.
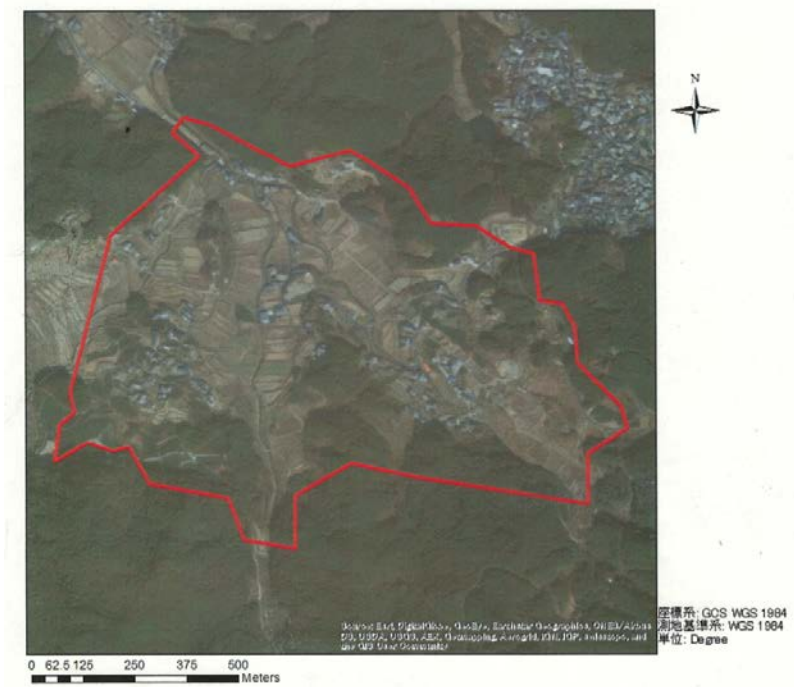

Fig. 2   An investigation place with UAV (in red line)

Fig. 2 shows an investigation place with UAV (in red line) in Onigi village. In this research, UAV was flown from two spots in one hour.
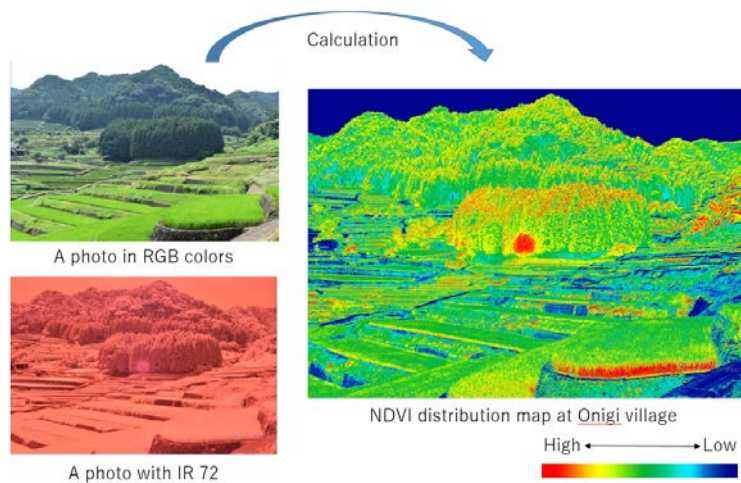
Fig. 3 NDVI at Onigi village

Fig. 3 shows NDVI distributions in Onigi Village. NDVI was equally middle in paddy fields. NDVI was low in fields and rice paddies that have been abandoned and are no longer cultivated. NDVI was middle or high in tea plantations
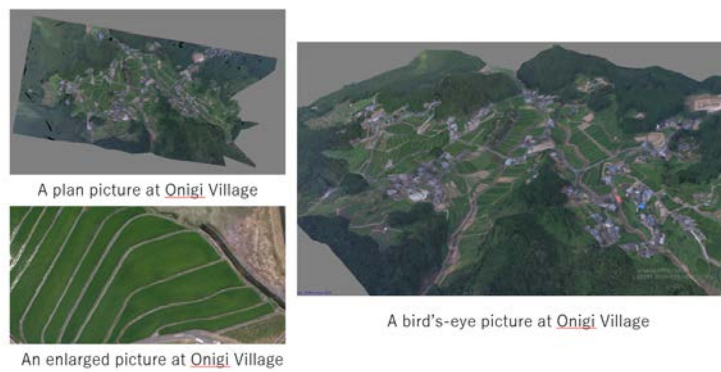
Fig. 4(a) 3D models at Onigi village
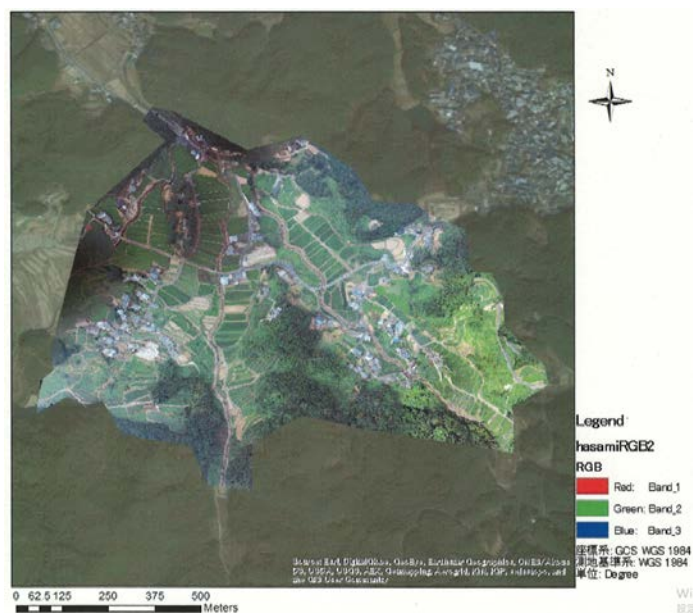
Fig. 4(b) Orthogonal map at Onigi village

Figs. 4(a) and (b) show 3D models at Onigi village and an orthogonal map at Onigi village respectively. 179 pictures were taken with UAV from 2 spots. A 3D model was made at Onigi village. The spatial resolution was 12.2 cm/pix. The cover area was 1.73 km^2. Also, pictures were taken with IR72 filter. But IR72 photos were not clear because it was cloudy. Unclear images did not enable to synthesize UAV photogrammetry and to make a 3D model with IR72.
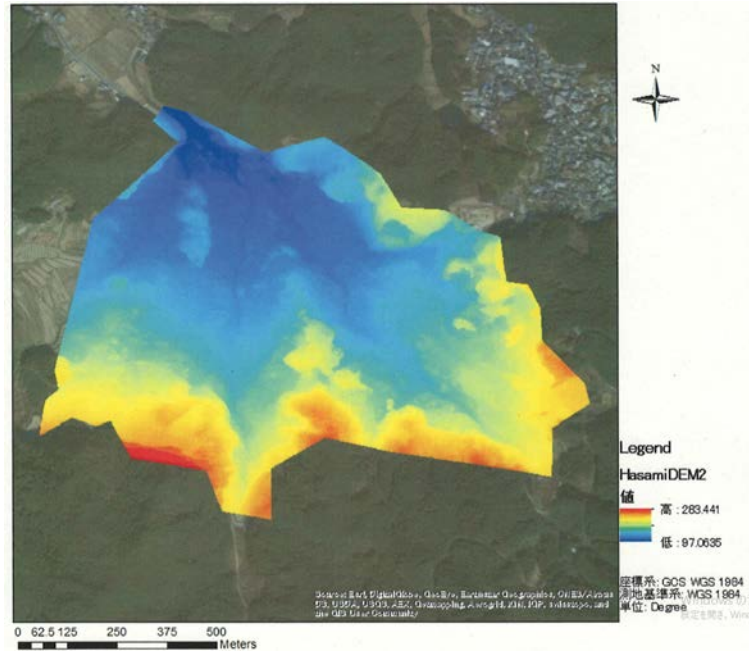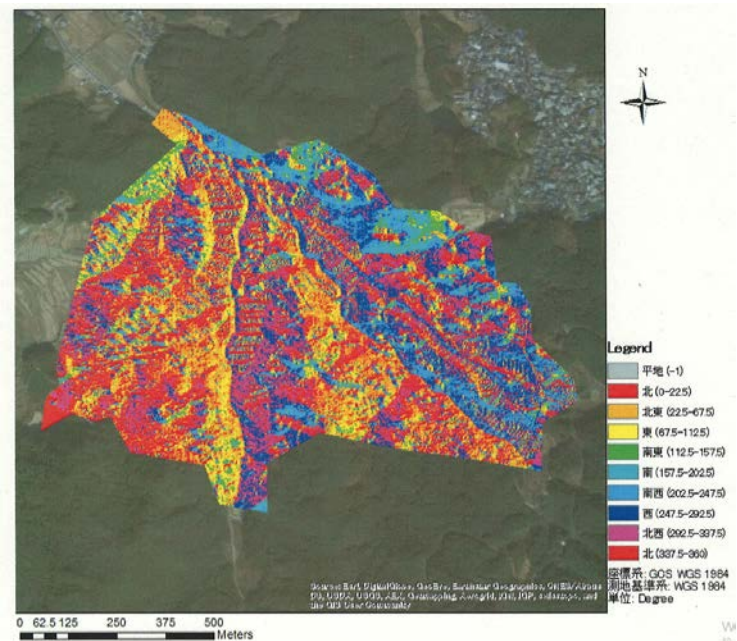

Fig. 5(a) DEM at Onigi village

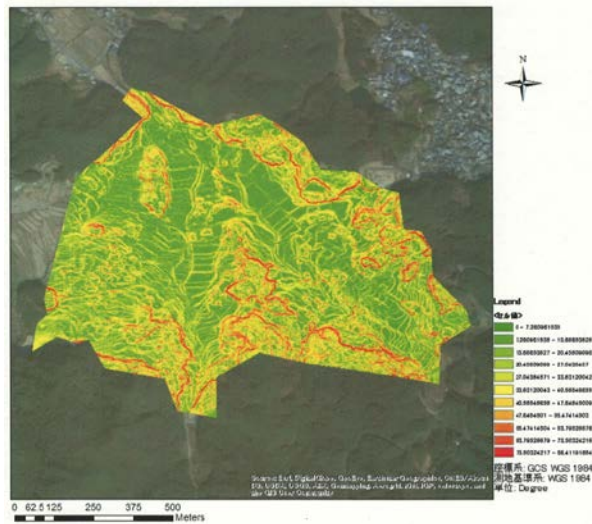Fig. 5(b) Direction of drips at Onigi village

Fig. 5(c) Angle of slope at Onigi village

Fig. 5(a) shows a DEM of Onigi village. Fig. 5(b) shows a direction of drips at Onigi village. Fig. 5(c) shows Angle of slope at Onigi village. The DEM of Onigi village has high resolutions and The DEM point density was 4.2 m^{-2}. According to Fig. 5(b), a direction of drips at west Onigi village was in a northeast direction and a direction of drips at east Onigi village was in a south direction. According to Fig. 5(c), a boundary was judged between rice fields.
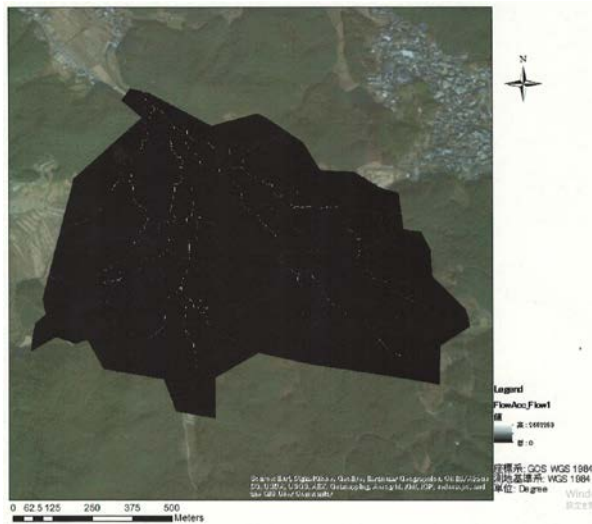

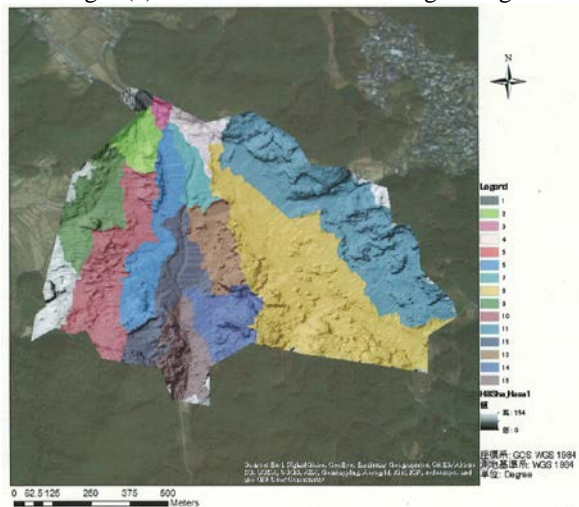Fig. 6(a) Cumulative flows at Onigi village

Fig. 6(b) Shaded-relief map and water catchment area at Onigi village

Figs. 6(a) and (b) show cumulative flows and a shaded-relief map and water catchment area in Onigi Village, respectively. Rivers were judged from cumulative flows and also cumulative flows enabled to estimate water catchment area.
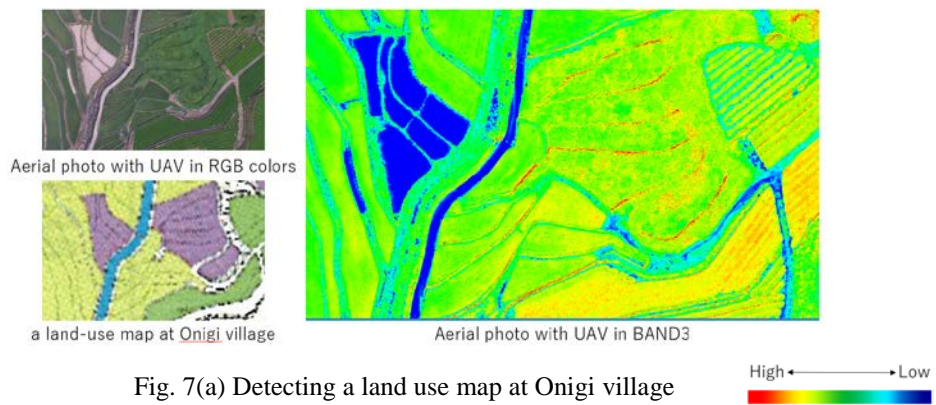

Fig. 7(a) Detecting a land use map at Onigi village
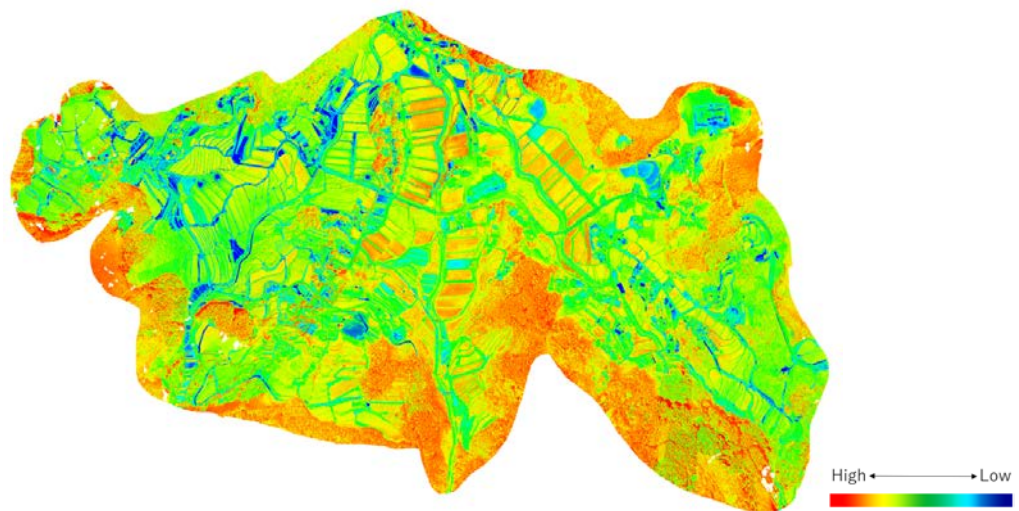

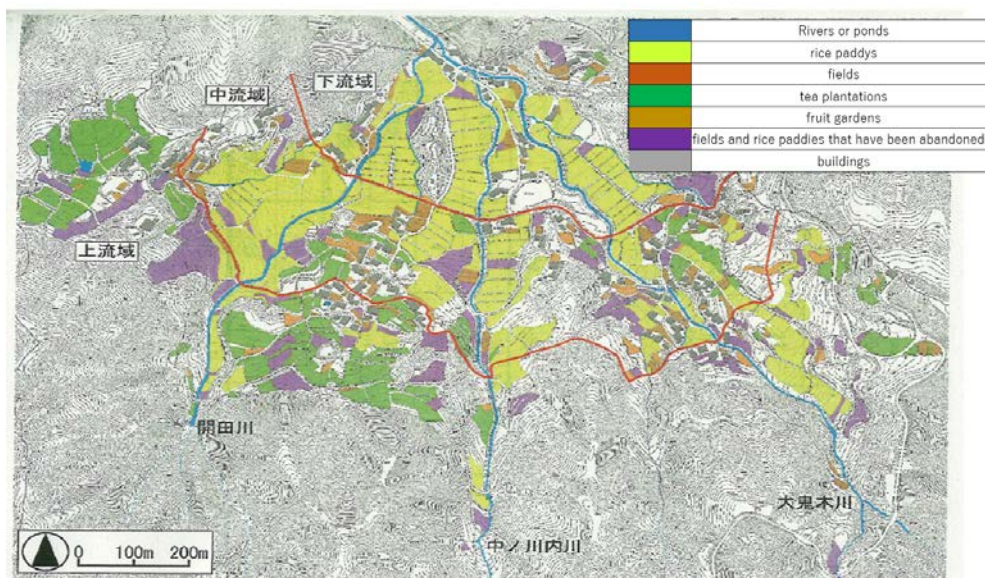Fig. 7(b) Aerial photo with UAV in BAND3 at Onigi village

Fig. 7(c) A land use map at Onigi village

Figs.7(a), (b), and (c) show detecting a land-use map, an aerial photo with UAV in BAND 3 at Onigi village, a land-use map in Onigi village. An aerial photo with UAV in BAND 3 at Onigi village enabled the authors to judge a land-use map. According to figs.7(a), (b), and (c), rice fields were green or yellow equally in BAND 3 photo, fields and rice paddies that have been abandoned and are no longer cultivated were blue or scattered green, red and yellow, and also tea plantations were red or yellow linearly.

4. CONCLUSIONS

The authors discussed contemporary states of UAV and applications for civil engineering. The objectives of this study was to construct a 3D model, to make orthogonal photos, and to calculate NDVI and water catchment areas from UAV photogrammetry. As a result, it was possible to calculate data in higher resolution than satellite data. A camera of UAV had high performance. It is effective for remote sensing with UAV in any climates except heavy rain expect wearing IR72 filter. Cloudy days did not enable to take a picture with IR 72 filter because of lack for sunlight. Additionally, the three-band photos were able to estimate a land-use map. Above all, the authors concluded that UAV would apply for many fields of civil engineering at local area.

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