THREE DIMENSIONAL VISUALIZATION OF FOREST USING FIELD MEASURED DATA, SATELLITE IMAGE AND FISH-EYE PHOTO

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Commission VIII/7

KEY WORDS: Photogrammetry, Forestry, Visualization, GIS, Three-dimensional

ABSTRACT:

Forest composed of many trees has an important role in maintaining environmental conditions suitable for life on the earth. There are many research which incorporate tree survey data into geographical information system, but those are not represented individual tree objects. A purpose of this study is to build the three dimensional forest map of individual tree level, by fusion of field measured data, satellite image, and omni-directional fish-eye photos. First, to obtain the field measured data, we have collected several kind of tree data in the test site. This area is 140 meter from west to east and 60 meter from north to south. In this site, the grid of 10 meter mesh is constructed using piles labeled alphabet and numeric characters. In this study, about 100 trees with height of 16 to 18 meter were selected in order to measure. The measured data are the tree stand locations, the eight distances between the tree trunk and outermost branches in eight directions, and the diameter at breast height. Second, we create the three dimensional forest space using OpenGL graphics library. By using the field measured data, each octagonal crown object which has the location and outermost shape of individual tree is created. The method of image-to-map rectification to identify tree crown from satellite image is performed for registration of high corresponding. The each registered region in IKONOS satellite image is rendering on the corresponding crown object. Next, using omni-directional fish-eye photos taken at the four viewpoints on the corners of the each grid, the rectangle trunk objects of four different directions are created. Finally, it became possible to visualize the three dimensional forest map of individual tree objects with attribute data. By using omni-directional fish-eye photos taken at different seasons, it is possible to show seasonal change of individual tree in forest. This system is useful for forest management and monitoring.

1 INTRODUCTION

Forest composed of many trees has an important role in maintaining environmental conditions suitable for life on the earth. Satellite remote sensing technology is the effective method for management and monitoring of forest resources.

In recent years, high spatial resolution satellites were launched, thereby it is possible to obtain detailed information about earth's surface. The IKONOS satellite image can recognize and identify an individual tree crown, it is suitable to monitor a forest covering wide-area. In order to obtain forest management inventories at the stand level, IKONOS satellite images are analyzed instead of the interpretation of aerial photographs (Gougeon and Leckie, 2006).

For sustainable forest management, there are many research which incorporate tree survey data into geographical information system (En-Mi Lim and Tsuyoshi Honjo, 2003, Kenji Omasa, Fumiki Hosoi and Atsumi Konishi, 2007), but those are not represented individual tree objects.

A purpose of this study is to build the three dimensional forest map of individual tree level, by fusion of field measured data, satellite image, and omni-directional fish-eye photos.

2 DATA SET

The Kitasaku test site of this study is located in the deciduous mixed forest of Nagano prefecture in Japan. This area is 140 meter from west to east and 60 meter from north to south. In this site, there are two flux towers to measure the exchanges of carbon dioxide between forest and atmosphere. In addition, the grid of 10 meter mesh is constructed using piles labeled alphabet and numeric characters. The illustration of the field survey in this site is shown in Figure 1.

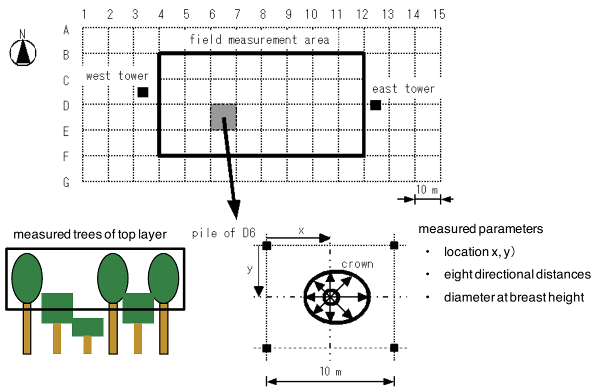

Figure 1: The illustration of test area. The grid of 10 meter mesh is constructed using piles labeled alphabet and numeric characters. There are two flux towers to measure the exchanges of carbon dioxide between forest and atmosphere. The field measurement area is 80 meter by 40 meter.

2.1 Field Measured Data

Field measurement survey was carried out on 28 Octorber 2007. 102 canopy trees with height of 16 to 18 meter were selected in

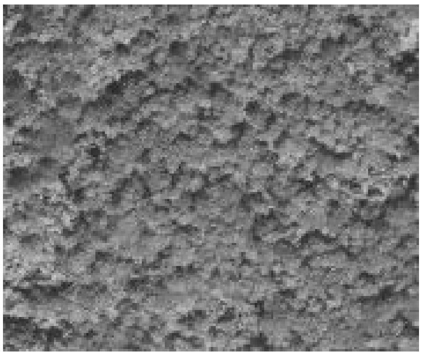

Figure 2: The IKONOS panchromatic image of the study area. This area is 180 meter by 150 meter. (C)Japan Space Imaging Co.

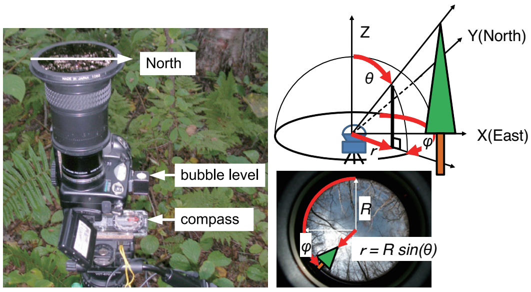

Figure 3: The fish-eye camera was mounted vertically on a tripod using the bubble level and the orientation of image was turned to North using the compass. The circular projection system of fish-eye lens is the sine function.

order to create the projected on-ground map. The relative location of the tree in this area is acquired by measuring the location in the labeled block where the tree stands. The following are the measurement parameters of each canopy tree in this survey:

(1) tree stand location (x, y) in the labeled block;

(2) distances between the tree trunk and outermost branch in eight directions (N, NE, E, SE, S, SW, W, NW);

(3) diameter at breast height.

2.2 Satellite Image

The satellite data used in this study is an IKONOS panchromatic image. The spatial resolution of analysis image is 1 meter by pixel. It can be recognized and identified an individual tree crown whose radius is more 2 or 3 meter. The image was acquired on 25 August 2003. Figure 2 shows the IKONOS image of the study area. The size of image is 180 meter by 150 meter.

2.3 Fish-eye Photo

The hemispherical photos of canopy were taken by using fish-eye camera on 4 April, 20 September 2006. The camera was mounted vertically on a tripod using the bubble level as shown in Figure. 3, and the orientation of image was turned to North using the compass. The circular projection system of fish-eye lens is the sine function. The canopy photos taken at each grid point are shown in Figure 4. The hemispherical photos of C10 canopy are shown in Figure 5. The size of image is 2240 pixel by 1680 pixel.

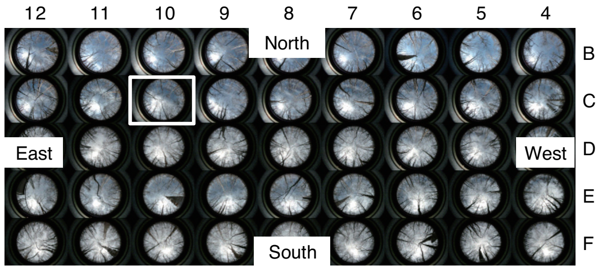

Figure 4: The canopy photos on 22 April 2006.

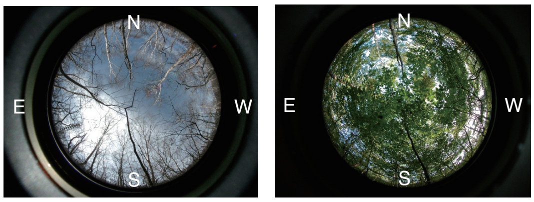

Figure 5: The hemisperical photos of C10 canopy on 22 April, 20 September 2006.)

3 METHODS

Figure 6 shows the illustration of three dimentional visualization of forest. First, using the field measured data, we create the projected map of crowns on the ground, which has the location and shape of canopy trees. Next, the method of image-to-map rectification to identify tree crown from satellite image is performed for registration of high corresponding (Kubo and Muramoto, 2008). The each registered region in IKONOS satellite image is rendering on the corresponding crown object with octagonal shape. Then, using omni-directional fish-eye photos taken at the four viewpoints on the corners of the each grid, the rectangle trunk objects of four different directions are created. Finally, it became possible to visualize the three dimensional forest map of individual tree objects with attribute data.

3.1 Crown Object

Figure 7 shows the illustration of image-to-map rectification. First, the regions of tree crown are detected from satellite image by using watershed segmentation. Then, the tree-to-tree matching algorithm is performed using the fitness value of the location and octagonal shape of both tree crowns in the satellite image and the

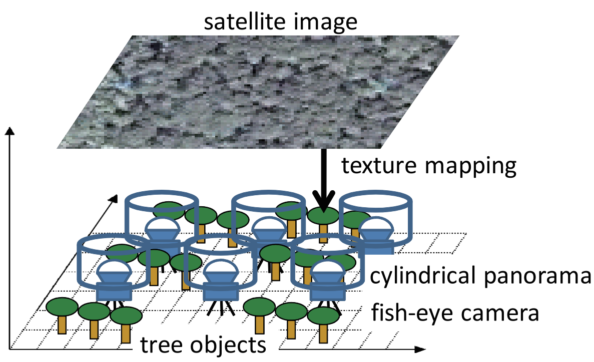

Figure 6: Three dimensional visualization of forest by fusion of field measured data, satellite image, and omni-directional fish-eye photos.

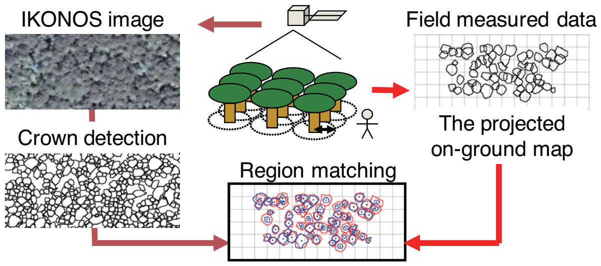

Figure 7: The illustration of image-to-map rectification. This method are detected individual crown regions from satellite image.

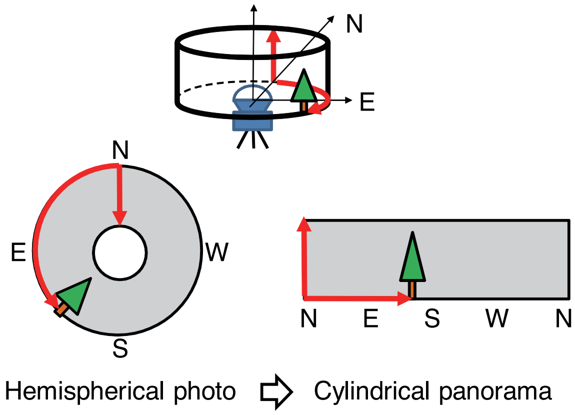

Figure 8: Transformation from hemispherical photo to cylindrical panorama.

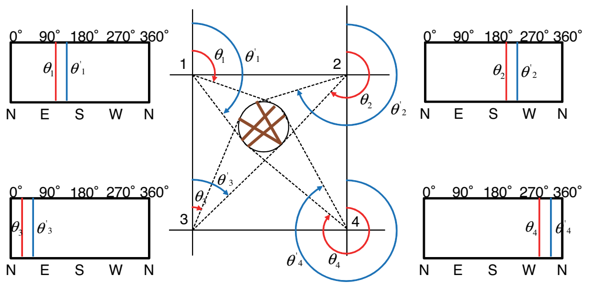

Figure 9: Panorama image and texture of four rectangle trunk objects.

projected on-ground map. Next, the crown object with octagonal shape are rendered the satellite image.

3.2 Trunk Object

First, the hemisperical photo is transformed to cylindrical panorama as shown in Figure 8. Next, using the panorama images taken at the four viewpoints on the corners of the each grid, the rectangle trunk objects of four different directions are created as shown in Figure 9. Then, the visible objects are selected by viewpoint as show in Figure 10.

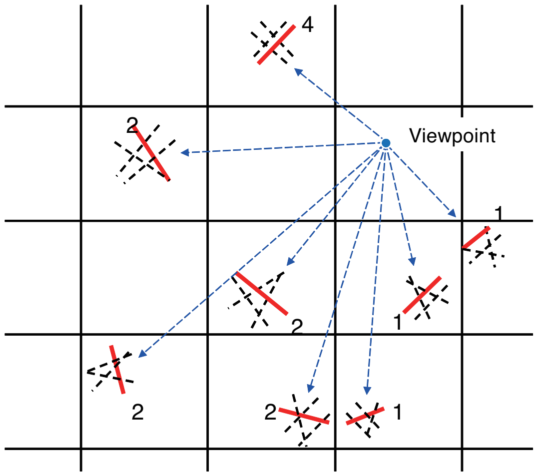

Figure 10: Selection of visible trunk objects by viewpoint.

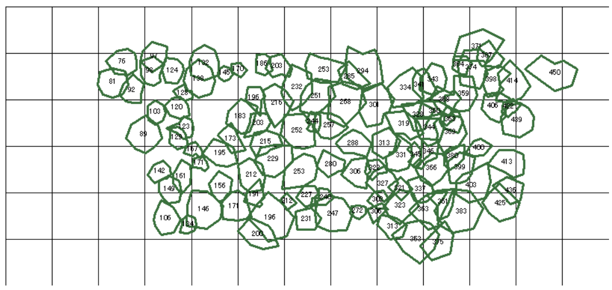

Figure 11: The projected on-ground map of measured 102 canopy trees.

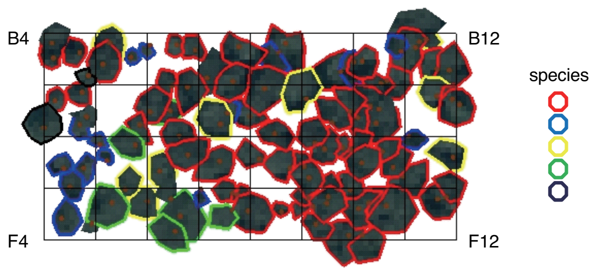

Figure 12: Rendering the satellite image on the octagonal shapes of crown, and tree species.

4 RESULTS

4.1 The Projected On-Ground Map

The projected on-ground map created from the measurement data of 102 canopy trees is shown in Figure 11.

4.2 Crown Object and Trunk Object

Figure 12 shows rendering the satellite image on the octagonal shapes of crown, and tree species.

Figure 13 shows the panorama projection of canopy three dimensional model at C10 point using OpenGL. Figure 14 and 15 show the panorama photos on 4 April, 20 September 2006.

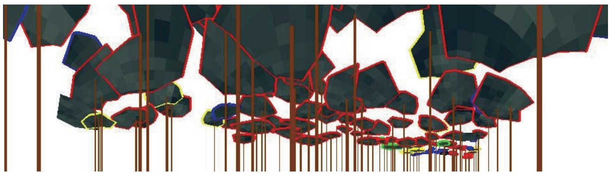

Figure 13: Panorama projection of canopy three dimensional model at C10 point using OpenGL.

Figure 14: Panorama photo on 4 April 2006.

Figure 15: Panorama photo on 20 September 2006.

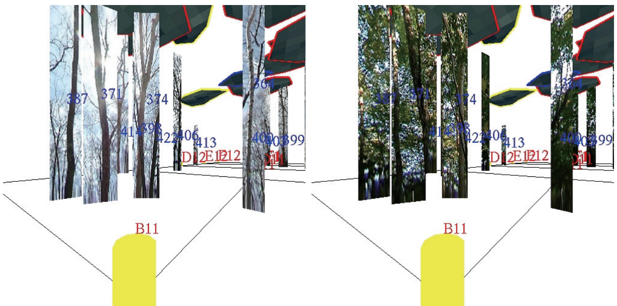

Figure 16: Tree dimensional visualization of forest by fusion of field measured data, satellite image, and omni-directional fish-eye photos.

5 CONCLUSION

In this study, we proposed the method to build the three dimensional forest map of individual tree level, by fusion of field measured data, satellite image, and omni-directional fish-eye photos. It became possible to visualize the three dimensional forest map of individual tree objects constructed octagonal crown and rectangle trunk with attribute data.

This system is useful for forest management and monitoring.

ACKNOWLEDGEMENT

This research was supported in part by Grant-in-Aid for Scientific Research (C) from Japan Society for the Promotion of Science (No.20580285).

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