DETECTION OF TOPOGRAPHIC CHANGE USING AERIAL PHOTOGRAPHS IN HILLY AREA OF OSAKA PREFECTURE, JAPAN

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ABSTRACT

A hilly area in southern district of Osaka Prefecture (Senboku area) was developed as a residential area from 1965 to 1980. Cutting ridges and filling valleys changed a landform of this area artificially. In this study, a topographic change was detected by comparison between Digital Surface Model (DSM) in 1961 and current Digital Elevation Model (DEM). DSM was obtained from aerial photographs using Structure from Motion (SfM) software. DEM published by Geospatial Information Authority of Japan was used as current elevation data. The amount of topographic change was computed simply by subtracting DSM from current DEM using GRASS GIS.

1. INTRODUCTION

In Japan, housing developments in hilly areas have continued since 1960's. These hilly areas are altered artificially by cutting ridges and filling valleys. It is important to detect valley-fill areas for disaster prediction because they are vulnerable to earthquake damage. They can be detected by comparing elevation data before and after the development. The elevation data is easily generated from aerial image stereo pairs using Structure from Motion software in a short time.

In this study, a topographic change in southern district of Osaka Prefecture (Senboku area) was detected by comparing elevation data before and after the development. The hilly area of Senboku was developed as a residential area from 1965 to 1980. The old elevation data before the development was generated from aerial photographs taken in 1961. Digital Elevation Model (DEM) published by Geospatial Information Authority of Japan was used as current elevation data. The amount of topographic change was computed simply by subtracting DSM from current DEM using GRASS GIS (Neteler and Mitasova, 2002).

2. GENERATION OF DSM FROM AERIAL PHOTOGRAPHS

DSM can be easily generated from aerial image stereo pairs using Structure from Motion (SfM) software. SfM is a technique of specifying camera positions and three-dimensional structures from two-dimensional images. In this study, PhotoScan Professional by Agisoft (2015) was utilized to generate DSM (Figure 1).

The study area is a hilly area in southern district of Osaka Prefecture (Figure 2). This area has about 28 sq. km (11.2 km × 2.5 km) with altitudes of 30 m - 170 m. DSM was generated from 12 aerial photographs taken in 1961. Procedure of DSM generation is shown bellow.

(1) Input aerial photographs and camera positions

Twelve aerial photographs and camera positions were input. The resolution of photo images is about two meters per pixel.

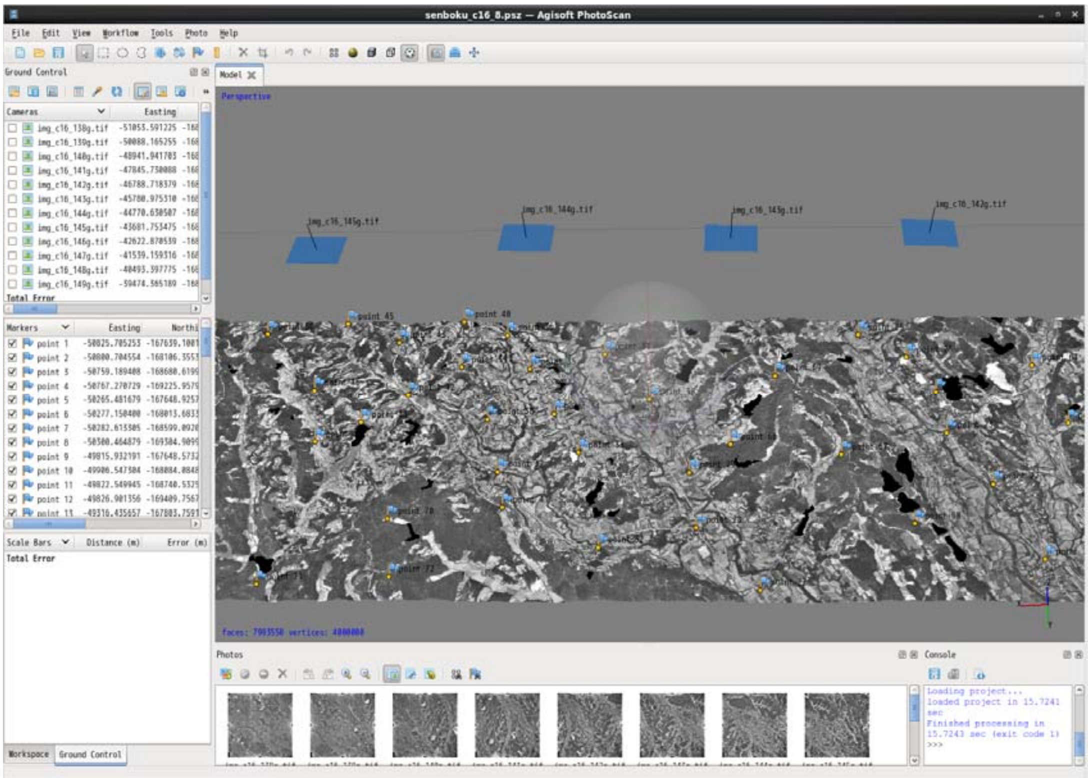

Figure 1. Generation of DSM by Agisoft PhotoScan.

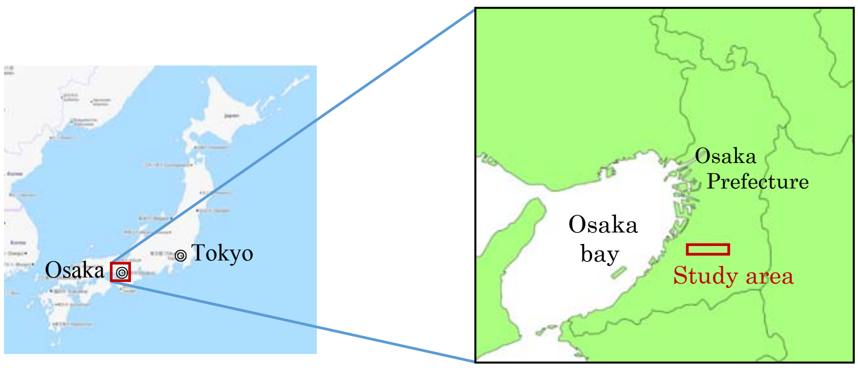

Figure 2. The study area.

(2) Search for common points on photographs and matches them

PhotoScan found matching points between overlapping images and built a sparse point cloud model automatically.

(3) Input Ground Control Points (GCPs)

In this area, 72 GCPs were input. The number and distribution of GCPs influence the accuracy of result. The location of GCPs is shown in Figure 3.

(4) Build a dense point cloud

PhotoScan built a dense point cloud automatically.

(5) Build a 3D polygonal mesh and generate texture from photographs

PhotoScan generated a 3D polygonal mesh model and texture based on the dense cloud data.

(7) Output DSM and orthophoto

DSM with five meter resolution and orthophoto were output in Plane Rectangular coordinates.

DSM generated from 12 aerial photographs is shown in Figure 4. The accuracy of DSM was inspected by comparison between it and a topographic map published by Osaka Prefecture in 1962. The comparison between contour lines is shown in Figure 5. The comparison between section lines is shown Figure 6. They are identical mostly although a height of DSM is higher than that of the topographic map at some ridges due to height of trees.

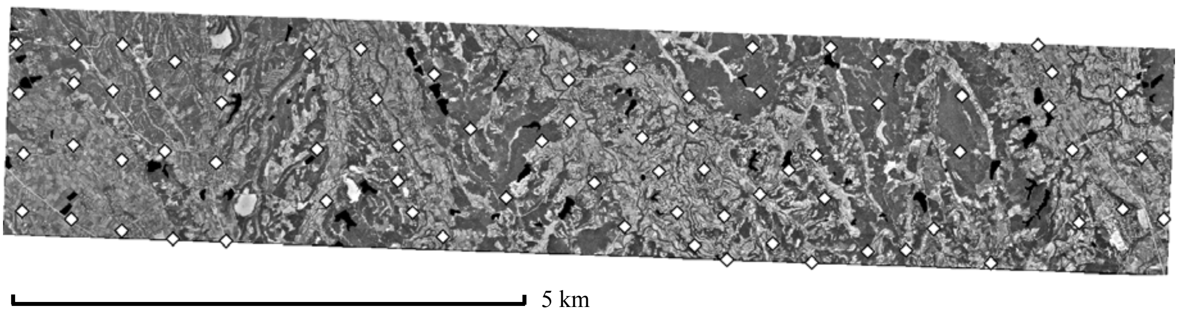

Figure 3. Distribution of GCPs. Diamond symbols show location of GCPs.

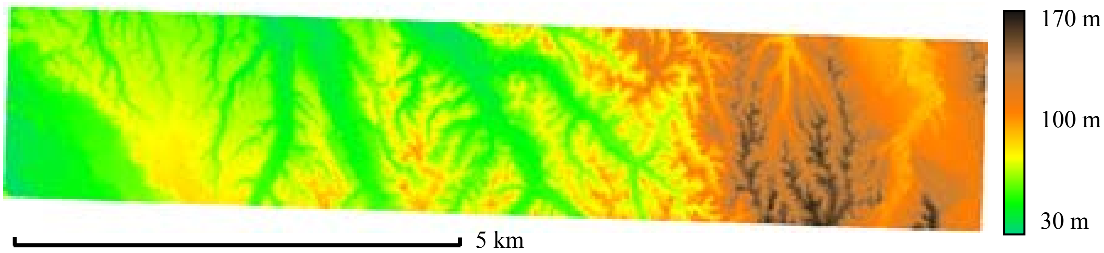

Figure 4. Digital Surface Model generated from aerial photographs in 1961.

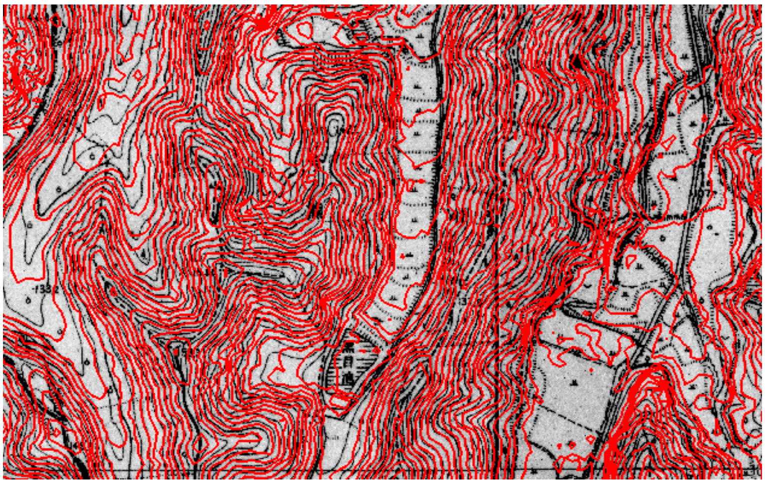

Figure 5. Comparison between contour lines.
The background is the topographic map. Red lines are contour lines of DSM.

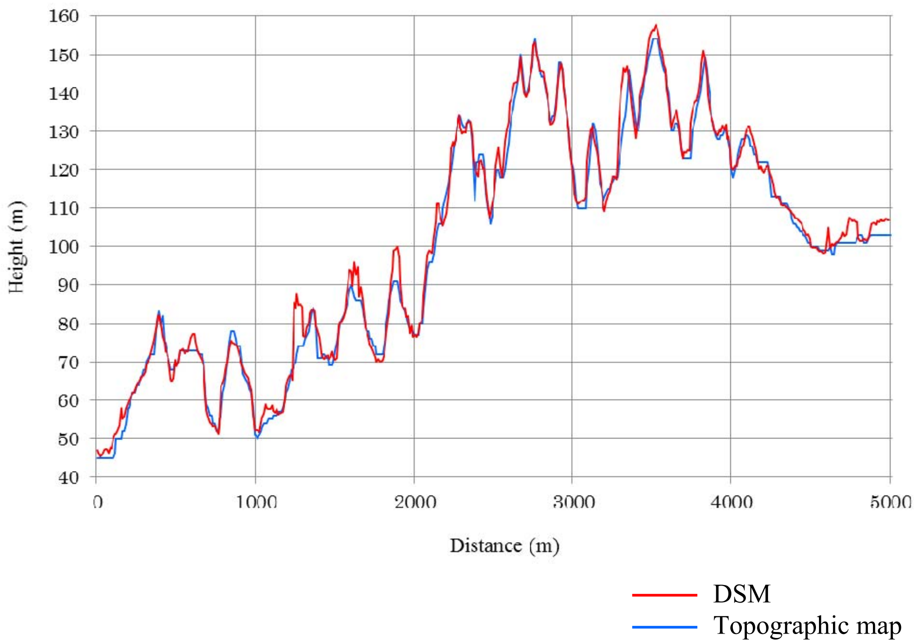

Figure 6. Comparison between section lines.

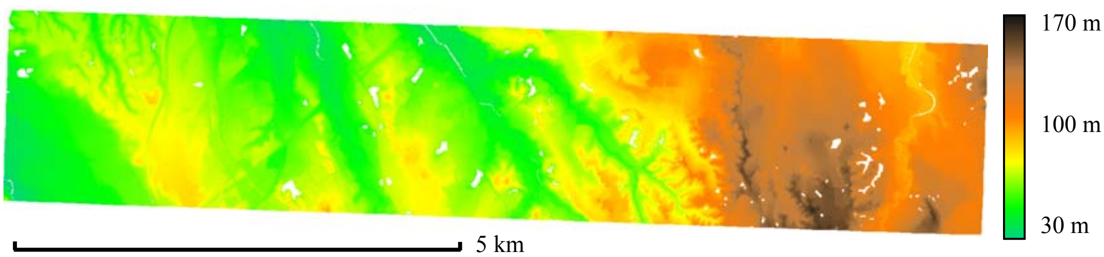

Figure 7. Digital Elevation Model (current elevation).

3. CALCULATION OF TOPOGRAPHIC CHANGE

The topographic change was calculated by comparison between current topographic surface and generated DSM. DEM published by Geospatial Information Authority of Japan was utilized as current elevation data (Figure 7). The amount of change was computed simply by subtracting DSM from current DEM although height of trees and buildings has to be removed from DSM to obtain a result with high accuracy (Figure 8).

It seems that filling thickness was calculated relatively appropriately at valleys where the influence of trees is small. In a central part of this study area, it was compared with a filling thickness by Hirai and Mitamura (2010). Hirai and Mitamura (2010) obtained the thickness of valley-fills by manually comparing contour lines of old topographic map with those of new topographic map. The filling thickness calculated in this study is identical mostly with it (Figure 9).

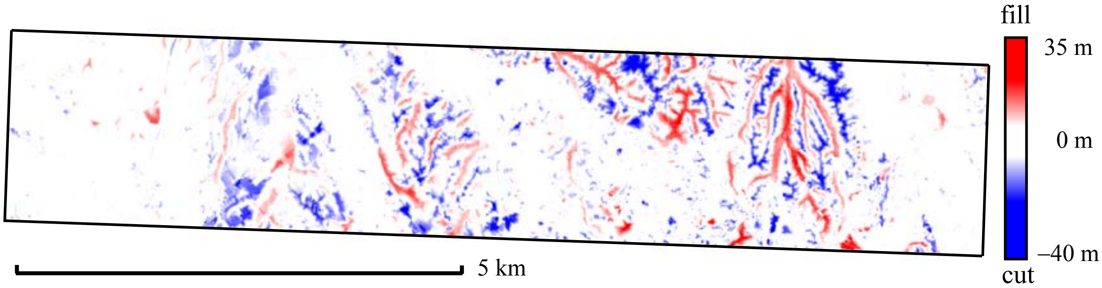

Figure 8. Amount of topographic change.

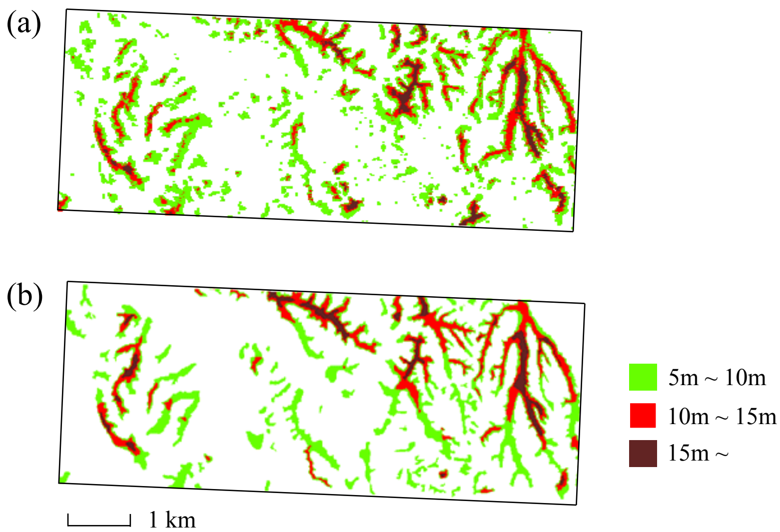

Figure 9. Comparison between filling thickness maps. (a) Thickness calculated in this study, (b) thickness by Hirai and Mitamura (2010).

4. CONCLUSIONS

The topographic change of hilly area in southern district of Osaka Prefecture (Senboku area) was detected by comparing current DEM with old DSM. The amount of filling thickness is identical mostly with that by Hirai and Mitamura (2010). It is necessary to remove height of trees and buildings from DSM to get a result with higher accuracy.

DSM could be easily generated from aerial image stereo pairs using SfM software in a short time. This method is useful for many studies which require high resolution topographic data because it can also be utilized in the area where aerial photographs are not available if stereo photographs are taken by a low-cost UAV (Unmanned Aerial Vehicle).

5. ACKNOWLEDGEMENT

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6. REFERENCES

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