# RECONSTRUCTION OF ORIGINAL SCENERY FOR LANDSCAPE EVALUATION BASED ON AIRBORNE LASER SCANNER DATA

Tsutomu Kakiuchi [a, *], Hirofumi Chikatsu [b]

[a] Aero Asahi Corporation, Research & Development Division, 3-1-1, Minamidai, Kawagoe, Saitama, Japan - tsutomu-kakiuchi@aeroasahi.co.jp
[b] Tokyo Denki Univ., Dept. of Civil and Environmental Engineering, 350-0394 Hatoyama, Saitama, Japan - chikatsu@g.dendai.ac.jp

**KEY WORDS:** Airborne Laser Scanner, Reconstruction, Original Scenery, Landscape Evaluation

**ABSTRACT:**

There are many antique maps and pictorial maps in Japan, these maps which show situation of land use in those days often give important information for global environmental changes. In these circumstances, reconstruction of original scenery from antique maps or pictorial maps are recently received more attention, and original scenery is realized using virtual reality of mixed reality. However, both reliable DTM (Digital Terrain Model) and realistic environment of those days are important issues for reconstruction of original scenery.

With this motive, reconstructions of original scenery are investigated using airborne laser scanning data, and creating realistic environments for landscape evaluation are also investigated using 3D Computer Graphics.

## 1. INTRODUCTION

Recently, reconstruction of original scenery for landscape evaluation using 3 Dimensional Computer Graphics (3DCG) has been receiving more attention since original scenery gives important information for understanding the view of the scenery in those days. Existing antique maps also gives important information for past situation of land use. Therefore, various reconstruction methods have been developing for landscape evaluation using antique maps, e.g., the extraction method of the attribute data using mathematical morphology and remapping method (Yamada & Chikatsu, 1999), and the efficient method for visualization of historical city using historical maps was proposed (Namatame & Chikatsu, 1999) and efficient reconstruction of the past objects and visual simulation "Palatitsa Palace", Greece (Sakamoto & Chikatsu, 2001). However, huge labor, time and expense are needed for landscape modeling of original scenery using 3DCG since the DTM (Digital Terrain Mmodel) for landscape model should be reconstructed manually using existing antique maps.

On the other hand, airborne laser scanner is widely adopted for city modelling, DTM generation, monitoring electrical power lines and detection of forest areas (Kakiuchi & Chikatsu, 2008). In generally, airborne laser scanning enables to acquire point cloud 3D data for surface of the ground or objects. In these circumstances, 3D reconstruction and simulation for historical landscape was investigated using airborne laser scanner in this paper and visualization of historical town "HATOYAMA", Saitama was demonstrated using 3D Computer Graphics.

## 2. STADY AREA

### 2.1 Historical Town "HATOYAMA"

"Hatoyama town", where is located in the central part of Saitama Prefecture is a historical town, 50 km from the central part of Tokyo. There are local cities around "Hiki area" and a lot of hills called "Hiki hill" in the northern part of Hatoyama, "the Iwadono hill" in the eastern part. Kamakura highways, which is one of the important old roads of the traffic connects Kamakura with Hatoyama, and rural landscape spreads along the Oppe River. However, there is urbanized by recent land readjustment project.

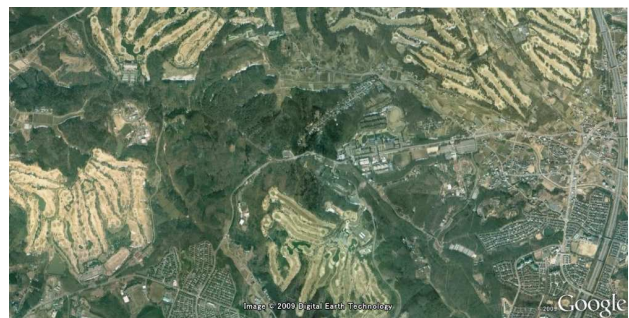Figure 1 shows the aerial photograph of Hatoyama town (Google earth).



Figure 1. Hatoyama town

## 2.2 Provisional Surveyed Map ( 迅速測図 )

Provisional surveyed maps known as existing colourful antique maps were produced at the Meiji period(1868～1912) in Japan. These map, made by the Japanese Army in the early Meiji period which show situation of land use and streets in those days often give important information for studying history of city planning, civil engineering, architecture and so on.

Figure 2 shows the provisional surveyed map used in this paper. The map is around Hatoyama area, Saitama in 1881, and the circumference for each attribute data such as shrine, house, street, river, contour lines and so on is drown by black line in this map.
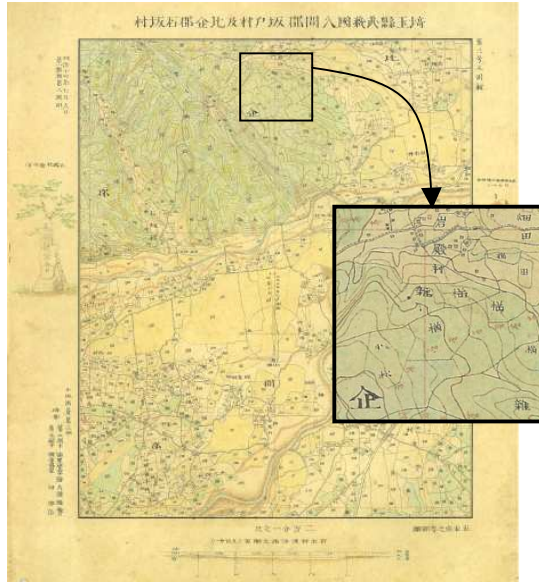


Figure 2. Provisional surveyed map

## 3. RECONSTRUCTIONS OF ORIGINAL SCENERY

In order to reconstruct the original scenery of Hatoyama in the early Meiji period using antique maps, overlapping the provisional surveyed maps and DTM, which generated by airborne laser scanner data are requested. For exact overlapping, provisional surveyed maps should be remapped so that provisional surveyed maps correspond to DTM. Remapping means geometric correction, and each provisional surveyed map and DTM was remapped using TIN model and Affine transformation (Fuse & Shimizu, 1998). Furthermore, in order to acquire altitude data for each contour line, DTM by airborne laser scanner data was overlaid with the map.

The main procedures for reconstruction of original scenery are as follows:

1) Airborne laser surveying was performed to generate DTM.
2) Remapping and overlapping were performed using TIN model and Affine transformation using DTM and provisional surveyed maps.
3) Extraction of contour line data was performed using provisional surveyed maps.
4) Classification of change area was performed using fractal analysis.
5) 3D modelling of the Hatoyama area was reconstructed using 3D CG software.

## 3.1 Laser Scanner System

Airborne laser scanning enables to acquire point cloud 3D data using laser pulses, which are reflected from the surface of the ground or objects. Airborne platform is classified into two different types: a fixed wing type as airplanes and a rotary wing type as helicopters. In generally, the more high dense 3D data and the more flexibility can be acquired, the lower speed by airborne. Therefore, helicopter was used in this investigation instead of airplane, and Inertial Measurement Unit (IMU) and Global Positioning System (GPS) were used. Figure 2 shows the airborne platform of laser scanner (helicopter), and Table 1 shows the specification of laser scanner system. Figure 3 shows the color gradation map, which was acquired using the laser pulse data for Hatoyama area, and Figure 4 shows the contour map, which generated by DTM.

| Platform | Helicopter (AS-350BA) |
|---|---|
| Model No of the system | ALTM3100-AG4(Optech Co.,) |
| Laser wave length | 1064nm(Nd:YAG) |
| Pulse repetition frequency | 100,000Hz |
| Scan frequency | 70Hz |
| Scan angle | ±30° |
| Beam divergence | 0.25mrad |
| Accuracy | Horizontal:1/3000* Altitude(m) |
| | Vertical:±0.15m/shot |

Table 1. Specification of laser scanner system



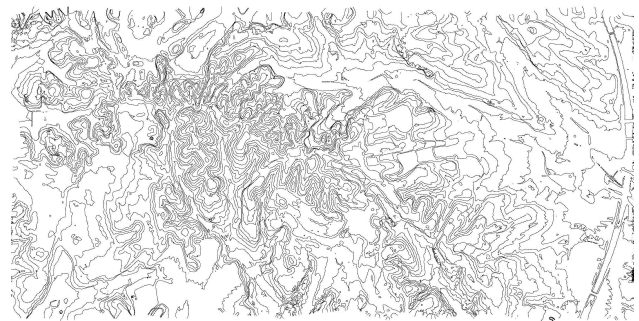Figure 3. DTM Gradation map by airborne laser data



Figure 4. Contour map generated by DTM

## 3.2 Remapping and Overlapping

In order to reconstruct the original scenery using antique maps, overlapping the provisional surveyed maps and DTM are requested. For exact overlapping, provisional surveyed maps

should be remapped so that provisional surveyed maps correspond to DTM.

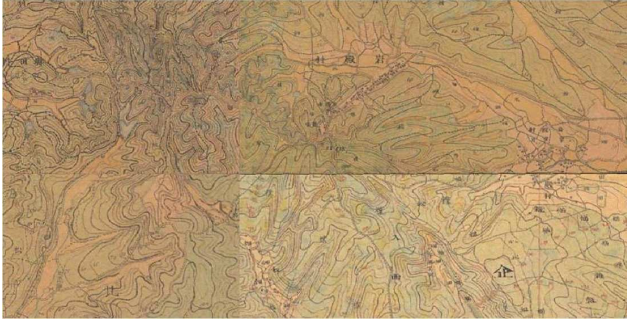Figure 5 shows the remapped provisional surveyed maps.



Figure 5. Remapped provisional surveyed maps

### 3.3 Extraction of Contour Line Data

In order to acquire information for altitude data, firstly contour lines in the maps were extracted from remapped provisional surveyed maps. Secondly, contour line was obtained via image processing procedures such as binarization, noise reduction and thinning procedures.

Figure 6 shows the extracted contour image from the provisional surveyed maps using image processing procedures.
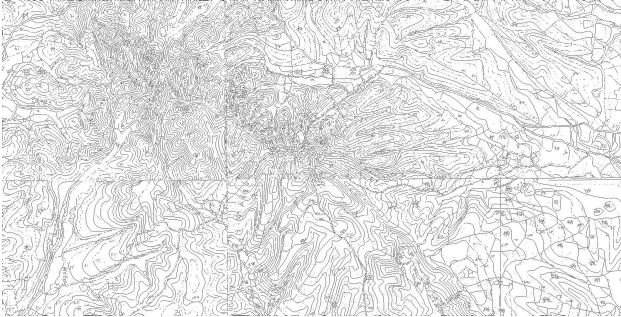


Figure 6. Extracted contour image (Provisional surveyed map)

### 3.4 Classification of Change Area

In order to reconstruct the original scenery using antique maps, change areas in the both contour maps was extracted using fractal analysis.

Fractal analysis has been used for texture analysis as it is highly correlated of pattern recognition and applied to quantifying the structures of objects such as biology and medicine and so on.

The fractal dimension of contour lines was measured by the box-counting method using following equation.

$$D_0 = \lim_{\varepsilon \to 0} \frac{\log N(\varepsilon)}{\log(1/\varepsilon)} \quad (1)$$

where    $D_0$ = fractal dimension
N = number of pixel
r = box size

Both fractal images (Contour map generated by DTM and Remapped provisional surveyed maps) were extracted using

box-counting method. These extracted fractal images are shown in Figure 7 and Figure 8.
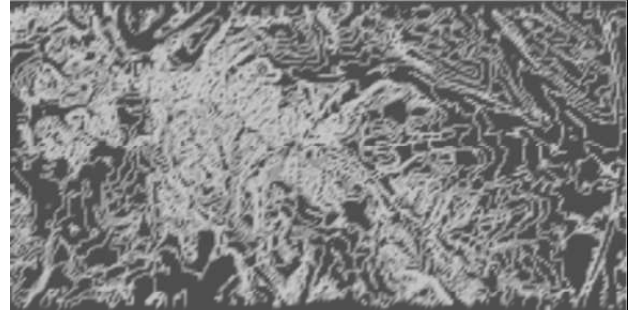


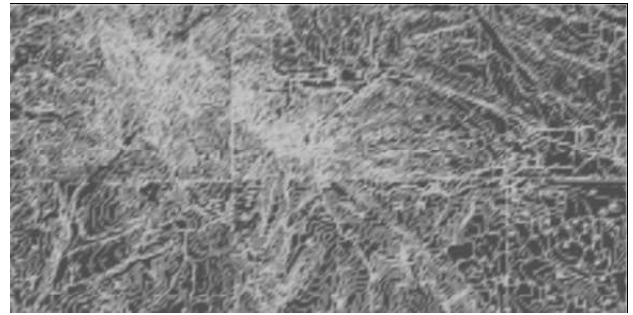Figure 7. Fractal image (Contour map generated by DTM)



Figure 8. Fractal image (Provisional surveyed map)

Figure 9 shows the extracted change areas using both fractal images using the finite difference.



Figure 9. Extracted change areas using Fractal images

### 3.5 3D Modelling of Original Scenery

Figure 10 shows the overlaid map (aerial photograph & change areas). It is understand that the change areas such as golf courses and housing areas were extracted using difference of fractal dimension.

As the next step, in order to acquire altitude data for each contour line, DTM by airborne laser scanner data was overlaid with the contour image of the provisional surveyed map. After scaling and rotating the historical map, the altitude data for each contour line was acquired by manually.

Figure 10.  Overlaid map (aerial photograph & change areas)

## 4.  LANDSCAPE EVALUATION

Recently, 3D visualization has been receiving more attention as a useful method to understand engineering phenomenon intuitively, or to find out important elements that we can't detect in usual simulation. Furthermore, visualization under virtual environment is efficient method from the viewpoint that people can appreciate or experience the archaeological objects or historical space through the computer. In order to perform visual investigation, landscape animation for the mound area is generated.

Figure 11 shows the photograph for the present Hatoyama Hakusandai, and the landscape for the early Meiji period from the same viewpoint, which was obtained using reconstructed 3D model. Figure 12 shows one of scene for 3D model for Hatoyama area. In addition, Vue 7(e-on software, inc.) was used in this paper as 3D CG software.

The difference in the road can be found from these figures.



Figure 11.  Present scenery by digital camera



Figure 12.  Original scenery by airborne laser scanning data

## 5.  CONCLUTION

In order to evaluate the efficiency of the method, reconstruction of original scenery for the Hatoyama area in the Meiji period was investigated.

In generally, huge labor, time and expense are needed for reconstruction original scenery from antique maps using 3DCG since the Digital Terrain Model should be reconstructing manually. However, these issues are drastically reduced by the proposed method, which was developed by the authors. In particular, the method has ability for applying other area under customizing representative structures for the area. Therefore, it can be said that the method is the efficient reconstruction method for landscape evaluation. Moreover, the method is broadly available not only the landscape simulation of original scenery but local disaster prevention and a city redevelopment project by taking into consideration attribute data such as wooden and an apartment, the number of floors, years after construction and etc.

However, there are issues, which need to be resolved before this system may become more operational. These problems are automatic contour line extraction from the antique map since characters are included residence areas and lines shows indistinct line, and extracting special data such as boundary lines or small characters and insufficient clarity color.

**References from Other Literature**:

Yamada Nobuhiro, Hirofumi Chikatsu, 1999. Remapping of historical maps using mathematical morphology and application, International workshop on mobile mapping Technology, p2-6-1 - 2-6-5

Namatame T, Chikatsu H, 1999. Approach to Efficient City Modeling for Visualization of Historical City, International Archives of Photogrammetry and Remote Sensing, Vol.XXXII, Part 5-3W12, pp.21-23

Sakamoto K, Chikatsu H, 2001. Efficient Reconstruction of the Past Objects and Visual Simulation, International Archives of Photogrammetry and Remote Sensing, Vol.XXXIV, Part 5/W1, pp.113-117

Tsutomu Kakiuchi, Hirofumi Chikatsu, 2007. Documentation and Visualization of ancient burial mounds by helicopter laser surveying, IAPRS, Vol. XXXVI-5/W47(CD-Rom), Zurich, ISSN 1682-1777.

Sprague, D. S., Iwasaki, N. and Takahashi, S., 2007. Measuring rice paddy persistence spanning a century with Japan's oldest topographic maps: georeferencing the Rapid Survey Maps for GIS analysis. International Journal of Geographical Information Science, 21（1）,83 - 95 .

Fuse, T., Shimizu, E. and Morichi, S., 1998. A study on geometric correction of historical maps, International Archives of Photogrammetry and Remote Sensing, Vol. XXXII, Part5, pp.543-548.

Shimizu, E., Fuse, T., and Shirai, K., 1999. Development of GIS integrated historical map analysis system, International Archives of Photogrammetry and Remote Sensing, Vol.32, Part5-3W12, 79-84.