RECONSTRUCTION AND VISUALIZATION OF ORIGINAL LANDSCAPE BASED ON REVERSE MAPPING

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ABSTRACT:

The reconstruction and visualization of original landscapes using 3D-CG (3 dimensional computer graphics) has been receiving considerable attention recently because an original landscapes provides important information that can be useful for understanding the view of the scenery in past times. Existing old maps also give important information on past situations with regard to original land use, the environment, etc. With this motive, the authors have been consecrating on the development of methods for the reconstruction and visualization of original landscapes using old maps.

However, there are issues need to be resolved before these methods can be more widely used. These issues involved the need for a reliable method to realize the realistic environment of past times for the reconstruction and visualization of original landscapes.

To this end, this study investigate the reconstruction and visualization of original landscapes based on reverse mapping using old maps as well as the creation of realistic environments using 3D-CG.

1. INTRODUCTION

Many antique maps and pictorial maps can be found in Japan that show the circumstances of land use in past times, and these maps often give important information regarding global environmental changes. Furthermore, attribute data (such as shrines, houses, streets, rivers, contour lines, map symbols, etc.) on antique maps or pictorial maps give important information on the realistic environment of original landscapes.

With this motive, the focus of the authors has been on the development of methods for the reconstruction and visualization of original landscapes using old maps, e.g. an extraction method for attribute data using mathematical morphology and remapping methods (Yamada & Chikatsu, 1999), the efficient reconstruction of the past objects and visual simulation of 'Palatitsa Palace', Greece (Sakamoto & Chikatsu, 2001), and an efficient method proposed for the visualization of historical city using old maps (Suzuki & Chikatsu, 2002).

A great deal of time, huge labour, and expense are needed, however, to reconstruct original landscapes from old maps using 3D-CG, since the realistic environment for landscape modelling must be reconstructed manually using existing old maps. Other problems include the automatic extraction of attribute data such as contour lines, map symbols, and so on from old maps, since the colour of contour lines and identification boundary line of map symbols are insufficiently clear.

Against this background, 'Reverse Mapping' was investigated using old maps, and the visualization of the original landscape of 'HATOYAMA Town' was demonstrated using 3D-CG. Furthermore, in order to evaluate the efficiency of the Reverse Mapping method, 3D reconstruction of the original landscape of 'HATOYAMA Town' was investigated in this paper.

2. STUDY AREA AND OLD MAP

2.1 HATOYAMA Town

'HATOYAMA Town' which is located in the central part of Saitama Prefecture, is a local town located 50 km from central Tokyo. There are local cities around the 'Hiki area' and many hills in an area called 'Hiki hill' in the northern part of Hatoyama Town, whose rural landscape spreads along the Oppe River. This area has been urbanized, however, by a recent land redevelopment project.

Figure 1 shows an aerial photograph for the present 'HATOYAMA Town' (Google Earth).

Figure 1. Aerial photograph 'HATOYAMA Town' (2009)

2.2 Provisional Survey Maps

The old map which is called 'Provisional survey maps' are the still-existing colourful old maps of Japan that were produced during early part of the Meiji period(1868 ～ 1912) by the Japanese Army.

Figure 2 shows one of the provisional survey maps used in this paper. The map shows the area around Hatoyama, Saitama in 1881. The circumference of each piece of attribute data such as

shrines, houses, streets, rivers, contour lines and the like are drawn in black lines, and land use such as paddy fields, dry fields, vegetation areas, etc. are divided into various colours. Furthermore, symbols for tree species (Japanese oak, cedar, pine, etc.) are indicated in Chinese characters.

These maps provide valuable information about original landscapes and agricultural land use in early Meiji period of Japan. Therefore, various analyses are performed using these maps, e.g., an overlay analysis for paddy fields between them and a modern land use map (Sprague & Iwasaki, 2007).

However, automatic attribute data extraction from the old maps is still issue since land use are shows insufficient clarity color, and identification boundary line of map symbols.
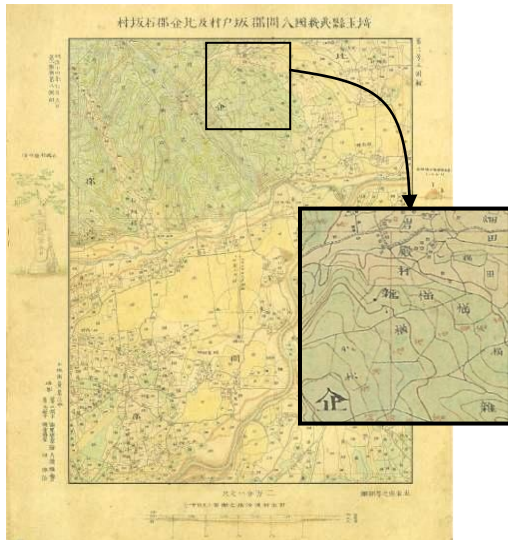

Figure 2. Provisional survey map (1881)

3. RECONSTRUCTION OF ORIGINAL SCENERY BASED ON REVERSE MAPPING

'Reverse Mapping' means the reconstruction and visualization of original landscapes using old maps and creating realistic environments using 3D-CG.

The main steps involved in Reverse Mapping are as follows:

1) Remapping and overlapping was performed using TIN model and affine transformation using old maps and current map.

2) The classification of land use was performed using color separation.

3) The extraction and identification of map symbols such as attribute data was performed using a template matching.

4) Terrain modelling for landscape model was performed using old maps and 3D terrain data.

5) 3D modelling of the original landscape and the creation of realistic environments was reconstructed using 3D-CG software.

3.1 Remapping and Overlapping

Remapping means geometric correction, in order to reconstruct the original landscape of Hatoyama town in the early Meiji period using old maps, the provisional survey maps must be remapped so that they correspond to the current map using the TIN model and affine transformation (Fuse & Shimizu, 1998, 1999).

On the other hand, an airborne laser scanner has been widely adopted for city modelling, DTM (Digital Terrain Model) generation, and the monitoring electrical power lines and

detection of forest areas (Kakiuchi & Chikatsu, 2008). In general, airborne laser scanning makes it possible to acquire point cloud 3D data for the surface of the ground or objects. Therefore, in order to acquire altitude data for each contour line, a DTM from airborne laser scanner data was overlaid as a current map on the provisional surveyed maps.

TIN models were generated using feature points common to both the provisional survey maps and DTM as a present map, and geometric correction was performed by affine transformation.

Figure 3 shows a colour gradation map that was acquired using airborne laser scanner data for the Hatoyama area. Figure 4 shows the remapped provisional survey maps.

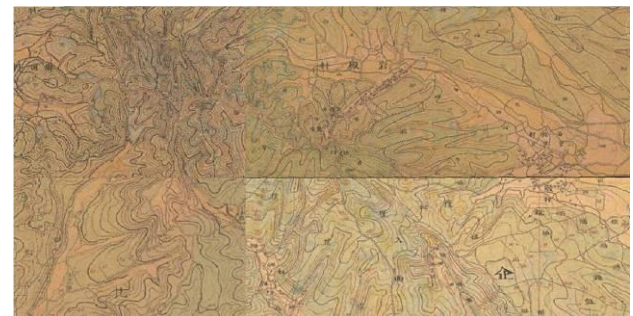Figure 3. DTM gradation map from airborne laser data

Figure 4. Remapped provisional survey maps

3.2 Classification of Land Use

The provisional survey map shows the distribution of land use, such as paddy fields, dry fields, and vegetation areas, which are divided into various colours. In order to acquire the attribute data automatically, extracted each land use categories was classified using colours separation.

Figure 5 shows the classifications of land use categories, and the kinds of textures for each land use categories are determined in terms of this colour information.
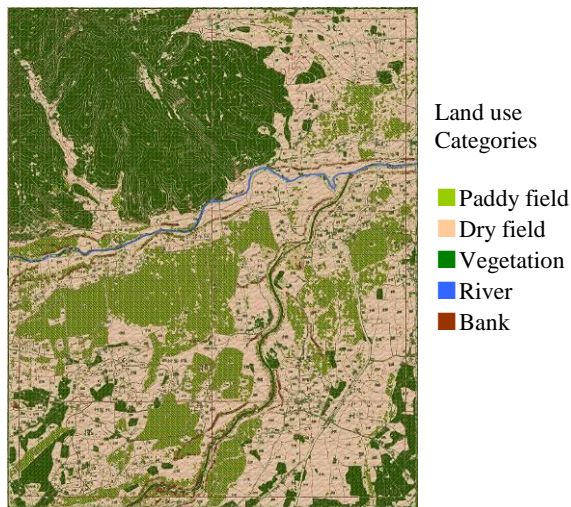
Figure 5. Classification by land use categories

3.3 Extraction and identification of map symbols

In this map, the circumference of attribute data such as streets, rivers, contour lines, etc. is drawn in black lines and the symbols for tree species are indicated by Chinese characters.

In order to create realistic environments of the original landscapes, not the land use but the vegetations at the time are important component for reliable description in past times. For these demands, representative tree models of the past era were reconstructed previously using 3D-CG software. Furthermore, a template window was generated around the map symbols, and template matching was performed for the remapped provisional survey maps so that the tree models could be arranged using 3D-CG software (Vue 7: e-on software, inc). Figure 6 shows the result of template matching.
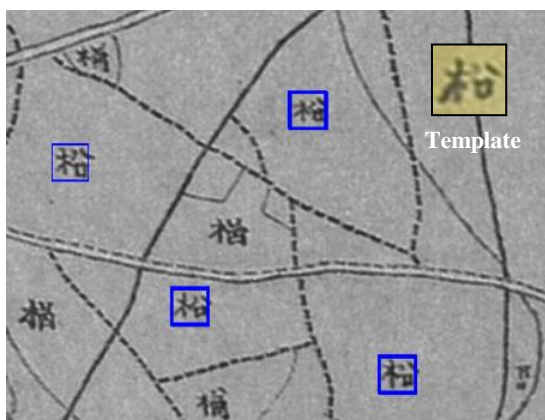

Figure 6. Result of template matching

3.4 Terrain modelling for landscape model

In order to acquire information for the altitude data, contour lines in the maps were first extracted from the remapped provisional survey maps. Secondly, contour lines were obtained via image processing procedures such as binarization, noise

reduction, and thinning procedures. In addition, in order to acquire altitude data for each contour line, DTM from airborne laser scanner data was overlaid on the map.

Figure 7 shows a contour map that was generated by DTM from airborne laser scanner data for the Hatoyama area.

Figure 8 shows the extracted contour image from the provisional survey map that was obtained using image-processing procedures.
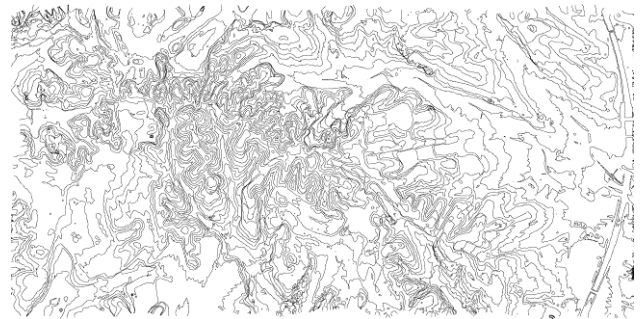

Figure 7. Contour map generated by DTM

Figure 8. Extracted contour image (Provisional survey map)

As the next step, in order to reconstruct the original landscape efficiently, areas of change in both contour maps were extracted using fractal analysis.

Fractal analysis has been used for texture analysis as it gives a high degree of correlation in pattern recognition, which is applied to quantifying the structure of objects in such fields as biology and medicine. The fractal dimension of the contour lines was computed by the box-counting method using the following equation:

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

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

Both fractal images (the contour map generated by DTM and the remapped provisional survey map) were extracted using the box-counting method. These extracted fractal images are shown in Figure 9 and Figure 10 (White: high fractal dimension = complex shape, Black: low fractal dimension = simple shape (not complex).
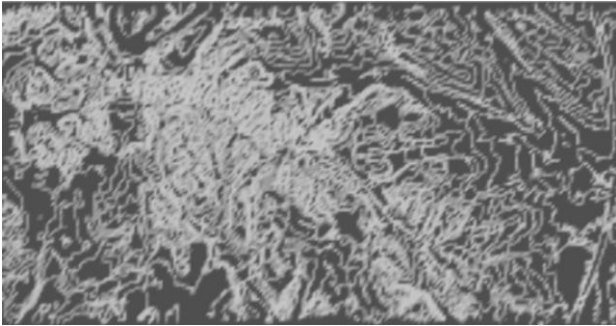
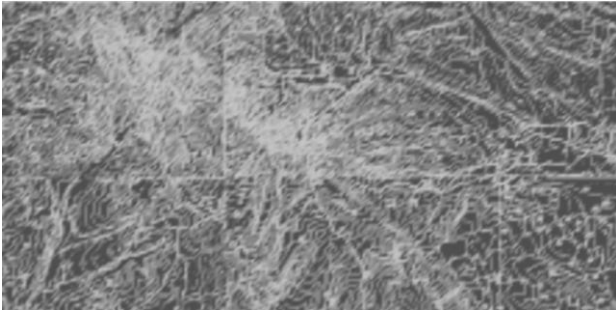Figure 9. Fractal image (Contour map generated by DTM)

Figure 10. Fractal image (Provisional survey map)

In order to extract change areas using both fractal images, difference image of fractal dimension were computed.

Figure 11 shows the extracted areas of change that were obtained from difference image (White: Changed Area, Black: Unchanged Area).
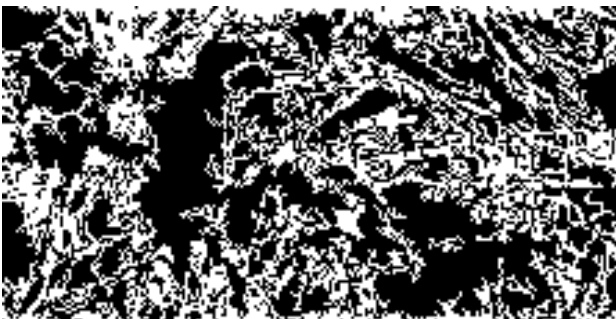

Figure 11. Extracted areas of change using fractal images

3.5 3D Modelling of Original Landscape

Figure 12 shows the overlaid map (aerial photograph and changed areas). It is understood that the changed area (white areas in Figure. 12) such as golf courses and housing areas were extracted using the difference in the fractal dimensions.

The next step involved the acquisition of altitude data for each contour line. In order to perform efficient landscape modelling, a DTM from airborne laser scanner data was overlaid with the contour image of the provisional survey map so that the altitude data for each contour line in unchanged areas is able to acquire automatically. After that, the altitude data for each contour line in changed areas were obtained manually.
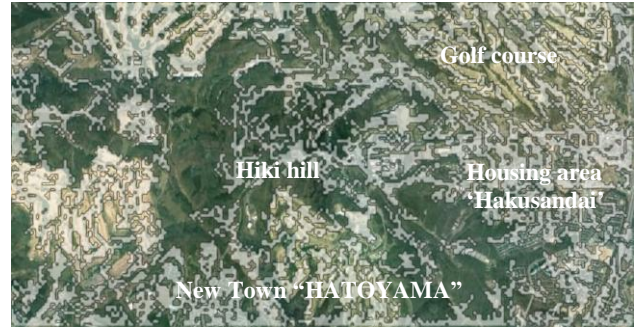

Figure 12. Overlaid map (aerial photograph and changed areas)

4. VISUALIZATION OF ORIGINAL LANDSCAPE

Recently, 3D visualization has been receiving more attention as a useful means of understanding engineering phenomenon intuitively, or to discover important elements that cannot be detected in usual simulations. Furthermore, visualization in a virtual environment is a useful method in the sense that people can appreciate or experience archaeological objects or historical space through the computer. In order to perform visual investigation, animation of the landscape in the Hatoyama area in the Meiji period was generated.

Figure 13 shows a photograph of the present Hatoyama Hakusandai, and Figure 14 shows the same landscape model for the early Meiji period, which was obtained using a reconstructed 3D model.

Figure 13. Present landscape, digital camera photo

Figure 14. Original landscape by Reverse Mapping

Figure 15. Aerial photograph 'HATOYAMA Town (2009)'(Left) and Original landscape(1881) by Reverse Mapping (Right)

Figure 15 shows one of the scenes from a 3D model of the Hatoyama area. The difference in the land use can be found from these figures, and it can be seen how change the view and show original landscape. Therefore, it can be said that original landscape modeling gives important information for city planning including preservation of historical view.

5. CONCLUSION

In order to evaluate the efficiency of the Reverse Mapping method, a reconstruction of the original landscape of the Hatoyama area in the Meiji period was investigated.

In general, a great deal of time, huge labour, and expense are needed for the reconstruction of original landscapes from old maps such as provisional survey maps using 3D-CG, since the realistic environment of a landscape model must be reconstructed manually. The magnitude of these obstacles, however, is drastically reduced by the proposed method, developed by the authors. In particular, the method has capacity to be applied to the construction of new and colourful maps. It can therefore be said that this method makes possible the efficient reconstruction of an original landscape. Moreover, the method is broadly applicable not only to the simulation of original landscape, but also to local disaster prevention and city redevelopment projects, by taking into consideration attribute data such as construction of wood, apartments, the number of floors, year of after construction, and etc.

The most remarkable aspects of this method are the following capacities that it offers:

+Automatic texture mapping of land use using colour separation.
+Automatic extraction and identification of map symbols as attribute data.
+Automatic detection of change areas for efficient landscape modeling using fractal analysis

Consequently, it is concluded that the method described in this paper is efficient for the reconstruction and visualization of original landscapes.

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