# VISUALIZATION OF FLOOD CONTROL HISTORIES BASED ON PAST GEOINFORMATION

Yuichi Honma, Hirofumi Chikatsu

Department of Civil Engineering
Tokyo Denki University
Hatoyama, Saitama, JAPAN, 350-0394
E-mail: {08smg20/chikatsu}@g.dendai.ac.jp

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**ABSTRACT:**

There are many past geoinformation such as antique maps, pictorial maps, old documents, lore and so on in Japan, and these past geoinformation often give important information for studying history of disaster, civil engineering, architecture, culture and so on. In particular, some past geoinformation give important information for damage and reconstruct situation, and countermeasures against natural disasters such as flood in those days. Furthermore, visualization of past natural disasters helps to make understanding risk management for natural disasters.
Recently, risk management using GIS have been receiving attention for warning, forecasting or monitoring disasters. In order to avoid natural disasters, understand countermeasures by forerunners and realize an importance of risk management, visualization of flood control histories in the Edo period, focusing volcanic flood by Mt Fuji at 1707, was implemented based on past geoinformation in this paper.

## 1. INTRODUCTION

Existing antique maps and pictorial maps were mostly produced at the Edo period in Japan, and these maps which show situation of land use in those days. Similarly, there are many old documents and lore, and these past geoinformation often give important information for studying history of disaster, civil engineering, architecture, culture and so on. As one of utilization of these past geoinformation, virtual reality has recently received more attention from possibility so that people can appreciate or experience the archaeological objects or historical space and art through the computer at any time without going to the museum. With this motive, Chikatsu has developed an efficient method for city modelling in Tsumago (Suzuki & Chikatsu, 2002) and castle town Kawagoe of the Edo period (Suzuki & Chikatsu, 2003), Hachinohe of the Taisho period (Ejima & Chikastu, 2005) using antique map.
On the other hand, risk management system for disasters using GIS (Michel & T.Sc.A, 2008) and warning, forecasting or monitoring system for disasters using CG (D.Mioc, et al., 2008) have been receiving attention. In particular, visualization of past geoinformation such as antique maps, pictorial maps, old documents, lore and so on share a common content from the view point of preservation of structures and items of cultural heritage, which will be decrepit, deteriorated, disappeared and lost.
In order to evaluate an effectiveness of visualization of past geoinformation for flood control history, visualization for past geoinformation regarding the Sakawa River on the Ashigara Plain of Kanagawa prefecture in the Edo period was performed in this paper.

## 2. ASHIGARA PLAIN AND SAKAWA RIVER

### 2.1 Ashigara Plain

The Ashigara Plain is an alluvial plain with a few ups and downs which is located in the west of Kanagawa, and surrounded by Mt. Hakonegairin and Mt. Ashigara. The Ashigara Plain often suffered from floods in the history, because plural branches joined the Sakawa River at the Ashigara Plain.

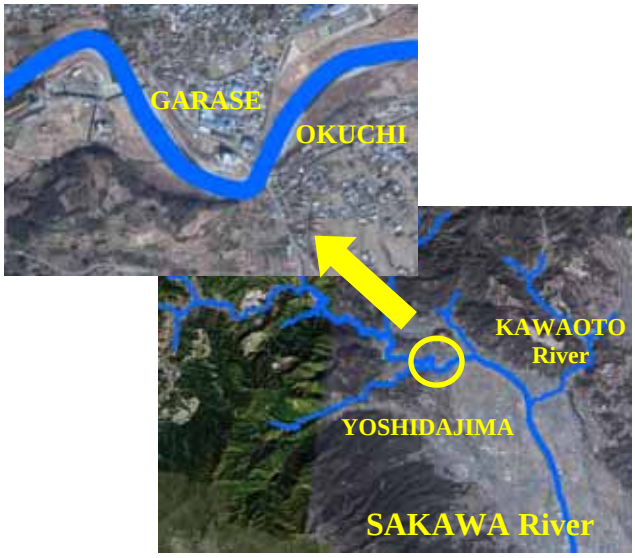



Figure.1 The Sakawa River and the Ashigara Plain

### 2.2 Sakawa River

The Sakawa River runs to the south on the center of the Ashigara Plain and discharges itself into Sagami Bay at Odawara. The flow of the river changes largely just upper Garase and Okuchi area, and flows into the plain region from Okuchi (Figure 1).
Full length and height difference of the Sakawa River are about 46km and 400m. As for distance difference between the source of the Sakawa River to the Plain is 31km, and the height difference is 325m. Furthermore, due to the flow of the Sakawa River changes greatly at Garase and Okuchi area. Therefore, the both area has often suffered great flood damage for a long time. Similarly, Yoshidajima area has often suffered great flood damage.
In these circumstances, flood control has been taken positively, flood control history for the Sakawa River has started with construction of open levee around middle of the 16 century. Furthermore, river improvement works in the Edo period such as unification of the Sakawa River by Okubo Tadayo and Okubo Tadachika, construction of embankment called Bunmeiseitei at Garase and Bunmeitoutei at Okuchi by Tanaka Kyugu, and construction of triangle embankment at joint position with the Kawaoto River by Mino Kasanosuke are famous flood controls which are handed down.
In order to document for theses flood control histories in the Edo period, visualization of the river improvement works along 14km from Garase to Yoshidazima are investigated by following 3 periods based on past geoinformation.

- The first period (～1602): Until unification of river channels by parent and child Okubo Tadayo and Okubo Tadachika.
- The second period (1603~1710): From the channel unification to the deluge by eruption of Mt. Fuji in Hoei era.
- The third period (1711~): From the deluge to completion of the river improvement construction by Tanaka Kyugu and Mino Kasanosuke.

The details of three periods are shown in table 1.

Table.1 River channel changes of the Sakawa River

| Period | River Condition |
|---|---|
| The first period:<br>Before the Edo period<br>(～1602) | Plural branches |
| The second period:<br>The early part of the Edo period<br>(1603~1710) | The East of the Plain<br>(same with the present river channel) |
| The third period:<br>After eruption of Mt. Fuji in Hoei era (1711~) | The west of the Plain |

## 3. GENERATING TOPOGRAPHIC MODEL

### 3.1 Geometric Correction

In order to visualize flood control history based on past geoinformation such as antique maps, pictorial maps, documentations and lore, these geoinformation have to be share common coordinate system. In particular, antique maps and pictorial maps were often deformed by the painters.

Therefore, antique maps and pictorial maps were corrected using a present map which was obtained by airborne laser surveying (altitude:700m, laser frequency：70,000Hz). Figure 2 shows outline for generating topographic model of the Ashigara Plain and the Sakawa River.

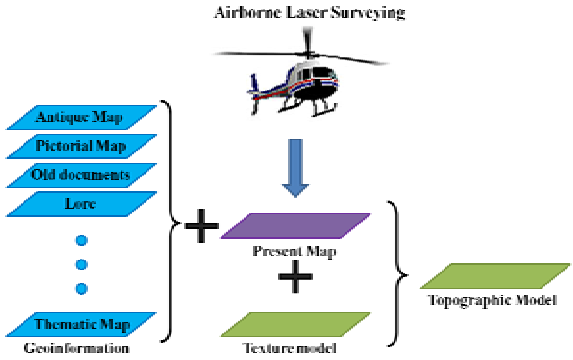



Figure.2 Outline of generating topographic model

As detail procedures of generating topographic model, TIN models were generated using common feature points both of the antique maps and the present map, and geometric correction was performed by affine transformation (Shimizu et al., 1999).
Figure 3 shows the present map and figure 4 shows one of antique maps. Figure 5 and 6 shows TIN model for each map respectively, and each triangulation in the TIN model for the antique map was corrected by affine transformation. Figure 7 shows corrected antique map.

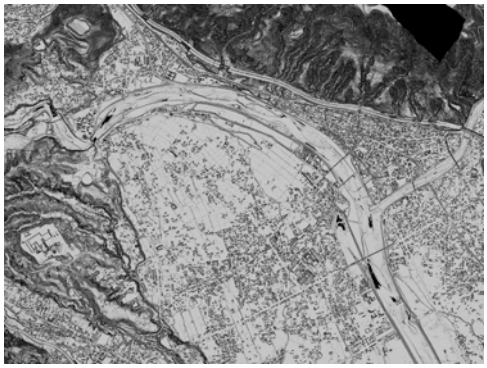


Figure.3 The present map

Figure.4 The antique map

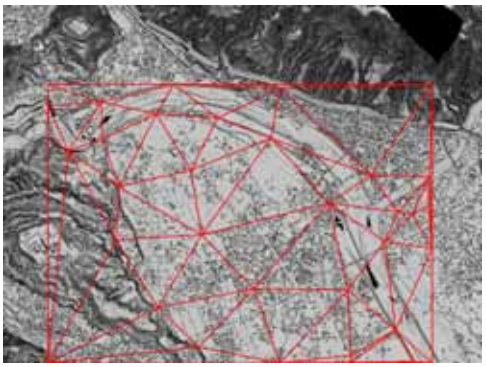


Figure.5 TIN model (The present map)

Figure.6 TIN model (The antique map)

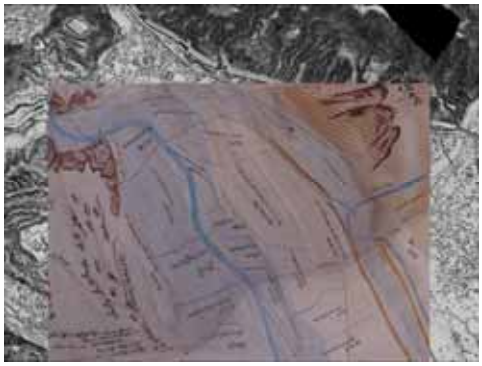


Figure.7 Antique map after geometric correction

Similarly, other geoinformation were corrected by the same procedures, and corrected geoinformation were overlaid as a topographic map at the Edo period. Figure.8 shows estimated topographic map at the Edo period.

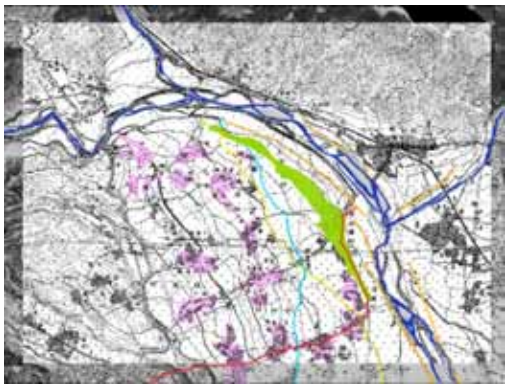


Figure.8 Topographic map at the Edo period

### 3.2 Texture model

In order to generate texture model for the topographic map, textures were painted by manually since there are not exist aerial photographs at the Edo period. Figure.9 shows texture model for the topographic map.

### 3.3 Topographic model

The texture model was generated based on the topographic map which was obtained through geometric correction using the airborne laser surveying. Therefore, 3-dimensional topographic model is generated automatically using 3-dimentional coordinates for each corresponding triangle point. Figure.10 shows 3-dimensional topographic model for the Ashigara Plain and the Sakawa River. 3-dimensional topographic model of the Ashigara Plain and the Sakawa River for each period shown in table 1 was generated by the same procedures respectively.

Figure.9 Texture model of the Ashigara Plain

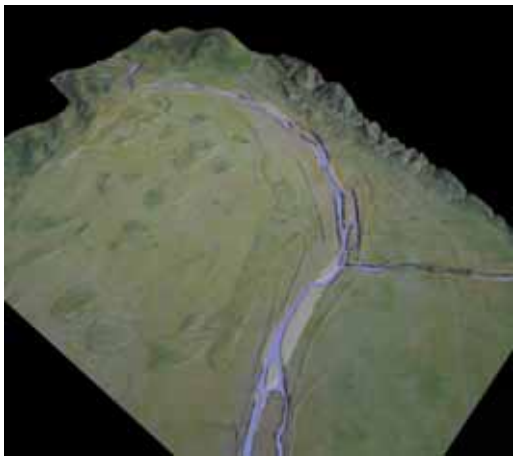


Figure.10 3D model of the Ashigara Plain

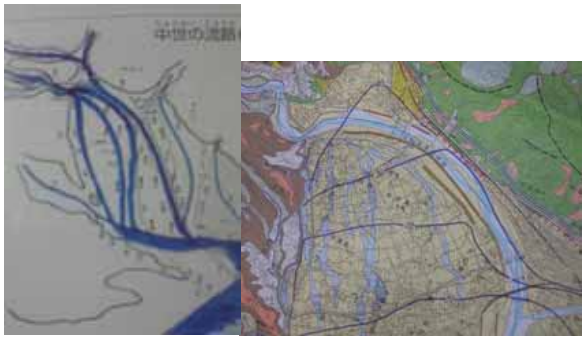
## 4. CHANGE OF RIVER CHANNEL

The changes of the river channel for the 3 periods are investigated based on past geoinformation such as antique maps, pictorial maps, old documents, lore and so on.

### 4.1 River channel in the first period (~1602)

There is not noticeable flood control history for the first period. However, it is estimated that the Sakawa River consisted of many branches and the branches flowed through the west parts

of the Plain from the figure 11. Figure 12 shows estimated river channel map in the first period.



(a) River channel map (b) Land condition map

Figure.11 Documents of river channel at the first period

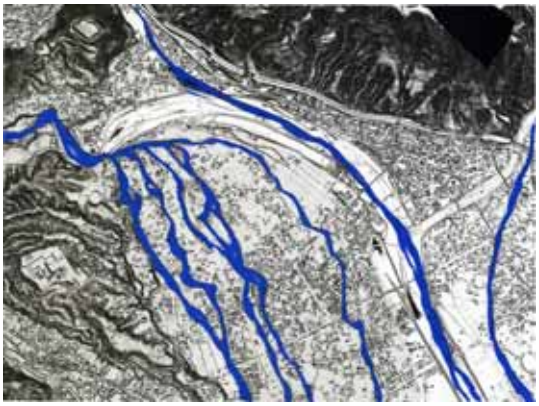


Figure.12 Estimated river channel at the first period

### 4.2 River channel at the second period (1603~1710)

The second period started from the beginning of the Edo period to the collapse of the Okuchi embankment (1711) after the eruption of Mt. Fuji in Hoei era (1707). The remarkable points in this period was flood control works by Tadayo Okubo and Tadachika Okubo, the plural blanches of the Sakawa River were unified and moved to the east of the Plain.

Figure 13 shows river channel situation of the period, and figure 14 shows estimated river channel by geomantic correlation. It can be seen from figure 14 that the river channel at the period shows same channel compare with the present map.

(a) Topographic map (b) River channel map

Figure.13 Documents of river channel at the second period

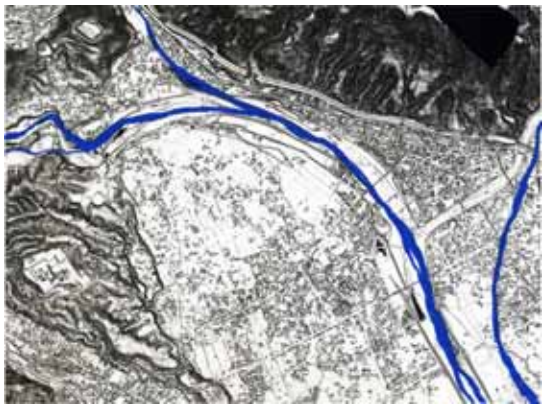


Figure.14 Estimated river channel at the second period

### 4.3 The river channel of the third period (1711~1735)

After the collapse of the Okuchi embankment (1711) to flood control works by Kyugu Tanaka and Kasanosuke Mino is the third period. Figure 15 shows the river channel for the third period, and it can be seen that the river channel in this period moved to west again. Figure 16 shows estimated river channel by geomantic correlation, and it can be obviously realized that the river channel at the third period moved to west again.

(a) River channel map (b) Pictorial map of Sakawa River

Figure.15 Documents of river channel at the third period

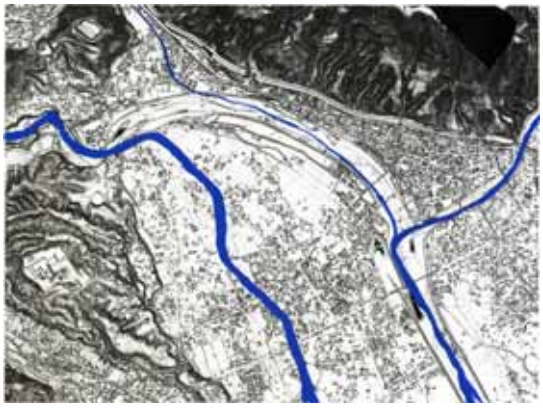


Figure.16 Estimated river channel at the third period

## 5. VISUALIZATION OF FLOOD CONTROL HISTORIES

Generally, 3D visualization has ability to make intuitive understanding or to find out important elements that we can't detect in 2D information. In particular, visualization of history to help understanding many historic backgrounds and factors. With this motive, 3D visualization of flood control history for the Sakawa River was performed based on past geoinformation such as antique maps, pictorial maps, old documents and lore. Figure 17, 18, 19 and 20 shows one scene of flood animation for the each period.

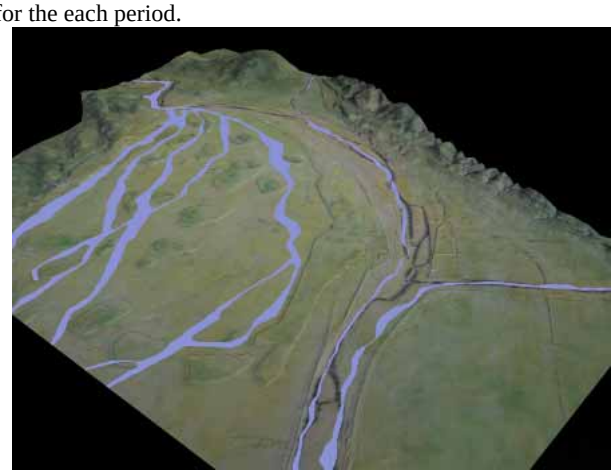


Figure.17 Flood animation for the first period

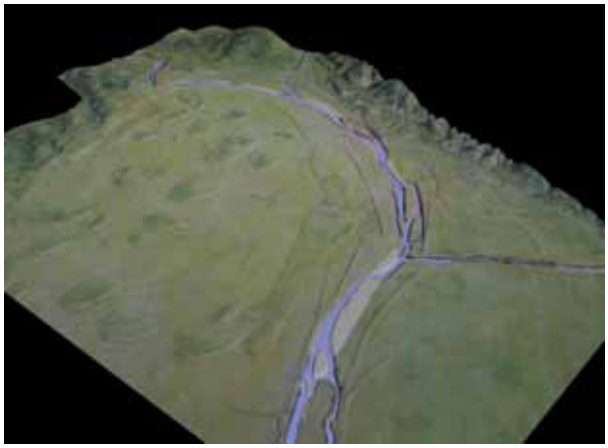


Figure.18 Flood animation for the second period

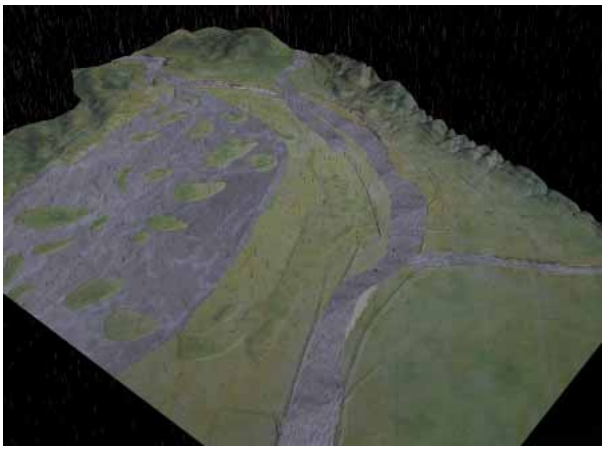


Figure.19 Flood animation after eruption of Mt. Fuji

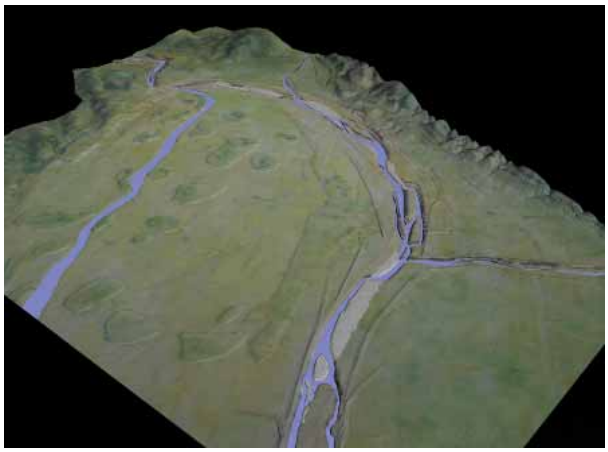


Figure.20 Flood animation for the third period

Furthermore, figure 21 and 22 shows flood animation of the open levee. The open levee has ability to control flood damage, and it can be realized the effectiveness of the open levee from these flood animation.

In addition, these flood animations are opened on the homepage of Chikatsu-laboratory, Tokyo Denki University. (http://www.chikatsu-lab.g.dendai.ac.jp/top.html)

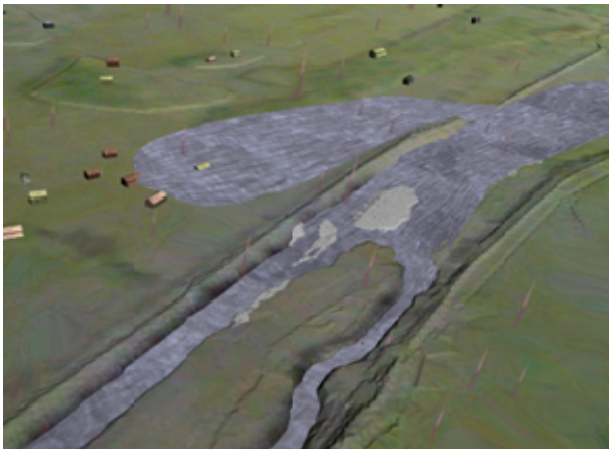


Figure.21 Flood animation before construction of open levee

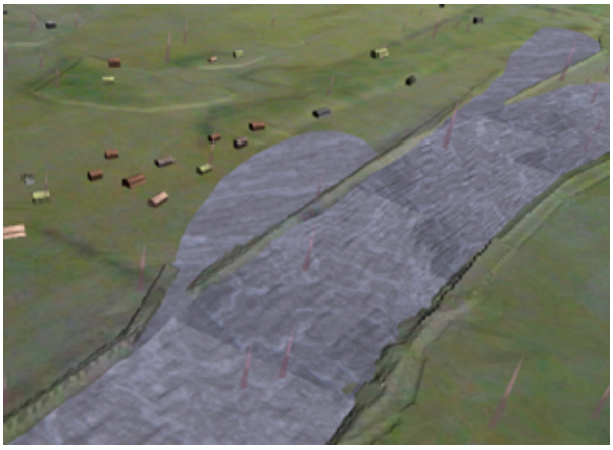


Figure.22 Flood animation after construction of open levee

## 6. CONCLUSION

3D visualization has ability to make intuitive understanding or to find out important elements that we can't detect in 2D information. In particular, visualization of history helps greatly to make understanding many historical backgrounds and factors of history through the computer at any time without going to the museum.

In order to evaluate the effectiveness of visualization of history, flood control history for the Sakawa River was investigated, in this paper. It was confirmed that visualization has ability to make intuitive understanding for all historical factors. In addition, visualization has also ability to make understanding role for the structures such as open levee or some specific embankments.

## 7. ACKNOWLEGEMENTS

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