Archive System to Browse the Roads in Miyagi Prefecture with Delayed Recovery after the 2011 Tohoku Earthquake

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***Abstract*—In our previous study, we identified the municipalities and each road within these municipalities for which road recovery was extremely delayed after the 2011 Tohoku Earthquake. In this study, we built an archive system to monitor these roads following the 2011 Tohoku Earthquake to identify and confirm the vulnerabilities of roads and raise their resilience. This system allows us to browse video images of vulnerable roads that are narrow, steep-walled, and located in mountainous regions. In Miyagi Prefecture, some of the vulnerable roads run near the coast lines. It was a little different from the situation of Iwate Prefecture that we had evaluated in our previous study. To date, we could identify the type of problematic roads using the proposed system.**

***Index Terms*—2011 Tohoku Earthquake; disaster archive system; disaster risk reduction; probe-car data; resilience to disasters; telematics data; vehicle-tracking map**

I. Introduction

A. Disaster archive system of the 2011 Tohoku Earthquake

Immediately after disasters such as the 2011 Tohoku Earthquake [1] [Figs.1 and 2], the people present in the disaster area are forced to focus on not only their survival but also the survival of their neighbors. After the situation settles down to some extent, people begin to consider sharing their experiences from the disaster with the next generation and utilizing these experiences for future disaster prevention. These disaster experiences could be of great interest to people for disaster prevention, not only in afflicted areas but also throughout Japan and the world. Therefore, we created an experimental archival system to preserve digital images from the disaster as archival material for the next generation [2].

B. Road usage recovery following the 2011 Tohoku Earthquake

In our previous work [3], [4], [5], we evaluated regional differences for road recovery in the Iwate Prefecture after the 2011 Tohoku Earthquake. For these studies, we used vehicle-tracking maps constructed from probe-car data that were made available on the Internet by Toyota Motor Corporation, Japan. In these studies [3], [4], [5], we also determined the municipalities and each road within these municipalities with extremely delayed road recovery after the earthquake.

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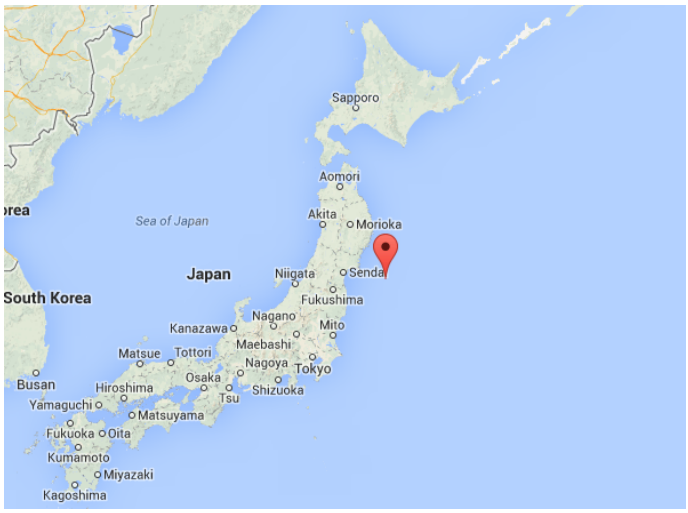

Fig. 1. The epicenter of the earthquake that occurred on March 11, 2011 in Tohoku (https://www.google.co.jp/maps/).

C. Purpose of this Study

In this study, by combining the scopes of our studies [2], [3], [4], [5], we built an experimental archival system for browsing roads with an extremely delayed recovery after the 2011 Tohoku Earthquake. The purpose of this system is to help identify the vulnerable road components to raise overall road resilience.

Our previous study [6] was focused on the entire area of Iwate Prefecture. On the other hand, the current study is focused on the entire area of Miyagi Prefecture (i.e., the Inland, Southern Coastal, and Northern Coastal areas) [Fig.4]. This study is one of our serial studies as to the disaster archive and the disaster risk reduction.

II. Methodology

A. Research area

All areas of the Miyagi Prefecture afflicted by the 2011 Tohoku Earthquake [Figs.3 and 4].

B. Research materials

In this study, we used video data for the roads in the Miyagi Prefecture with extremely delayed recovery after the 2011 Tohoku Earthquake. The video images were captured in the afflicted area of the Miyagi Prefecture, following post-disaster road recovery.

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Fig. 2. The epicenter of the earthquake that occurred on March 11, 2011 in Tohoku (magnified, https://www.google.co.jp/maps/).

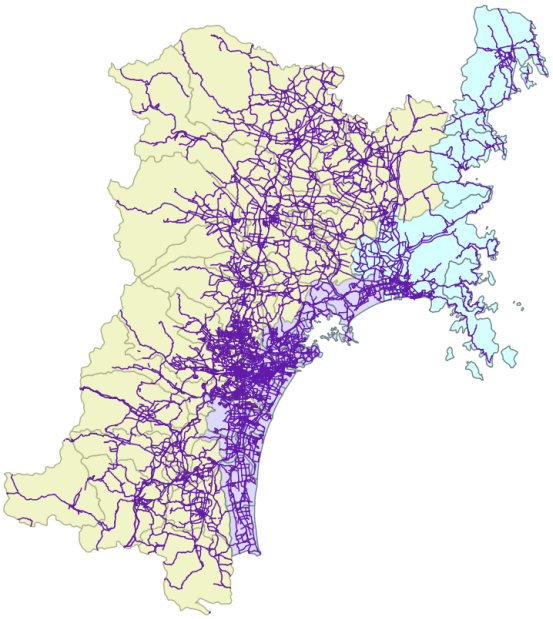

Fig. 3. Vehicle tracking map of Miyagi Prefecture

C. System

1) The server for providing the content: Hardware: a PC server assembled by the author

Software: The operating system(OS) was Linux. Apache HTTP server was used as the HTTP server software.

2) The client for creating the content: Hardware: a PC client

Software: Notepad was used for writing and editing the code of the system. The system was deployed on a web browser such as Firefox or Internet Explorer.

3) The role of the local server: We used the server for serving HTML, ASX files, and video data to the clients. The ASX file functions will be mentioned in the following section.

4) The role of the web service: We used the Yahoo! JavaScriptMap API as the platform (the developing environment which was provided by Yahoo Japan) to draw background maps. Accordingly, the system was programmed in JavaScript. Using this web service, we could build a sophisticated system rather easily.

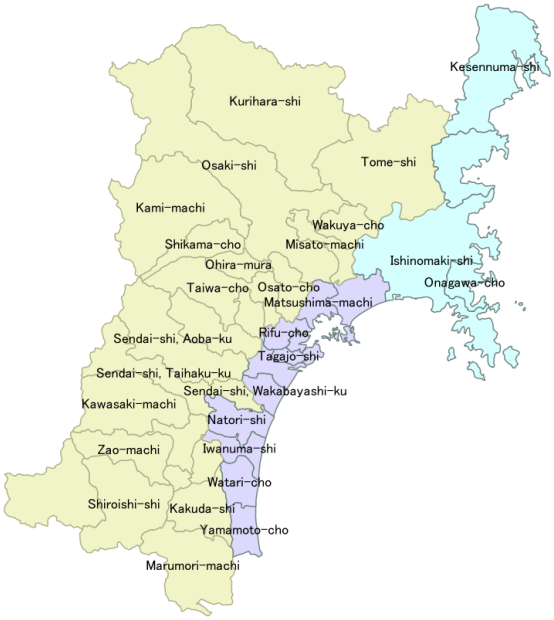

Fig. 4. Miyagi Prefecture divided into Inland, Northern Coastal, and Southern Coastal areas. The perimeter of a city is shown by a gray polygon.

III. Construction of the Archive

The method used in this study was similar to the one used in our previous study [2].

By linking video data and high-resolution satellite images, captured in the target earthquake disaster area, with the digital map of the area, we built an archival system for browsing disaster images clearly and easily.

A. Specifying the exact route of the video

Images uploaded on the Internet do not often have exact geospatial attributes and exact route attributes. Therefore, initially, we specified the start point, midpoints, and end point of the video file. We watched the video and map of the location in the video simultaneously. The routes in the video were specified based on the signs of structures such as buildings and roads. We recorded the route information as a geospatial attribute.

B. Making links from each node to the video scene

We measured the time from the initial node to each node and made ASX files to play the video between two nodes (beginning node to end node) by clicking on the beginning node. We used the Yahoo! JavaScript Map API to link the map images and ASX files. This has been illustrated in Figs. 5, 6, 7, and 8.

C. The role of ASX files

An ASX file is a type of Windows meta file that makes it possible link web pages and Windows Media Audio (WMA) servers or web server content. Using an ASX file, we were able to control the playback of Windows Media Video

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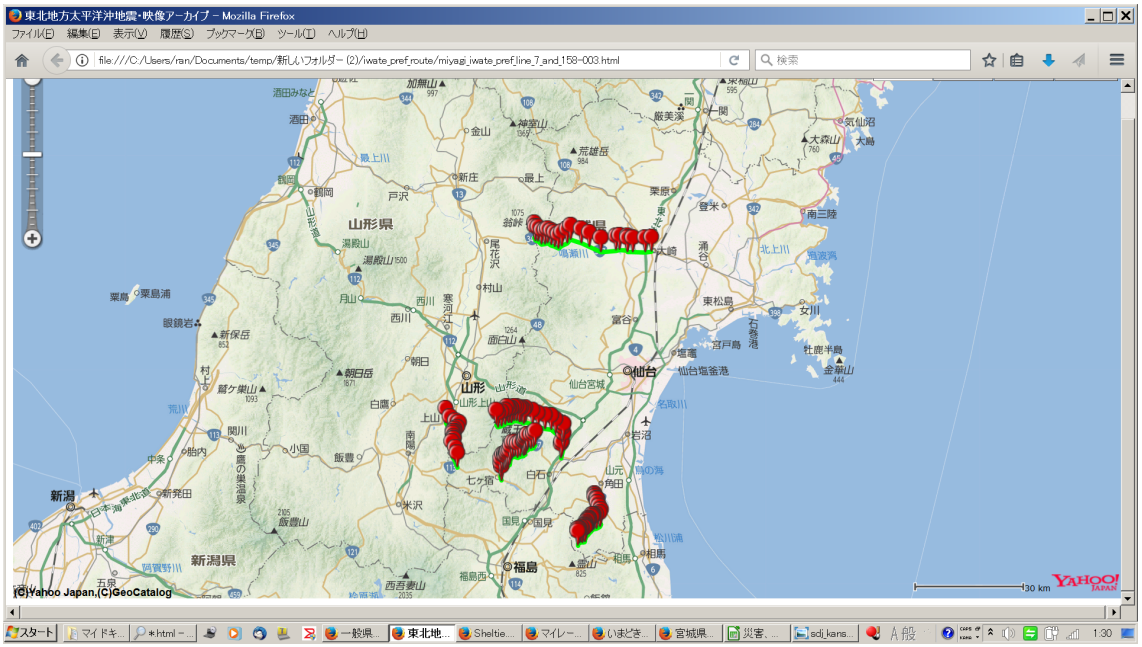

Fig. 5. An example map for browsing the roads with an extremely delayed recovery following the 2011 Tohoku Earthquake.

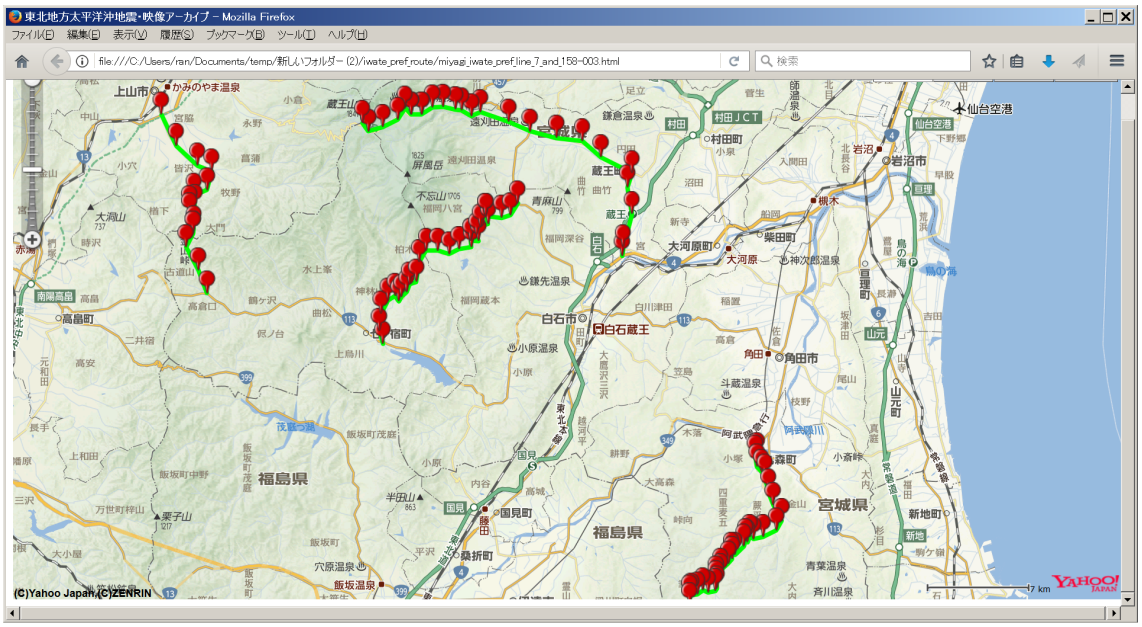

Fig. 6. An example map for browsing the roads with an extremely delayed recovery following the 2011 Tohoku Earthquake(magnified). Left one indicates Miyagi Prefectural Road number 13 (Kaminoyama-Shichigashuku line). Middle upper one indicates Miyagi Prefectural Road number 12 (Shiroishi-Kaminoyama line). Middle lower one indicates Miyagi Prefectural Road number 51 (the Minamizao-Shichigashuku line). Right one indicates Miyagi Prefectural Road number 45 (Marumori-Ryozen line; near Hippo).

(WMV) files. We could specify the beginning of the video by using the StartTime tag. Additionally, we could specify the playback duration time of the video using the Duration tag. This made it possible to set multiple playback patterns for one video file. Therefore, in this study, we were able to consider a video without any geospatial attributes as one with geospatial attributes.

IV. Results

A. Archive System Operation

Figures 5 and 6 depict the example map containing the routes of the video data taken around Miyagi Prefectural Route 12, 13, 45, and 51. This map also contains the routes of the video data taken around National Route 307.

System users can play the video between two nodes (the beginning and end nodes) by clicking on the beginning node on the map [Fig.7]. When the cursor is pointed at each node, the number of the nodes appears at the bottom of the map.

B. Difference between Miyagi and Iwate Prefecture

In Miyagi Prefecture, some of the vulnerable roads run near the coast lines [Fig.8]. It is a little different from the situation of Iwate Prefecture that we reported in our previous study [6].

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Fig. 7. A video image of the road with an extremely delayed recovery following the 2011 Tohoku Earthquake (Miyagi Prefectural Road 13).

Fig. 8. A video image of the road with an extremely delayed recovery following the 2011 Tohoku Earthquake (Miyagi Prefectural Road 225).

V. Discussion

A. Upgrading public Internet images to geospatial data

Although the images provided by the media, such as TV stations, were useful with regard to the 2011 Tohoku Earthquake, the images uploaded on the Internet proved to be more informative. However, images uploaded on the Internet usually have no exact geospatial attributes. In particular, the route information is completely absent. This means that they do not have much value as geospatial data.

Accordingly, in this study, we added routing data to images uploaded on the Internet to upgrade them for their use as geospatial data. Finally, we accumulated the data to build an earthquake disaster archive of the 2011 Tohoku Earthquake. We particularly looked for images from areas around main roads because we considered that most people would be interested in information about the roads. These images can be used for the disaster education of both children and adults and hopefully in preventing a future earthquake disaster.

B. About research materials

In the WCECS 2017 conference, we recieved some responses on our previous study [6]. They were about the accuracy and the quality of video images which were uploaded to the Internet (such as images on YouTube service).

As for the video accuracy, we are usually able to confirm the road number by the sign boards beside roads. There is usually no problem of it.

On the other hand, we quite agree with the paticipant for the video quality. In some cases that we can not obtain high quality images, we had better use the video image which are taken for ourselves instead of the images which are uploaded to the Internet.

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C. Problem of Copyright

In general, we can not edit and reuse video movies uploaded to the Internet without authors' permission. If an archive system has many data, it may be very complicated to get all authors' permission. So, if an author permit the edit and the reuse of his video works, the Creative Commons License may be recommended. This is one of the best solutions to avoid complicated processes when a person other than authors would like to build an archive.

D. Problem of Map Update

Using the Web service, we could build the Tsunami disaster archive rather easily and economically. Though the Web service system contributed very much for our system, the map update of the Web service will be contrarily rather unfavorable for the 3.11 disaster map. That's because we need the map layer when the 2011 Tohoku Earthquake occurred for our system. If the Web service would keep containing the map layer above described for a long time, we would appreciate it very much.

E. Roads vulnerable to the next disaster

Using this system, we could browse the video images for vulnerable (problematic) roads. These roads were narrow, steep-walled, and located in mountainous regions. They were just what we had expected from the results of our previous study [5].

Until now, we were only able to identify the type of problematic roads but had not developed techniques to increase their resilience. The next step is to identify the vulnerable points on the roads in detail. To realize this, we have to collect the documents containing the recovery history of the roads and evaluate them in future studies.

F. High quality drive recording system with GPS function

Currently, some kind of drive recorders have a high quality recording function. This kind of recorders usually have a Global Positioning System (GPS) function as well.

So, if there were no problems with their accuracy and stability, we could record geo-referenced video images more easily.

For this reason, we would like to evaluate this type of video equipment in our future studies.

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