Analysis of Vehicle Tracking Maps in Iwate Prefecture Following the 2011 Tohoku Earthquake

Noriaki Endo, Member, IAENG, and Hayato Komori

Abstract—We calculated the usable distance of the main roads in the coastal area of Iwate prefecture following the 2011 Tohoku Earthquake. Calculations were based on a vehicle tracking map built from G-BOOK telematics data using QGIS, an open source geographic information system. The main findings are as follows.

1) The change in the accumulative usable road distance ratio during the research period differed by city.
2) The ratio increases in the usable distance of Kuji, Iwaiizumi, and Noda were extremely delayed.
3) In our previous study, we determined that the use of the main road in the southern coastal area of Iwate prefecture was completely recovered by April 29, 2011.

However, in this study, when we precisely observed the change in the usable road distance ratio during the research period for each city, the ratio increase in the usable distance of Kamaishi was delayed compared to other southern coastal cities.

Index Terms—2011 Tohoku Earthquake; G-BOOK telematics data; Iwate prefecture; big data

I. INTRODUCTION

A. The 2011 Tohoku Earthquake

When the March 11, 2011 Tohoku Earthquake [Fig. 1] struck, the northeastern coast of Japan was severely affected by the subsequent tsunami.

Following the earthquake, electricity, water, and gas supplies were shut down in both coastal and inland areas. In addition, road travel was shut down in many locations in the region.

B. Previous study

Our previous study [1] focused on the use of the main roads in the southern coastal area of Iwate prefecture [Fig. 2]. The usable distances of the main roads following the 2011 Tohoku Earthquake were calculated from G-BOOK telematics data [2].

The main findings were as follows.

1) The usable distance of the roads in a weekly period increased continuously from March 18 to April 7, 2011, but fluctuated thereafter.
2) Defining the accumulative usable distance up to September 30, 2011 as 100%, it was determined that 80% of the road distance was usable by April 7, 2011 and 90% by April 29, 2011.
3) Use of the main road in the coastal area of Iwate prefecture was completely recovered by April 29, 2011.

N. Endo and H. Komori are with Iwate University, Morioka City, Iwate, Japan e-mail: (see http://www.hss.iwate-u.ac.jp/endo/).

II. TELEMATICS DATA AND VEHICLE-TRACKING MAP

Telematics is a general term encompassing telecommunications and informatics. A telematics service provides various personalized information for users, especially for drivers of automobiles. G-BOOK is a telematics service provided by Toyota Motor Corporation.

To calculate the usable distance of the main roads, we applied the vehicle tracking map originally created by Hada et al. [3] after the 2007 Niigataken Chuetsu-oki earthquake.

That vehicle tracking map was based on telematics data provided by Honda Motor Company. Similarly, in our study, we used the vehicle tracking map based on telematics data provided by Toyota [ks G-BOOK system [Figs. 3 and 4].

Registered members of G-BOOK can access telematics services to acquire GPS data for car navigation systems and interactive driving data, such as traffic jam points, road closures, and weather reports.

Such comprehensive data acquisition is possible because the telematics system server receives accurate location data (geographic coordinates) from its registered members.

Telematics services are extremely useful to drivers. Because the accurate driving routes of registered users remain in the system server, they are accessible to traffic researchers in various fields.

III. RESEARCH METHODS

A. Research area

Our previous research [1] focused on only the southern coastal area of Iwate prefecture [Fig. 4].

The current study has focused on the entire coastal area of Iwate prefecture (i.e., both the southern and northern coastal areas).

B. Research materials

This study used the vehicle tracking map built from G-BOOK telematics data, which, in the aftermath of the 2011 Tohoku Earthquake, was made available on the Internet on March 17, 2011 [2].

The data used in this study were collected between March 3 and September 30, 2011 (approximately six months after the 2011 Tohoku Earthquake).

C. System

Hardware:
Calculations were performed on a standard laptop PC with a Core i5-4200U CPU (1.6 GHz) and 4 GB memory (SONY VAIO PRO 11).

Software:
The software used in this study was QGIS version 2.6.1 (the latest version at the time) [5] and LibreOffice Calc 4.2.7.
IV. RESULTS

We calculated the usable distance of the main roads in the coastal area of Iwate prefecture following the 2011 Tohoku Earthquake.

Calculations were based on a vehicle tracking map built from G-BOOK telematics data utilizing open source software, i.e., Linux, ogr2ogr, QGIS, and LibreOffice Calc.

We calculated the accumulative usable road distance ratio of the main roads for each city in the region [Fig. 5].

1) The change in accumulative usable road distance ratio during the research period differed by city.
2) The ratio increases in the usable distance of Kuji, Iwaiuzumi, and Noda were extremely delayed.
We could determine related roads by analyzing the maps generated by QGIS software.

For Kuji and Iwaiuzumi, delays were mostly dependent on Iwate Prefectural Road number 7 (Kuji-Iwaiuzumi line).

For Noda, the delay was mostly dependent on Iwate Prefectural Road number 273 (Akka-Tamagawa line).

3) In our previous study [1], we defined the accumulative usable distance up to September 30, 2011 as 100%. Note that 80% of the distance was usable by April 7, 2011 and 90% by April 29, 2011. And we determined that the use of the main road in the southern coastal area of Iwate prefecture was completely recovered by April 29, 2011.

However, in this study, when we precisely observed the change in the usable road distance ratio during the research period for each city, the ratio increase in the usable distance of Kamaishi was delayed compared to other southern coastal cities.

For Kamaishi City, the delay was mostly dependent on Iwate Prefectural Road number 249 (Sakuratoage-Heita line).

V. DISCUSSION

In this study, all application software used was open source software. The performance of the software used was very high and could satisfy all the required functions properly.

According to our results, we consider that the recovery condition of the regional roads after the 2011 Tohoku Earthquake differed by city.

To improve the resilience of regional roads, we should enhance roads whose utilization was more delayed compared to other roads.

Alternatively, construction of bypass roads for such roadways would significantly contribute to the resilience of the region.

We believe that the recommended enhancements should be realized before the next large disaster occurs.

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Fig. 1. Center of the 2011 Tohoku Earthquake occurred on March 11, 2011.

Fig. 2. Main roads in the southern coastal area of Iwate prefecture.
Fig. 3. Vehicle-tracking map of eastern Japan.
Fig. 4. Vehicle-tracking map of Iwate prefecture, shown by violet lines. The perimeter of a city is shown by a gray polygon.

Fig. 5. Accumulative usable road distance ratio. Vertical scale displays the accumulative distance proportion of usable roads (relative to accumulative distance on September 30, 2011) for each date.