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Investigate on automation of earthquake damage estimation system

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ABSTRACT

This paper describes a new automatic estimation system of seismic damage. By this system, the damages in an urban area due to a mega earthquake can be estimated in 30 minutes by reducing the focused area automatically.

INTRODUCTION

To prevent the damage caused by disasters is a very important issue, even in these days. However, it is unrealistic to do it perfectly. When a mega earthquake occurs, the quick and accurate deployment of rescue teams is necessary. In the South Hyogo prefecture earthquake in 1995, the rescue activities by neighborhood who lived in damaged area worked effectively because the neighborhood generally knows their situation instantly, while the ambulance service could not know the prior information.[i]

To solve the problem, a damage estimation system was developed. This system uses the average velocity of observation point and each mesh data which was made by a national census. For quick rescue, it is necessary to calculate faster. At Kobe city, Hyogo in 1995, 10% of victim could survive if the rescue got in 15 minutes[ii] based on an accurate information. However, usual estimation system is manual, so that it is difficult to calculate in midnight or holiday. In this study, an automatic system is developed. Moreover, it is necessary to use more accurate indices based on the vibration data and the national census for more exact rescue. Because of the limitation of the budget, it is difficult to set more observation points, though it is the best way.

The purpose of this study is to propose a new method of faster calculation by reducing the estimation area without decreasing accuracy.

EARTHQUAKE DAMAGE ESTIMATION SYSTEM

There are official index such as “Magnitude” and “Scale of Earthquake”, which Japanese government uses. However, in this study, another index which uses critical periodic band is applied to estimation because it corresponds the actual damage better than estimation based on the official ones.[iii] And we didn’t only calculate damage rate but also number of people in the collapsed building because it is more useful than damage rate to know situation of damage.

Earthquake damage estimation system requires a vibration data of observation point for calculation. The spectrum of the vibration data is interpolated on whole area by triangle linear interpolation. The damage rate of each mesh is estimated by the interpolated data and damage function[iv].Finally, the number of people in the damaged building is calculated by the damage rate and data of number of people in the building which was predicted from census population database.[v]

DEVELOPED AUTOMATIC SYSTEM TO ESTIMATE DAMAGE OF EARTHQUAKE

First, to solve the problem which is difficult to estimate in midnight and holiday, we developed automatic estimation system which has watched home page of NIED (National Research Institute for Earth Science and Disaster Prevention) without special calculator.

Second, the usual system used map which cannot be zoomed in and out after output. But we enabled to indicate on google map by using Google Maps API.

Finally, to examine this system, we experimented it about 4 passed earthquakes which is called Noto Hantou Earthquake in 2007(**NH-2007**), The Niigataken Chuetsu-oki Earthquake in 2007(**NCO-2007**), The Iwate-Miyagi Nairiku Earthquake in 2008(**IMN-2008**), and Tohoku Region Pacific Coast Earthquake in 2011(**TRPC-2011**).

RESULT OF EXPERIMENT

The parameters of four earthquake cases are **Table 1**. The parameter of **TRPC-2011** is much large than others. Estimation time is **Table 2** and number of mesh which has damaged building is **Table 3**. The result shows high accuracy comparing with the actual damage and passed estimation (**Figure 2**, **Figure 3**, **Figure 4**). The number of outputted mesh is enough small to display except **TRPC-2011**. It can also display on portable device like smartphone. Figure.1 – 5 are view of google map for each earthquake.

Each map fits real data and passed estimation. But map of **TRPC-2011** cannot display on usual computer because program of Google Maps API is written by JavaScript, so that it needs over spec for computers to describe mesh. We solved the problem to reduce storage which has useless data.

However, this way can be used for **TRPC-2011** only because vibration characteristic of **TRPC-2011** has different periodic band with critical one and there were less damage by quake.[vi] If mega earthquake which has critical characteristic occurs, estimation cannot display because of over capacity.

Besides, estimation time of **TRPC-2011** was 2 hour over. It was too longer to supply rescues, and this result shows that larger damage, the longer time and larger capacity of data. As long as setting up calculator which can calculate whole of country is not realistic, it is efficient to restrict calculated area.

RESTRICTION OF ESTIMATED AREA

In the past method, the estimation system calculated whole quaked area. But in **TRPC-2011**, calculation time becomes over 2 hour. And the estimation time of **TRPC-2011** is almost occupied by time of read and interpolation (**Figure 5**). For example, when we calculate 10 times 6 mesh which is 60 mesh in green box on **Figure 6**, the estimation time will be about 10 minutes without less accuracy because damage is calculated by only 3 observation point around them.

Table 1 Parameters of the subjected earthquake

	NH-2007	**NCO-2007**	**IMN-2008**	**TRPC-2011**
The Name of Earthquake	Noto Hantou Earthquake	Niigataken Chuetsu-oki Earthquake	Iwate-Miyagi Nairiku Earthquake	Tohoku Region Pacific Coast Earthquake
Amount of data（MB）	225	236	168	458
Mesh toward longitude(num.)	98	127	150	1821
Length toward longitude（km）	49	63.5	75	910.5
Mesh toward latitude(num.)	98	73	78	506
Length toward latitude（km）	49	36.5	39	253
Whole mesh(num.)	9604	9271	11700	921426

Table 2 Parameters of the subjected earthquake

	NH-2007	**NCO-2007**	**IMN-2008**	**TRPC-2011**
The Name of Earthquake	Noto Hantou Earthquake	Niigataken Chuetsu-oki Earthquake	Iwate-Miyagi Nairiku Earthquake	Tohoku Region Pacific Coast Earthquake
Download data	270	287	288	512
Decompressed	22	22	36	32
Estimation and Mapping	348	331	251	7244
Total Time	640	640	575	7788
Total Time written by minutes	10.7	10.7	9.58	129.8

(Unit: sec)

Table 3 Parameters of the subjected earthquake

	NH-2007	**NCO-2007**	**IMN-2008**	**TRPC-2011**
The Name of Earthquake	Noto Hantou Earthquake	Niigataken Chuetsu-oki Earthquake	Iwate-Miyagi Nairiku Earthquake	Tohoku Region Pacific Coast Earthquake
Number of the outputted mesh	58	115	29	1859

Figure 1 Noto Hantou Earthquake in 2007(NH-2007), Anamizu in Ishikawa

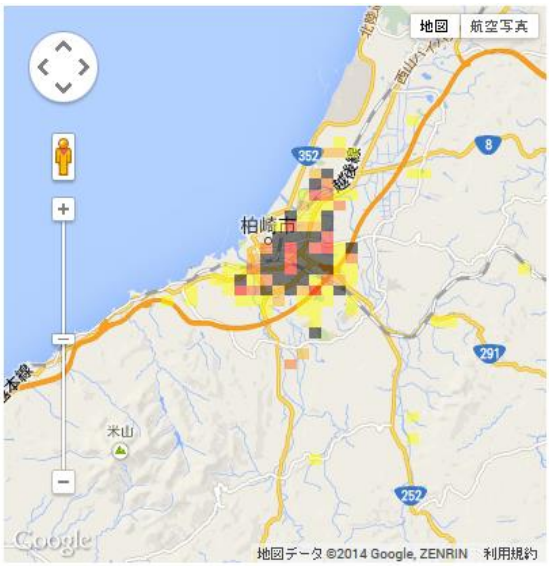

Figure 2 The Niigataken Chuetsu-oki Earthquake in 2007(NCO-2007), Kashiwazaki in Niigata**.**

Figure 3 The Iwate-Miyagi Nairiku Earthquake in 2008(IMN-2008), Osaki in Miyagi

Figure 4 Tohoku Region Pacific Coast Earthquake in 2011(TRPC-2011), the middle part of Miyagi

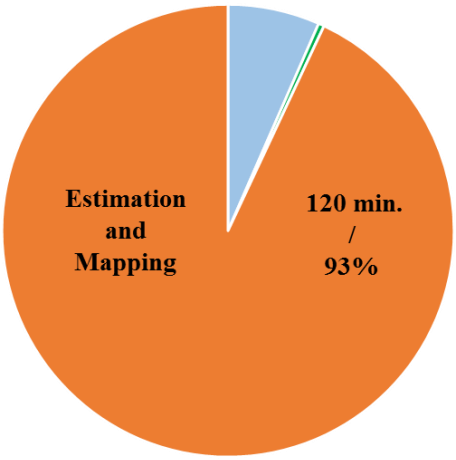

Figure 5 Rate of calculation time in TRPC-2011

Figure 6 Damage estimation result for Tohoku Region Pacific Coast Earthquake in 2011(TRPC-2011), Center of Osaki in Miyagi

CONCLUSION REMARKS

In this paper, we propose automatic earthquake damage estimation system and new method to reduce estimation time by restricting calculated area. Automatic system is efficient to estimate when we cannot run the program. Almost estimation time of sample earth quake is less than 15 minutes, but in case of mega earthquake like Tohoku Region Pacific Coast Earthquake in 2011, it is suggested to take a long time for estimation by result of this experiment. To reduce the time substantially, we proposed restricting calculated area and estimate the time by restricting.

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