3D Visualization of Earthquake Big Data

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***Abstract*—Visualization is one of the most intuitive and perceptible way for information representation. It is especially true for data which is too complex, or too large to be easily handled. Many visualization techniques are developed for effectively representing different type of information. However, few of them dealt with the earthquake big data.**

In recent year, strong earthquake disasters occur very frequently around the world. Many scientists suggested that earth has entered the active seismic period. Taiwan is located in a seismically active zone, too. Therefore, in this project, we developed a 3D visualization system which aims to further enhance users' awareness of earthquakes in Taiwan.

Keywords—3D Visualization, Big Data, Earthquake, information representation

I. Introduction

Taiwan is located at the junction of the Eurasian plate and the Philippine Sea plate. These two plates are continuously colliding and squeezing with each other. And these plates collisions cause more than 20,000 earthquakes to happen every year in Taiwan. In fact, in the Jiji earthquake on 21 September 1999, 2,415 people were killed, and 11,305 injured in Taiwan.

Geographically and geologically speaking, Taiwan and Japan are very close to each other. Both of these two areas are located in a seismically active zone, within so called the Pacific Ring of Fire. In comparison with Japan, most of the earthquakes registered in Taiwan did not cause significant damage just because they occurred at the east seabed, or coast where is sparsely populated. And this may be one of the reasons why Taiwanese are much more indifferent with the issues of earthquakes than Japanese.

When an earthquake occurs in Taiwan, most people used to access the information only through television or from the Central Weather Bureau website. In general, there will be an earthquake report available in the form of 2D map containing the information of epicenter, magnitude, and intensities about 5 minutes after the earthquake.

However, earthquakes can also possibly cause the secondary disasters. For example, on March 11th, 2011, the Tōhoku earthquake occurred in Japan. This earthquake caused a serious tsunami. Ninety percent of the deaths in this disaster were caused by the tsunami. Following the earthquake and tsunami, Fukushima Daiichi Nuclear Power Plant had the nuclear accidents. Moreover, the Tōhoku earthquake happened in March. And the average temperature at Tōhoku region was less than 10 ℃. The low temperature reduced the survival rates.

On the other hand, with the popularization of Internet, people share and exchange information on Facebook, Twitter, and other social networking platforms every day. Many reports have been published to suggest how social networks can be utilized for supporting the disaster response, rescue efforts, and community recovery. There are still some limitations and weaknesses of social networks, such as rumors, fake news, and failure of electric power. However, users' opinions still serve as an interesting index to an earthquake.

As mentioned above, the information of earthquakes contains so tremendous, dynamic and diverse data sets. Therefore, it is consequently necessary to represent earthquake information through an effective visualization system.

II. Related Work

A. Big Data

Big data refers to a huge data set that cannot be retrieved manually nor manipulated on a single computer in a reasonable time [1]. In this information age, every day, every minute, big data is being created and accumulated on the Internet with a continuously increasing speed.

Earthquake information is undoubtedly a kind of big data. It also complies with the four definitions (4Vs) of big data: Volume, Velocity, Variety [2] and Veracity. [3] First, from the past to the present, there are a tremendous amount of seismic data been recorded and studied. And second, in fact, earthquakes are always happening. According the reports of US Geological Survey, there are averagely 130,000 earthquakes located each year in the world. Thus the amount of earthquake data is continuously growing. Third, the earthquake information may not just contain the epicenter, magnitude and intensities, but also the information of secondary disasters, weather, life line supports, and so on. This information may also be in different formats, such as text, pictures, or movies. Finally, there are also the veracity issues exist, but an official earthquake report is expected to be published by the government. [4]

B. Data Visualization

Using graphics to transmit the messages effectively is the purpose of data visualization. Both of the aesthetic and functionality issues need to be considered for visualization.

For human beings, the speed of the message transmitted through images is faster than through plain texts. H.C. Chen indicated that users can absorb information more effectively and produce a stronger memory through visually represented data [5]. Many visualization techniques have been developed for representing different type of information. [6]

For earthquake information, there are two seismic visualization system available in Taiwan currently. The first system integrates the historical seismic data from Wikipedia. Showing the epicenter of the earthquake and the number of deaths. Data are available from 1736 to 2013. This system is no longer updated with new information. The second system illustrated the epicenter, depth and Richter magnitude scale of earthquakes from 1995 to 2015, based on the information from the Central Weather Bureau. Both of these systems provided limited information only, with limited visual performance and interactions. [8]

III. System Architecture and Implementation

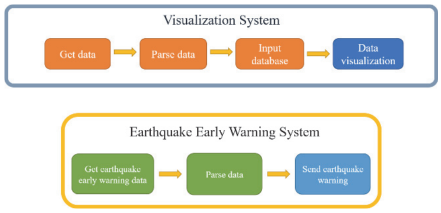

Fig. 1. System architecture

As shown in Fig. 1, our system can be divided into two parts: a visualization system in the blue box, and an earthquake early warning system in the yellow box.

A. Collecting earthquake information

We use the Central Weather Bureau's data as our data resource. After an earthquake strong than Magnitude 3.0 happened, the CWB will publish an earthquake report on its website in five minutes. Our system crawls the time, epicenter, Magnitude Scale, depth and the seismic intensity from the CWB's website. And stored the above data since 1992 until now into our database.

Moreover, as shown in Fig. 2, we integrate and visualize the collected data in a three dimensional manner. The red ball represents the epicenter and the number on it represents the Magnitude Scale. The height of each column indicates the magnitude measured by each observation station in Taiwan. This visualization window is developed by using the WebGL API, so our system can be used on cross-platforms.

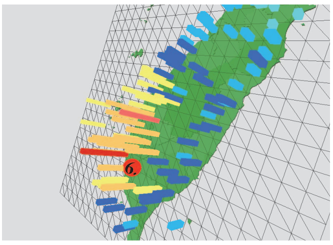

Fig. 2. 3D visualization window.

B. Collecting the opinions on PTT

PTT is the largest bulletin board system (BBS) with more than 1.5 million registered users in Taiwan. It provides an online platform for users to post more than 20000 articles and 500000 comments every day. If user want to comment on an article, there are three modes can be chosen: commendation, criticism and general publication. Commendation represent the approval to the article and criticism is the opposite. Based on this mechanism, we can easily know the users' emotion to the article.

The system uses the PTT Crawler program to automatically crawls the title, text content, and time of articles on PTT.

Then we parse these data to extract keywords and construct a keyword table. In the prototype system, for the research convenience, we manually assigned the emotion values to each keyword, where "-1" means negative word, "1" means positive word and "0" is neutral. After then we count the numbers of negative and positive keywords to determine the scores of the article per day.[9]

C. Collecting other relevant information

A great amount of information, which may be associated with earthquakes, can be retrieved from the governmental open data platforms. For example, the information about fault zones and soil liquefaction in Taiwan is available at http://data.gov.tw/. And the above information is also visualized in our system.

D. Early warning system

In order to get the early warning data, we have signed an agreement with Taiwan Central Weather Bureau Seismological Center. We also developed a simple robot which keeps monitoring the early warning data through the Messaging API. When a warning message from CWB SI is detected, it will be immediately forward to our users through Facebook messengers.

IV. EXPERIMENT RESULTS

Fig. 3 illustrates the website interface of our 3D visualization of earthquakes. In the main window, red ball indicates the epicenter, and the number on red ball means the Richter magnitude scale. The position of each column stands for the location of the observatory. The color means the strength of intensity. And the black lines on map shows the fault zones. The time when the earthquake happened is shown in the upper left corner.

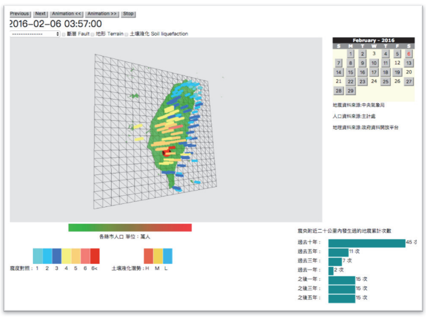

Fig. 3. System interface

Users can switch to the previous or next window by clicking the relative buttons on the top menu bar, or jump by directly choosing the day icons on the upper-right calendar. Furthermore, users can watch a continuous animation of all earthquakes occurred within a user-defined period of time.

A statistical chart, which shows the sum of seismic magnitude of an individual observatory, will popup when users enter a place name and choose the time unit. For example, Fig. 4 is the summary graph in Nantou, Taiwan.

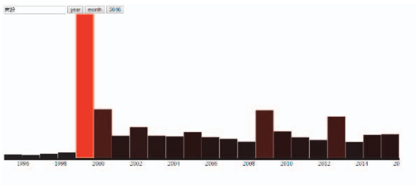

Fig. 4. Earthquake data of Nantou

Users can also check the numbers of articles about earthquakes on PTT. For example, in Fig. 5, the quantity of article in February is higher than other months in 2016, because the 206 Kaohsiung earthquake happened and caused widespread damage and 117 deaths.

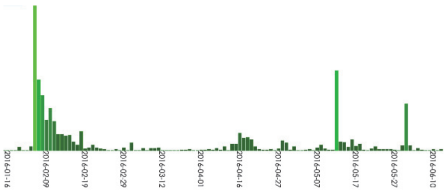

Fig. 5. The number of articles of earthquakes on PTT

The emotions of these articles are also visualized, where red bars mean negative scores and green bars mean positive scores. For the example of 206 Kaohsiung earthquake, when people or pets are successfully rescued, the averaged emotion of articles shifts to positive as shown in Fig. 6.

When system get the early warning's forecast data from the CWB, the early warning messages will be immediately send to our users through Facebook messengers. In this message, the basic earthquake information such as expected earthquake arrival time, epicenter, and magnitude scale are all included (Fig. 7). After the earthquake, users can receive more information by sending a simple query to our system. Furthermore, users can investigate more details of earthquakes by entering our website to use our 3D visualization system of earthquake.

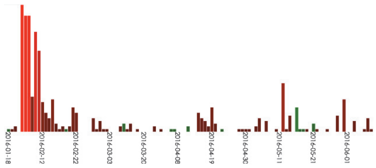

Fig. 6. The emotions of articles

V. Conclusion

In this paper, we proposed a multi-resolution 3D visualization system of earthquake big data. By zooming in/out, and rotating the map, users can obtain both overviews and detail views of earthquakes. Through this system, not only the information of epicenter and magnitude are visualized, but also other information such as fault zones can be chosen and represented. Furthermore, the spatial-temporal data of earthquakes are animated in timeline for users to observe the frequency and distributions of earthquakes.

System Web Site:

http://cgda.csie.ncnu.edu.tw/grass/new/earthquake/3dmap4.html

This project is supported by No. 106-2221-E-260-023.

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