Disaster Prevention System Utilizing Social Media Information

● Naoshi Morita ● Makoto Hayakawa ● Norisuke Takao

Information on disasters has conventionally been obtained by using physical sensors such as water/rain gauges, weather radars, and meteorological satellites, with national and local governments playing the central role. However, putting physical sensors in place requires time and is costly, and installing a sufficient number of them is not always possible. Fujitsu has worked jointly with the National Institute for Land and Infrastructure Management (NILIM) at the Ministry of Land, Infrastructure, Transport and Tourism. Together, we have researched and developed a system that can collect and analyze in real time the disaster-related information posted on social media by residents (social sensor system), and implemented it in society. The system can pick up information that is useful for grasping disaster situations out of a large amount of information (big data) by utilizing AI technology for location estimation and filtering out unnecessary information. In addition, it can estimate when and where a disaster is occurring at the municipality level by statistically processing the posted information collected. By using this feature and combining the information posted by residents (social sensor information) and the information from physical sensors installed in the field, the system helps disaster prevention personnel to make prompt decisions and carry out disaster-related activities. This paper describes our solutions to issues for realizing the social sensor system and outlines the system.

1. Introduction

Every year, Japan suffers natural disasters due to torrential rains that cause river overflows, inundation, and landslides. The sensing technology used in weather radar, meteorological satellites, etc. has advanced to be able to roughly capture large-scale meteorological phenomena such as typhoons. In recent years, however, short-lived, intensive rains have been increasingly frequent,[1] and there is increasing interest in grasping more localized, microscopic phenomena (e.g., so-called "guerrilla" downpours, landslides, and tornadoes).

The central and regional governments have been installing physical sensors, such as precipitation recorders, water level gauges (on rivers, dams, and reservoirs), water immersion sensors (urban and coastal areas), and wire sensors (slopes) in many places to maintain dams, rivers, roads, and other social infrastructure. However, localized disasters like landslides can occur anywhere in the country, making it almost impossible to ensure 100% monitoring coverage. Furthermore, when disasters will occur cannot be easily predicted, and relying entirely on the physical sensors alone would be a costly business.

Meanwhile, it has been some time since information about natural disasters began being circulated on blogs and other modes of social media by users such as local residents. Today, the provision of disaster-related information on Twitter and other media can be observed not only in urban areas but also in rural regions thanks to the widespread use of smartphones.

Taking this as an opportunity, the National Institute for Land and Infrastructure Management (NILIM) at the Ministry of Land, Infrastructure, Transport and Tourism and Fujitsu Laboratories have conducted a joint research project to explore the concept of supplementing the information that the existing physical sensors are unable to capture, such as occurrences or precursory phenomena of landslides, by means of a social sensor (people posting information on social media

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about the phenomena they experience or perceive in the real world).[2] We then employed a co-creation approach to aim to address social issues and arrived at a "social sensor system," which was then implemented in society.

This paper explains this social sensor system.

2. Previous situations and challenges

We considered Twitter as the social media service to utilize for the social sensor. Twitter is characterized as having more postings, being more in real time, and the information on the platform being more open to the general public than other social media services. However, the following challenges must be addressed in order to use social media to collect disaster-related information:

1) Need to estimate the location of tweets

Twitter has a location feature that enables users to add geographic coordinate information to their tweets using smartphones. Through data collection and analysis, however, Fujitsu Laboratories found that only 0.5% of the collected tweets had the coordinate information attached.[3] While the numbers of Twitter users and tweets are great in Japan, tweets with location information represent only 0.5% of all postings, making it insufficient as a data sample (or a data set). Therefore, a system must be developed that enables users to estimate the locations from which the tweets are posted using information other than attached location information.

2) Need to extract valid information

The social sensor system requires the information residents post upon directly perceiving a disaster taking place. In this sense, it is better to exclude media news and reports, information based on secondary sources, and retweets. It is necessary to filter out these pieces of information in order to make effective use of the information collected through social media in disaster-related activities.

3) Need to summarize a large amount of information (big data)

In the case of a natural disaster that covers a wide area, hundreds of thousands of tweets are posted in a day. It is impossible for a person to read them all manually. A system is needed that summarizes information and issues alerts based on the data from collected tweets.

3. Methods to address these problems

To address the challenges discussed in the previous section, we designed a social sensor system. We will outline its overall process, with **Figure 1** as a reference point.

The data processing at each stage after the data collection is as follows:

3.1 Estimation of locations

In order to address the problem that only 0.5% of all tweets had the location information attached, we applied a technique to estimate the location from the tweets to the system.

This technique employs a Japanese text analysis of user profiles and tweet texts. It applies a text analysis technology developed by Fujitsu Laboratories, which

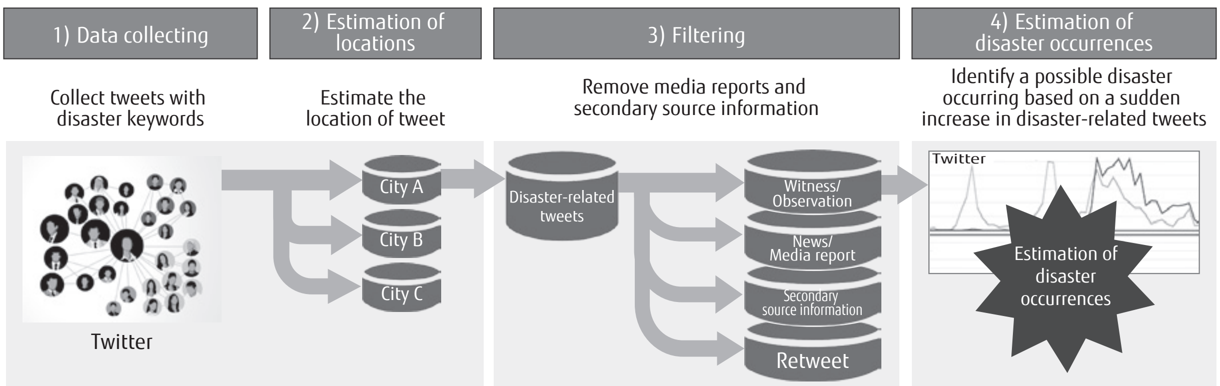

Figure 1
Overall process of the social sensor system.

enables the estimation of locations based not only on a dictionary of local names but also from information in context. For example, while there are Minato wards in Tokyo, Nagoya, and Osaka, the system can identify which city a mentioned Minato ward is in based on context.

3.2 Filtering

We introduced filtering technology into the system to enable the estimation of disaster occurrences, which we will describe in detail later. This uses a filtering engine based on AI technology and excludes tweets other than that posted by residents upon direct perception of a disaster taking place, including news, media reports, and information based on secondary sources.

In preparation for the application of this filtering engine, we had tens of thousands of tweets read by humans, who extracted news reports and information from secondary sources. These extracted data were used as a learning material, and the engine underwent machine learning, from which we created a classification model.

With this model as a reference point, the filtering engine accords scores to the information from news reports and secondary sources, and filters out unnecessary tweets based on the given scores.

While we employed this filtering engine to exclude media-based and secondary source information, the social sensor system may be employed with different filtering categories through machine learning, with different sets of learning materials.

3.3 Estimation of disaster occurrences through big data analysis

This feature statistically estimates occurrences of disasters based on a large number of collected tweets. The target disasters to be identified are the following three:

- River overflows
- Inundation
- Landslides

The system processes collected tweets statistically and facilitates the identification of occurrences of these disasters on the municipal level. Fujitsu Laboratories' unique method is applied to this tweet-based estimation feature with the capability to estimate the occurrences of disasters on the municipal level.[4)]

3.4 Superimposition of physical sensor data

For the system we have developed, we considered it beneficial to superimpose the data from the physical sensors onto the information gained through the social sensor system to more accurately understand the disaster-related information. Thus, we equipped the system with a feature to superimpose precipitation data from the radar on the map.

Conversely, the system also has a web application programming interface (API) to facilitate data output to other systems.

4. Display of social sensor system

Figure 2 illustrates the display that shows the social sensor system information with data from physical sensors superimposed. The standard display features of the social sensor system are implemented in a Web browser. The screen is divided into two panes arranged side by side.

1) Timeline display

The left pane of the display shows the timeline. Tweets taken from the Twitter service are displayed in chronological order to facilitate an easy understanding of the latest postings.

2) Map display

The map display shows the information processed by the social sensor system as well as GPS markers, location markers, results of disaster-occurrence estimation, and the data from physical sensors. The tabs at the top are used to switch the display to a list of images (in thumbnails) that are tagged to the collected tweets. The images thus collected are very useful for understanding disaster situations.

5. Effects of the new solution

The social sensor serves as a source of information that did not exist before, and it collects information that physical sensors cannot provide, filling the spatiotemporal information gap. The social sensor system is expected to provide the following benefits to disaster prevention personnel and other disaster-related activities:

1) Early identification of disaster situations

It potentially enables users to collect disaster-related information more quickly than relying on official reports from sites and media reports. A disaster response officer who used the social sensor system

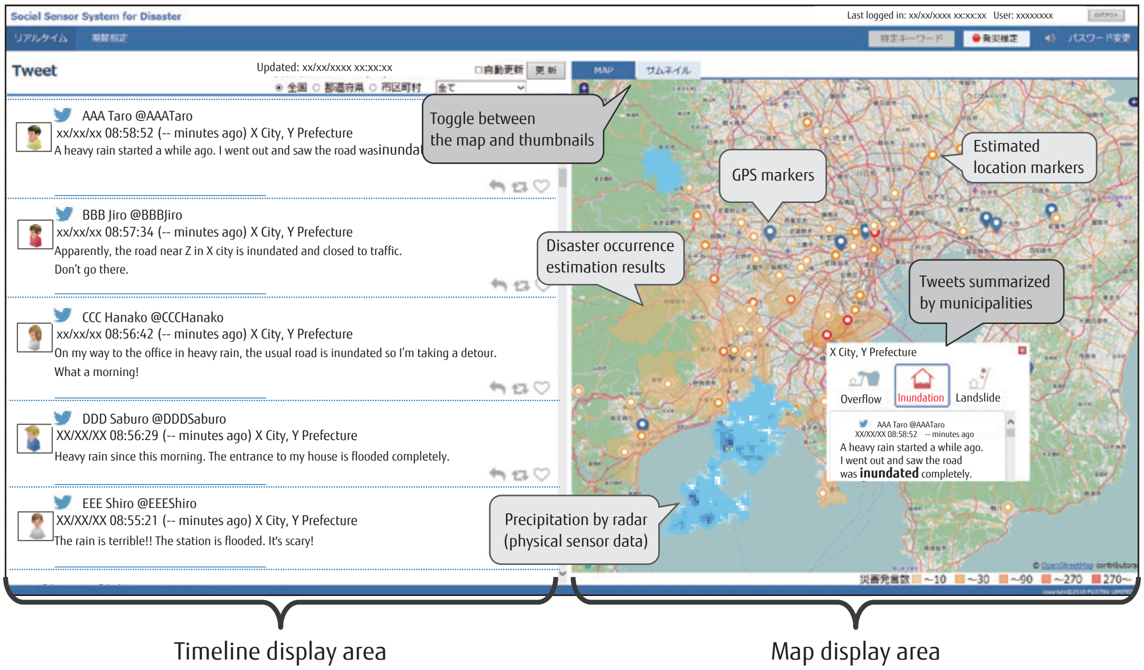

Figure 2
Social sensor system display.

in a trial commented in an interview that the system enabled them to gain information on landslides more quickly than by any other means.

2) Estimation of the locations of disaster occurrences

The system enables users to identify the areas where a disaster is most likely taking place, based on the data collected from Twitter. By issuing an alert triggered by the estimation results, it can serve as a prompt for initial responses in the event of a natural disaster.

6. Co-creation activities

The social sensor system has been put to social application as a result of the efforts to co-create it with customers. The efforts started from exchanges between Fujitsu Laboratories personnel and our customers who deal with landslide disasters. We then matched up the challenges (needs) in their pursuits with our technologies (seeds). Through this, Fujitsu Laboratories' basic research gained the attention of our customers and eventually we pursued a two-year joint research project with NILIM.[5]

During a trial in the joint research, we developed a simple app for collecting disaster-related information from social media, which disaster prevention personnel used in the field, and which they gave favorable and critical feedback regarding. Initially, a core feature was developed in a short period of time to be put to officers' use, and we examined their responses. Based on the results gained, we developed a method for the development of the social sensor system, then applied it in a social context.

7. Future direction

We are considering the following two points as potential future directions to take:

1) Further development of AI technology

The social sensor system has adopted FUJITSU Human Centric AI Zinrai technology,[6] which is applied to location estimation and noise filtering. We will continue enhancing the accuracy of analyses using the AI engine. We will also consider new applications such as new context filtering, different from the news reports and secondary source information filtering.

2) Platform compatibility

In order to realize knowledge integration to link knowledge in different areas and generate new value in the field of disaster prevention, it is important to connect disaster-prevention services on a platform. For this reason, the social sensor system also needs improved API features, thereby connecting to various systems and creating new value in the future.

By coordinating with other systems using the disaster-related information that is collected through the system, it can facilitate to create new value for customers in their disaster-prevention efforts.

We will continue our efforts to develop solutions that create new value by bridging knowledge in the area of disaster prevention.

8. Conclusion

The social sensor system has enabled us to collect disaster-related information from social media, but we did not consider that the system would cover all disaster situations. By adding more information sources to the social and physical sensors that we employed this time, a more comprehensive understanding of disaster situations will be possible. To achieve this, the concept of knowledge integration is useful. As examples of knowledge in the disaster prevention field, the following may be considered:

- Image data collected through the social sensor system
- Information taken from physical sensors (sensing data from observatory stations, radar, monitoring cameras, satellites, airplanes, drones, etc.)

In addition to disaster-related information that integrates data from physical and social sensors, reports and correspondence from officers and crews in the field and from relevant organizations, and the knowledge possessed by customers must inform judgments and decisions about strategies and disaster response initiatives. It is thus important that the social sensor system connects to various systems and creates new values for customers in the future.

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Naoshi Morita
Fujitsu Ltd.
Mr. Morita is currently engaged in the planning of national disaster prevention solutions.

Makoto Hayakawa
Fujitsu Ltd.
Mr. Hayakawa is currently engaged in the planning of national disaster prevention solutions.

Norisuke Takao
Fujitsu Ltd.
Mr. Takao is currently engaged in the development of systems for safety confirmation.

