Information Integrated Visualization System for Heavy Rainfall Risk Analysis

Masahiko Itoh*
National Institute of Information and Communications Technology, and The University of Tokyo

Takeshi Sagara†
InfoProto Co., Ltd.

Ukyo Suzuki‡
Picolab Co., Ltd.

Kazutoshi Umemoto§
National Institute of Information and Communications Technology, and The University of Tokyo

Naoki Yoshinaga¶
The University of Tokyo

Masashi Toyoda‖
The University of Tokyo

Koji Zettsu**
National Institute of Information and Communications Technology

Yutaka Kidawara††
National Institute of Information and Communications Technology

Abstract

This paper proposes an information integrated visualization system for heavy rainfall risk analysis. It utilizes multiple sensor data, such as weather data obtained from two kinds of weather radars and event information extracted from Twitter data, and visualizes the extracted risks from each sensor data. We show the effectiveness of the system by demonstrating a case study where a risky situation caused by a typhoon was analyzed using real data. The visualization results show the typhoon caused many problems, some of which continued after the downpour. Our visualization system is useful to judge risks that cannot be understood by visualization of only one kind of data.

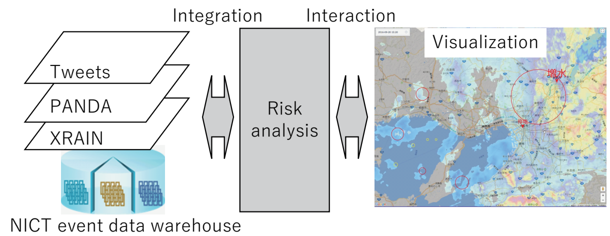

Figure 1: Architecture for our integrated visualization system for rainfall risk analysis. XRAIN is real-time rain observation system using high-performance weather radar. PANDA is phased array weather radar enabling prediction of occurrence of localized torrential rain.

1 Introduction

Various sorts of disasters, such as sudden downpours, typhoons, tornadoes, and thunderbolts, occur almost every day in the world and cause various kinds of risks in our lives. It is necessary to understand disasters and their risks to determine how we act in such situations. To understand those risks, we need to observe the current situation and what kind of things will happen in the future from various viewpoints. For example, in a situation where sudden downpours occur, we need to observe the following things to decide our action: 1) information on the place where it is currently raining, 2) prediction of where the next storm will occur, and 3) what kind of problems, such as floods, landslides, blackouts, and traffic obstacles, happen on the ground. Therefore, we require an environment where various sensor data can be integrated and observed.

We have been developing an information integrated visualization system for analyzing risks caused by heavy rainfalls and/or typhoons using multiple kinds of data from radars and social media such as Twitter. Several systems have been proposed to visualize multiple kinds of sensor data complementarily [1, 2, 4, 5]. However, these systems have some limitations: the system did not support the fusion and visualization of results from multiple data in the same visualization space [2], the data that could be integrated was limited [2, 4, 5], or a user could not observe the details of events such as traffic jams [4]. Itoh et al. have proposed a framework for designing 3D visualization applications to compare multiple data and/or different times [1], but they did not consider the mechanism for risk analysis.

This paper proposes an information integrated visualization system for heavy rainfall risk analysis. Moreover, we show the effectiveness of the system by demonstrating a case study where a risky situation caused by a typhoon is analyzed using real data.

2 Integration for Analyzing Risks of Downpours

The proposed system integrates multiple kinds of data using location and time as clues, extracts risky situations from such data, and visualizes them in the same visualization space (Figure 1).

We utilize three kinds of data resources in this paper: (1) data from XRAIN (eXtended RAdar Information Network), which is a real-time rain observation system using high-performance weather radar, (2) data from PANDA (Phased Array weather radar and Doppler lidar Network fusion DAta system), which predicts the occurrence of localized heavy rainfall, and (3) data from Twitter as a social sensor. From these data, we extract information on risky situations.

This paper introduces the first prototype that extracts locations and times with high risk independently from each type of data and visualizes the location and time at which all the risks extracted from each data overlap.

2.1 Extracting risky situations from precipitation radar data

The number of disasters caused by localized torrential rain has increased dramatically, and this has become a serious issue because of global warming and heat-island phenomena. The National Institute of Information and Communications Technology (NICT) has been developing a decision support system for localized torrential rain. This system uses phased-array weather radar (PANDA) installed in Osaka and Kobe for early detection of vortexes that indicate development of cumulonimbus clouds (localized torrential rain baby cells). It then predicts areas on the ground where rainfall exceeding

*e-mail: imash@tkl.iis.u-tokyo.ac.jp
†e-mail: sagara@info-proto.com
‡e-mail: ukyo@picolab.jp
§e-mail: umemoto@tkl.iis.u-tokyo.ac.jp
¶e-mail: ynaga@iis.u-tokyo.ac.jp
‖e-mail: toyoda@tkl.iis.u-tokyo.ac.jp
**e-mail: zettsu@nict.go.jp
††e-mail: kidawara@nict.go.jp

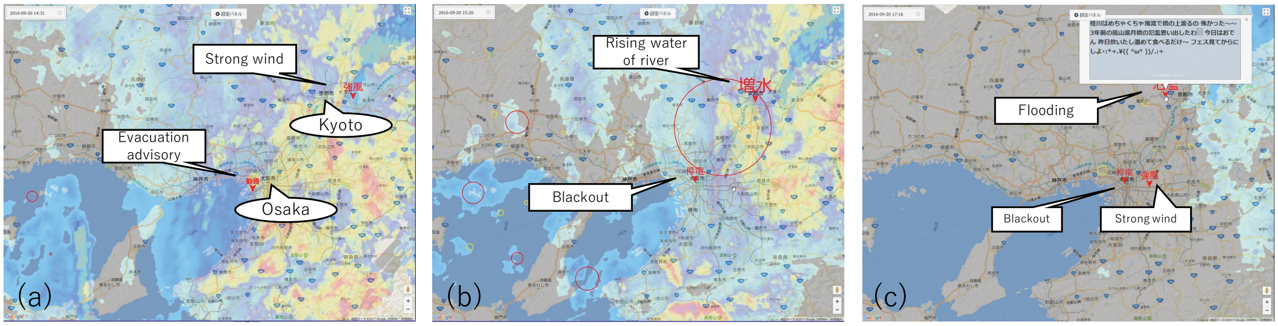

Figure 2: Visualization of changes in situation in Osaka and Kyoto on day when Typhoon Malakas struck on September 20, 2016. (a) - (c) visualize the changes in rainfall area per minute obtained from XRAIN data, predicted heavy rainfall warning circles per minute obtained from PANDA data, and changes in word-clouds extracted from Twitter every ten minutes.

50 mm/h will occur within 30 minutes, and this is visualized on a digital map (localized torrential rain early detection) [1].

In addition to the localized torrential rain early detection by PANDA, data from X-band precipitation radars (XRAIN) is also utilized for discovering torrential rain. XRAIN is a rainfall observation network composed of 38 X-band dual polarimetric radars built by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT). It features a 250 m radial resolution for improved observation of local downpours. We conducted integrated analysis of PANDA data and XRAIN data for discovering torrential rain disaster areas, each of which has a rainfall exceeding 30 mm/h for more than 10 minutes in daytime. For example, the red circles in Figure 2 indicate the discovered areas.

2.2 Extracting risky situations from Twitter data

We first extracted data about the events and corresponding tweets related to the heavy rainfall that was concentrated in specific places and at specific times through the method proposed by Itoh et al. [3] to extract information about risky areas caused by a downpour detected by the social sensor. We extracted the events using keywords such as "strong wind," "downpour," "pouring," and "rain" in this paper. We utilized the Twitter data collected by Kitsuregawa-Toyoda Lab., the University of Tokyo.

We extracted the areas and times with a particularly high number of extracted tweets related to the keywords as places and times with high risk. The extracted events are visualized on the map as word-clouds (Figure 2). The sizes of the words represent the importance of the events, which were calculated based on the total number of their occurrences [3]. By selecting a word, a user can display the original tweets that are related to the word and explore more detailed information (Figure 2 (c)).

3 Case Studies

Figure 2 shows the changes in the situation in Osaka and Kyoto on the day Typhoon Malakas[2] struck on September 20, 2016. Typhoon Malakas brought torrential downpours to western Japan.

Figure 2 (a) - (c) visualize the changes in rainfall area per minute obtained from XRAIN data, the heavy rainfall warning circles per minute obtained from PANDA data, and the changes in the word-clouds every ten minutes. In Figure 2 (a), the visualization results of XRAIN data show that there was extremely heavy rainfall in Osaka. The word-clouds show that many people tweeted that evacuation recommendation due to heavy rainfall was announced in Osaka, and the strong wind affected the operation of the railway in Kyoto. In Figure 2 (b), the visualization result of XRAIN shows that heavy rain had already passed through Osaka, but it was still raining hard in Kyoto. Moreover, we can see that PANDA's warning circles appeared over a wide range, which means the possibility of heavy rainfall still remained. The word-clouds and tweets show that the water level of the Kamo River in Kyoto rose a great deal. The visualization result of XRAIN in Figure 2 (c) shows that the rain went to the east. However, the event about flooding is still displayed in Kyoto. The tweets about the event show that "Katsura River is a terrible muddy stream now, so I remember the flooding three years ago" is a topic.

[1]It also sends warnings to pre-registered e-mail addresses, indicating areas such as water catchments that rainfall will flow into and underpasses and other areas susceptible to flood damage, before the localized torrential rain occurs. We are currently conducting a field test of this system in cooperation with the Kobe city office.

[2]https://en.wikipedia.org/wiki/Typhoon_Malakas_(2016)

4 Conclusion

This paper proposed a system for risk analysis of heavy rainfall through integrating and visualizing multiple sensor data, such as weather data obtained from two kinds of weather radars, and event information extracted from Twitter data. The visualization results actually show the heavy rain caused many problems, some of which were continuing after the downpour finished. It is useful to judge risks that cannot be understood only by visualization of XRAIN data. We can understand or predict when and where and what will happen from the situations of rainfall by observing and understanding the visualization results of past disasters. Our visualization system is useful for setting up the action guidelines for municipalities and organizations for disaster prevention.

We plan to provide methods for automatically detecting risks and determining their importance from multiple sensor data. We intend to extend our method to extract information from social media in accordance with the situation and purpose such as information for drivers or for people who want to go out to have fun.

References

[1] M. Itoh and M. Toyoda. EventStacks: Integration of Event Visualizations for Physical and Social Sensor Data. In *An IEEE VIS 2016 Workshop on The Event Event: Temporal & Sequential Event Analysis*, 2016.

[2] M. Itoh, D. Yokoyama, M. Toyoda, Y. Tomita, S. Kawamura, and M. Kitsuregawa. Visual Fusion of Mega-city Big Data: An Application to Traffic and Tweets Data Analysis of Metro Passengers. In *Proc. Big Data 2014*, pp. 431–440, 2014.

[3] M. Itoh, N. Yoshinaga, and M. Toyoda. Word-Clouds in the Sky: Multi-layer Spatio-Temporal Event Visualization from a Geo-Parsed Microblog Stream. In *Proc. IV 2016*, pp. 282–289, 2016.

[4] R. Krüger, D. Thom, and T. Ertl. Visual Analysis of Movement Behavior Using Web Data for Context Enrichment. In *Proc. PacificVis 2014*, pp. 193–200, 2014.

[5] B. Pan, Y. Zheng, D. Wilkie, and C. Shahabi. Crowd Sensing of Traffic Anomalies based on Human Mobility and Social Media. In *SIGSPATIAL/GIS*, pp. 334–343, 2013.