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Post disaster situation awareness and decision support through interactive crowdsourcing

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Abstract

In today's world, online social media has established itself as one of the most important information carriers, and that applies in the field of disaster management as well. However, posts in online social media like Twitter and Facebook are mostly unstructured, and it is extremely difficult to extract meaningful information from such unstructured posts. Therefore, disaster management authorities face problems in using these posts for proper situation analysis and decision-making. To alleviate this problem, we propose a decision support framework that collects situational information through interactive crowd-sourcing using SMS from the "crowd" present at the disaster site, and summarizes such responses to have situational awareness and appropriate decision-making regarding damage or need assessment. We evaluated our proposed system using 3000 real-time interactive responses from a disaster-prone coastal area of India (named, the Sunderbans). Since the use of smart-phone in rural India is significantly low, SMS from the "crowd" were used to form the core information repository for post-disaster situation analysis.

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1. Introduction

According to the World Disasters Report 2013 [1], when disaster strikes, access to situational information is as important as access to food and water. During and post disaster, responding organizations deal with severe uncertainties in making vital decisions. They need situational information (e.g., status of the civil, transportation and information infrastructures), together with information about available resources (e.g., medical facilities, rescue and law enforcement units) [2]. Accuracy, timeliness, and reliability of situational information help decision-makers make appropriate decisions as well as reduce deaths and injuries, prevent secondary disasters, economic losses, and social disruption.

Lots of work has been done on extracting situational information through crowdsourcing, e.g., through analysis of content posted on online social media like Facebook and Twitter using data mining and natural language processing techniques. All these prior works rely on data gathered passively; hence what information can be extracted is limited by what is posted generally by the crowd. Along with extraction of general situational information, what is also required is *answering of specific questions*. For instance, NGOs like SPADE (a voluntary organization working for community empowerment and disaster resilience in West

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Bengal, India) [3] has a set of around 20 rapid need assessment questions arranged in nine different categories (viz., Affected Area Profile, Health and Medical Infrastructure, Food Aid and Nutrition, Water and Sanitation, Education, and others), aimed to understand the post-disaster situation, some of which are shown in Table 1. It is very difficult to extract the answers to such specific questions from the passive crowd-sourced data gathered from online social media. The best practices in social media for disaster management are ensured only when people are taking part in answering questions and when ICT takes advantage of volunteerism [4]. In this context, *interactive crowdsourcing* has the potential to provide a solution for efficient and fast supply of relevant situational information. Interactive crowdsourcing is an automated process that involves interactive dialogue between an online system and each member of the crowd (disaster victims/ volunteers/ first responders in our case) willing to contribute consistent information that helps the system to build a structured repository of situational information.

Table 1. A sample set of rapid need assessment questions used for interactive crowdsourcing.

Category	Question No.	Question
Affected Area Profile	1	Name of the area with type - District/ Block/ Gram Panchayet
	2	Profession of majority? Agriculture/ Fishing/ Poultry/ Labour/ Others (specify)
	3	Is there any change in profession due to disaster?
Health & Medical Infrastructure	4	Is availability of medicines sufficient in hospital or health centers located in the area?
	5	Current status of the hospitals nearby - well equipped/ poorly equipped and adequate staff /inadequate staff
	6	Names of the generally dominant diseases prevailing in the area
	7	Any outbreak of epidemic during or after disaster? - diarrhea/ cholera/ plague/ other (specify)
Food Aid and Nutrition	8	Whether markets that existed before disaster are functioning now? How well?
	9	Do local markets have sufficient food stock?
Water & Sanitation	10	From what source is clean drinking water available?
	11	Major water source affected after disaster - stream/ river/ hand pump/ others (specify)
	12	What is lacking in terms of sanitation?

In this paper, we employ interactive information crowdsourcing to extract the answers to such specific questions. We conducted a field trial (details in Section 3), where we actually sent a set of post disaster situational awareness questions to people in a disaster-affected region and collected their answers. Once the answers were collected, we used state-of-the-art text summarization algorithms to summarize the answers and acquire situational awareness (Section 4). Such summarized information will potentially assist the disaster management authorities in taking decisions regarding time critical assessment of damages and needs. Motivated by the utility of interactive crowdsourcing, we also propose the architecture of a novel disaster management system which collects information via passive as well as interactive crowdsourcing, and analyses the collected information to generate various reports useful for disaster management services (Section 5).

2. Related work

In this section, we review existing works on information crowdsourcing. A lot of work has been done in the field of crowdsourcing particularly in the perspective of decision support. For instance, Chen et al [5] used an automated question-answering system for spontaneous reporting of adverse drug reactions (ADR) in a crowdsourced manner. They showed that information crowdsourcing is a proficient way to track and ascertain cases of ADR. Laskey et al [6] showed that crowdsourcing is a very powerful tool as a decision support system to solve complex business problems. Basu Roy et al [7] in their visionary paper introduced an interactive crowdsourcing system that includes the human factor in interactive crowdsourcing. The system is adaptive in nature and optimizes the process in a dynamic situation. It improves by learning the users' skill sets and uses the users' capabilities to the best.

In the context of disaster management using crowd-sourced data, most of the prior work is on extracting situational information from Twitter during disasters and on summarization of tweets [8]. Whereas almost all of the prior works consider passively collected data, the present work focuses on interactive information crowdsourcing to support decision making in the context of disaster management that has not been considered in any of the prior works to the best of our knowledge.

3. Field trial and results

To test our Interactive Information Crowdsourcing System a field trial was organized with 20 volunteers from SPADE in three remote villages in the Namkhana region of West Bengal, India, namely, North Chandanpiri, South Chandanpiri, and Haripur. The field trial took place six months after the said region was affected by a flood in mid- 2015, and was aimed to assess the post disaster "Social Continuity". Social continuity can be defined as the process of returning back to the originally prevailing socio-economic conditions of the local inhabitants after being perturbed by a disaster.

The volunteers interacted with more than 150 inhabitants/ responders of the villages and mobilized each of them to respond to