

Disaster management and social media use for decision making by humanitarian organizations

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Abstract

In times of a crisis, disasters or extreme events, affected people use social media solutions to share information about the situation. Hence, the use of this information for supporting humanitarian operations is becoming a valuable source to develop a real time understanding about the situation even before they arrive at the ground. From a scholarly perspective, the use of social media management during and after a disaster has hit has been researched, but no special focus has been given to the needs of humanitarian organizations and how their management phases can be supported by social media analytics in real time. In this research, we will identify the few papers that have been concerned with this topic and will apply a theoretical lens from disaster management to investigate viable areas where social media research can support humanitarian organization in the different phases of disaster response.

1. Introduction

With the emergence of social media as widely used information and communication technologies (ICT), it is possible to have now for the first time real - time information about the situation at the ground of a crisis or disaster zone from the affected people themselves. Rather than waiting for non-governmental organizations (NGO) and governmental organizations to bring in technology to do the surveying and intelligence of the situation for managing the disaster relief efforts, the people affected quite often have still access to social media and provide information electronically. For example, a majority of social media users in Oklahoma turned their social media access into a tool to provide and find information about the damage but also about

their friends and families wellbeing after a tornado struck the area [18].

Before that, communication of disaster information was unidirectional: disaster information was communicated from the governments and relief organizations to the public. However, the general public now uses social media accounts in a disaster in order to gain and contribute information [16]. Moreover, people are reorienting [25] their personal social media to propagate information and support the relief efforts in disaster situations. In the aftermath of hurricane Katrina, the public stood by their community by forming online forums to help and support affected victims [26]. Essentially, they switched to their personal communication channels when traditional communication channels failed, facing difficulties to operate during a catastrophe [20].

Humanitarian relief organizations are now able to receive real time and detailed information that once was difficult or impossible to access. Such user-generated content can be key in disaster situations. It contains valuable information regarding geographic information, which would otherwise not be accessible, such as the situation of the event, victims' needs, urgency of supplies and so on. Hence, research on social media during disaster situations is gaining prominence. Overall, one can observe a paradigm shift in the use of social media during disasters, away from the idea of bringing in intelligence technologies by humanitarian agency to help public towards an increasing focus on existing, already available technology such as social media possessed by the public.

To our knowledge, the transition from focusing on dedicated technologies for disaster relief towards the existing social media has not been specifically investigated yet. Moreover, it is unclear how the user-generated content can help humanitarian organizations in real-time for decision management

and organizing their disaster management and operations. Thus, this study addresses this research gap by conducting a systematic literature analysis to answer essentially two research questions, namely, *how far does existing research reflect the real-time use of social media based information in disasters and how can the existing research findings be used to help humanitarian organizations to respond?*

The remainder of the paper is organized as follows: In the methodology section, we explain the structured literature review and the method we followed to analyze and categorize the articles. In the analysis section, we present the mapping of disaster social media uses [8] to disaster management phases [3], the analysis and our findings of articles and mapping them to disaster management phases. Finally in the last section we discuss the findings and conclusion.

2. Methodology

In order to find answers to our research questions, as a starting point, we conducted a systematic literature review [28] to gather the bibliography to analyze the articles. Moreover, this approach also sheds light on which different directions the research on the use of social media in disasters is heading to. The combined keywords used for the literature search were social media and disaster, social media and crisis, Twitter and crisis, Twitter and disaster, Facebook and disasters, Facebook and crisis, ICTs and disasters, and ICTs and crisis. Furthermore, it should also be noted that we not only selected the articles focusing on social media and disasters or crisis but also the articles that mentioned ICTs, for example web forums or blogs.

The literature review has been done in two stages. Initially, by using the combined keywords we searched for the scholarly literature on that topic published in the senior scholar basket of eight journals and also in information systems (IS) conference proceedings such as ICIS, ECIS, AMCIS, HICSS, and PACIS. Because of the nascent nature of the research area, we used the same keywords and conducted a search for relevant articles in Google scholar and also performed backward and forward search on the collected articles. The final sample of articles comprised 45 articles, including articles from various conference proceedings such as ISCRAM, CHI, WWW.

We analyzed all the 45 articles and started to cluster them to understand how many research articles are focusing on the real-time social media information analysis of users affected by a disaster.

In our research, we consider content from social media users who are not only direct victims of a disaster but also of witnesses present at the time a disaster took place, sharing their observations of a disasters as it happens or shortly afterwards. Overall, the 45 articles are clustered into four different categories based on their research focus. In the first category, the focus is on real-time data coming from end-users through social media, and activities during a disaster. In the second category, even though the research was conducted on disaster data of end-users, the data collection and analysis were performed subsequently after a disaster took place. Especially in this category, the articles focused on rumors, user behavior, re-tweets, and uses of social media at the time of disaster and so on. In the third category, the research focus of the articles is about crowd-sourced/open source software applications, tools and systems that either evolved during the times of disasters or developed afterwards to analyze the user-generated content of social media witness accounts of the disaster, for example, to generate insights in the catastrophe that might be useful in tackling future disasters. A few articles belonging to the last category are dealing with the use of social media by the humanitarian organizations themselves, for example for fundraising or other communication purposes. In order to answer our research questions, we focused on the first and third paper categories, resembling together solely 15 articles.

For the analysis of the papers, we further sub-categorized the papers as being part of one of four disaster management phases, and started coding the articles based disaster social media uses drawn from the functions of disaster social media [8] as further discussed in the analysis section.

3. Analysis

A disaster is a sudden event that seriously affects the normal routine conditions of a community or society. It has not only an economic and environmental impact but also an important humanitarian component [9]. Disasters could be natural calamities such as earthquakes, tornadoes or hurricanes but also man-made destructive activities such as terrorist attacks or industrial accidents. These kinds of disasters occur suddenly, that demands immediate and fast relief activities in devastated areas. Other kinds of man-made or natural crises such as epidemic diseases or economic crises also have an impact on society but occur not as disruptive over time which is the reason while the role of real-time intelligence is not as important. Clearly, each type of

disaster has to be managed differently [3], while for all disasters being able to reach victims as fast as possible to provide first aid and supplies are of paramount importance for any humanitarian organization. Thus, in order to perform the humanitarian operations efficiently and effectively, commanding over good intelligence for planning and organizing the disaster management activities is of vital importance.

Since disaster management activities are rather complex, comprising several sub-tasks and specialist decision making and skills in the different disaster management phases, humanitarian operations research is studied by many disciplines applying different perspectives. For example, research on the recovery phase is conducted from a process management perspective [14], while natural disaster management has been researched from a design science perspective [22], as well as from a humanitarian logistics and supply chain management point of view [3].

While some literature on the humanitarian logistics and disaster management phases [3] mentions that there are some disagreements about the structure and nomenclature of the disaster management phases, there seems to be a general agreement that the disaster management can be modeled into four phases, namely mitigation, preparedness, response, and reconstruction. Having a good strategy for each of the phases is essential for an efficient disaster management. In order to accomplish this, managers need proper information about the different activities within each of the four disaster management phases [10]. With social media information is now accessible in real-time, so those activities can be planned more accurately. Thus, we adopted the disaster management model and its phases in our research to map where and how social media information can be used to improve the decision making [3].

While social media platforms have not been designed to be used in disaster management, the people affected by a disaster nevertheless turn to those medias to communicate, thereby also changing the role of the general public from receiving information about a catastrophe to producing and sending important information [2, 16]. From a disaster communication point of view, Houston et al. [8] developed a comprehensive framework containing 15 disaster social media uses and their applicability from a communication perspective. They reviewed online information and official websites in addition to scientific literature to explain the disaster social media uses and users. Given the two-way communication nature of social media, the

authors considered the users as producers of information and mainly categorized them as: individuals, organizations, governments, communities and news media. Since the research angle they applied primarily considers social media from a communication point of view, the social media uses are more generic. Even though we considered the 15 social media uses in our study, we only considered and integrated those uses which are relevant for the real-time use within the disaster management phases.

In order to set a theoretical basis for this research, we adopted two guiding frameworks, dealing with the functions of disaster social media use [8] and disaster management phases [3]. As mentioned before, we categorized the research of the collected articles into four disaster management phases, as shown in Figure 1. Instead of categorizing the existing research into disaster management phases directly, we added the disaster social media uses because they represent a more fine-grained perspective of social media within a disaster. Moreover, in applying the disaster social media uses to traditional disaster management phases allows us to integrate literature about potential social media activities into the disaster management model. This will act as a theoretical lens to categorize the existing research into disaster management phases.

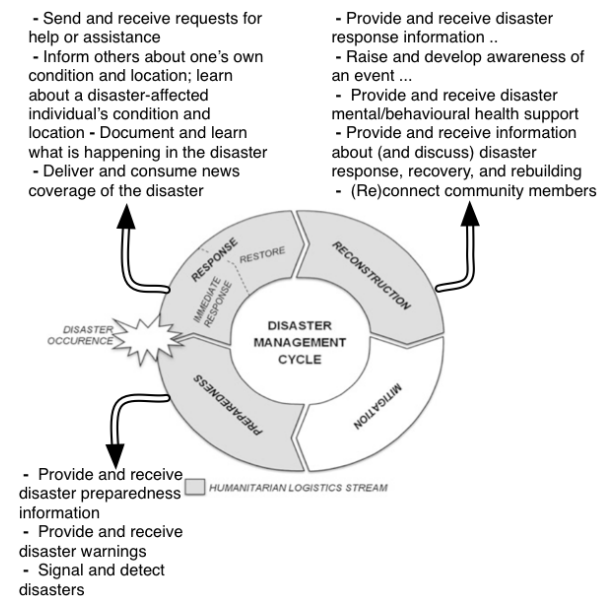


Figure 1 Use of social media in different disaster management phases (adapted from [8, 3])

Even though Houston et al. [8] proposed their framework from a communication point of view, it is

useful to shed some light on the disaster situations where social media is facilitating communication during disasters from different actors or stakeholders. Moreover, most of the disaster social media uses where apparent in more than one disaster management phase in Houston et al. [8].

In order to categorize the discovered literature, firstly we mapped the disaster social media uses to disaster management phases as shown in Figure 1. We coded the literature along the two dimension (disaster management phase and disaster social media use) and whenever we believed an article could be categorized in one or more of the categories we did so. The resulting figure allowed us to understand how the social media in disaster classification actually resonates with the more commonly used disaster management phases. Since the disaster social media uses explain the fine grained activities performed during disaster, we coded 15 articles to these activities and thereby categorized them into different phases of disaster management. The result of the analysis is discussed below.

3.1. Categorization of articles into disaster management phases

In the following, the findings will be discussed now in more detail. Most of the disaster social media uses we found in literature have an overlap across different disaster management phases. Hence some of the articles are related and mapped to more than one phase.

Mitigation: The mitigation phase focuses on measures that either try to prevent the disaster or try to reduce the impact of the disaster [1]. We were not able to identify any articles that fit into that category, as we have confined ourselves to either research on real-time data during disaster or the applications that will be useful in future disasters. Thus, it could be due to our focus that we have not detected research on social media to support disaster management in the mitigation phase. An alternative explanation could be that there are only limited application areas imaginable how social media can be off use before a sudden, unexpected disaster takes place. In case of flooding or wildfire it is nevertheless thinkable that social media can be used to mitigate the most severe effects of such catastrophes if there is enough time to prepare the general public. However, here we have a clear overlap to the preparedness phase.

Preparedness: In the preparedness phase, the aim is to prepare people to respond to a disaster. The articles that are relevant to this phase falls into two categories in our framework as described below.

Twitter-based monitoring applications: The first category under preparedness mainly focuses on the recently developed applications and tools [11, 21] that monitor, track and analyze the tweets for event detection and location extraction. In other words, it gives situational awareness. One of those applications [11] provides information to first respondents and the other one acts as an earthquake responding system [21].

Twitter-based data analysis: In this category, research focus is mainly on micro blogging or Twitter data either to find out the process of information production and distribution by general public or to identify the information shared by local residents to enhance situational awareness. Twitter users and communities shared local disaster information such as flood levels, wind direction and fire paths, which lead to the preparatory activities [24, 27]. These situational updates are useful in humanitarian relief operations as well as to the affected community members to prepare themselves to respond actively for a disaster.

Response: The response phase is the most important stage where the concern is to preserve the community, environment and saving lives by deploying proper resources [1]. One can notice that most of the papers are categorized into the response phase. According to our framework, the articles falls into four categories.

Role of ICTs for disaster response: Communities and individuals seeking and providing disaster/crisis information for emergency response. The main key practices observed in the communication are sharing of real-time information, extending moral support to communities, proposing relief activities. Citizenry are also asking for help, suggesting to the officials what kind of actions need to be taken, and giving moral support to the community members through ICTs such as web forums, blogs, Facebook. The ICTs during disaster events [23], despite being back channels acted as main channels to fulfill the timely needs of the people [25]. Moreover whenever a crisis occurs in a networked world [17] online communities are responding positively to disasters [20].

Role of microblogging for disaster response: Twitter has been widely used for risk and crisis communication in crisis/disaster response events. End users by self-organizing themselves disseminate crisis/disaster related information as a way to reassure other victims and to help in relief activities. Some of the articles are dealing with the social life of microblogged information where authors discussed the information production on Twitter at the time of floods. For example, Twitter helped the end users to

self-organize themselves by producing as well as distributing the flood relevant information [24]. Moreover, a microblogging site acts as a system to share different types of messages for different purposes such as situational updates, asking for help, expressing opinion and emotional support [19] and also for the crisis communication [7]. Others discuss the role of microblogging in response situations such as in the case of re-tweeted messages after the Fukushima nuclear radiation disaster [12]. One important finding of the Fukushima nuclear radiation disaster [12] is that, even though government organizations tried to create situational awareness and calmed the end-users via microblogging, the user engagement in re-tweeting the information shared by government has been very low due to lack of trust and increased fear among public. However, the information that is shared by the end users is useful to the humanitarian organizations to act in the response phase of any crisis or disaster.

Twitter-base applications for response: Monitoring applications based on tweets were developed to visualize the disaster-affected area and to provide geo location information. This situational awareness is also helpful in the disaster response phase. This helps humanitarian relief activities to act and reach the victims. The reviewed articles are concerned about location extraction from disaster-related microblogs [13], and emergency situation awareness [29].

Crowd-sourced applications for disaster response: The crowd-sourced open software applications collect data from different disparate sources and provide the visual information of affected areas as well as needs and urgencies of the victims. This information is especially helpful in humanitarian relief activities to coordinate and allocate the resources effectively [4, 6].

Reconstruction: In the aftermath of a disaster, the reconstruction phase involves both long-term and short-term activities to stabilize and bring the community to normal conditions [1]. In the reconstruction phase, the research is primarily focused on ICTs such as web forums and Twitter.

Role of ICTs and microblogging in the reconstruction phase: Mainly individuals used ICTs to inform others about their safety and also enquiring about others safety. People through web forums and Twitter trying to re-connect to their community [19, 20, 23, 25]. However, crowd-sourced applications are also useful in reconstruction phase to find their missing family members.

Given to the nature of disaster social media uses that are useful to disaster management phases, some of the articles are also categorized into more than one

phase. However, primary motivation for clustering the discovered articles from preparedness phase to reconstruction phase, (for example role of ICTs in response, role of microblogging for response, so on) is to observe a paradigm shift in the gradual use of different ICTs during disasters, away from the idea of bringing technologies by NGOs or governmental organizations to help towards an increasing focus on social media possessed by the general public. Along with the technological developments general public also switching to their own accessible latest social media, for example, web forums to Twitter during disasters.

4. Discussion and Conclusion

In this research, our focus was to explore reflections of existing research on social media in disasters. The motive of our study is to affirm the transition where end-users started using social media for humanitarian disaster relief purposes. This transition is changing the way of doing things both at emergency management level as well as at end-users level/societal level. Moreover, applying the research findings of the collected articles to disaster management is an attempt to shed more light on the true potential of social media in the emergency management. Applicability of real-time information to disaster management is important because “social media is already making significant changes in emergency and crisis management” [5]. However, even though non-profit organizations used social media at the times of a disaster as a public relationship tool, it failed to exploit the two-way communication and true potential of the social media [15]. The reason could be either lack of proper analytical intelligence methodologies to extract necessary valuable information from the social media or lack of a structured development and use of social media with focus on the disaster management phases. However, our findings revealed that social media has the capability to assist as decisions support system through which NGOs and emergency organizations perform their decision making activities efficiently. Not only is this, for example, the fact in a wild fire case, if the information comes from people witnessing it, it also will help in evacuation instructions. However, based on our analysis, we state that there is a need for more research in the areas where social media is used but not exploited successfully in disaster management. Moreover there is also a need to encourage IS research in general to engage more with humanitarian organizations to help them to develop more aligned solutions.

Out of the 45 collected articles dealing with social media use in relation to disaster management, only 15 articles were found to deal with the real-time use of social media to support humanitarian organizations for managing their disaster response activities. In the framework of functions disaster social media [8], the authors categorized disaster social media uses to disaster phases: pre event, event and post event. Most of the social media uses are categorized into event and post-event of disaster phases, but only few uses fall into the pre-event category. Similar to the work of Houston et al. [8], in our literature analysis, most of the articles are categorized into response and reconstruction phases primarily. None of the research articles are categorized into the mitigation phase, whereas only few articles are mapped to preparedness phase. The reason could be that the research in disaster social media is still in its infancy. Moreover, the end users are the information contributors in the disaster social media and their activity is mainly confined to the disaster response phase and partially to the preparedness and recovery phases.

Based on the systematic literature review we conclude that because social media is a relatively new technology and has not been designed in the first place to support humanitarian aid in disasters, research in that area is still scarce. Despite the high research interest in that area, very few articles are relevant or useful to emergency management. Moreover there is neither a holistic methodology/approach nor sufficient theoretical foundations on using social media to disaster management across the different phases. To the best of our knowledge, we did not come across any research work that tries to apply social media to all the phases of disaster management.

It can be concluded that currently, NGOs or other relief organizations are not able to exploit social media to its full potential since the areas social media can be used are rather fragmented and they are not aligned with the disaster management phases typically in use. Hence there is a need for further development of systematic methodologies for harnessing the social data. For example, there is a need for automation certain social media coding approaches so that they can provide real-time information rather than providing only analytical insights in the aftermath of a disaster. Furthermore, promising crowd-based approaches need to be analyzed regarding their real-time applicability: If a disaster is not able to garner enough attention then the crowd coding, for example, pictures taken from devastated areas might not be coded in time due to a lack of crowd-interest.

This study has certain limitations as we only tried to look for articles that analyzed the real-time data during disasters and application or tools. Hence we have limited ourselves to few articles. Another limitation of the study is that we considered all the disasters as in one category. Each disaster is different in its own right depending on their characteristics such as manmade verses natural, long response duration verses short and immediate response and so on.

References

- [1] N. Altay and W. G. Green, "OR/MS research in disaster operations management", *European journal of operational research*, 175 (2006), pp. 475-493.
- [2] N. Cook, *Enterprise 2.0: how social software will change the future of work*, Gower Publishing, Ltd., 2008.
- [3] A. Cozzolino, *Humanitarian logistics: cross-sector cooperation in disaster relief management*, Springer Science & Business Media, 2012.
- [4] P. Currión, C. d. Silva and B. Van de Walle, "Open source software for disaster management", *Communications of the ACM*, 50 (2007), pp. 61-65.
- [5] G. F. For-mukwai, "The Transformative Power of Social Media on Emergency and Crisis Management", *International journal of information systems for crisis response and management*, 2 (2010), pp. 1.
- [6] H. Gao, G. Barbier and R. Goolsby, "Harnessing the crowdsourcing power of social media for disaster relief", *IEEE Intelligent Systems*, 26 (2011), pp. 10-14.
- [7] T. Heverin and L. Zach, "*Microblogging for Crisis Communication : Examination of Twitter Use in Response to a 2009 Violent Crisis in the Seattle-Tacoma , Washington Area*", *Proceedings of the 7th International ISCRAM Conference*, 2010, pp. 5.
- [8] J. B. Houston, J. Hawthorne, M. F. Perreault, E. H. Park, M. Goldstein Hode, M. R. Halliwell, S. E. Turner McGowen, R. Davis, S. Vaid, J. A. McElderry and S. A. Griffith, "Social media and disasters: a functional framework for social media use in disaster planning, response, and research", *Disasters*, 39 (2015), pp. 1-22.
- [9] IFRC, "*About disasters*", The International Federation of Red Cross and Red Crescent Societies, 2015.
- [10] V. Jayaraman, M. Chandrasekhar and U. Rao, "Managing the natural disasters from space technology inputs", *Acta Astronautica*, 40 (1997), pp. 291-325.
- [11] S. Kumar, G. Barbier, M. Abbasi and H. Liu, "*TweetTracker: An Analysis Tool for Humanitarian and*

- Disaster Relief*", *Proceedings of the Sixth International AAAI Conference on Weblogs and Social Media*, 2011, pp. 661-662.
- [12] J. Li, A. Vishwanath and H. R. Rao, "Retweeting the Fukushima nuclear radiation disaster", *Communications of the ACM*, 57 (2014), pp. 78-85.
- [13] J. Lingad, S. Karimi and J. Yin, "Location extraction from disaster-related microblogs", *WWW 2013 Companion - Proceedings of the 22nd International Conference on World Wide Web*, 2013, pp. 1017-1020.
- [14] P. Mousavi, O. Marjanovic and P. Hallikainen, "Disaster Recovery-The Process Management Perspective", *PACIS*, 2012, pp. 67.
- [15] S. Muralidharan, L. Rasmussen, D. Patterson and J.-H. Shin, "Hope for Haiti: An analysis of Facebook and Twitter usage during the earthquake relief efforts", *Public Relations Review*, 37 (2011), pp. 175-177.
- [16] L. Palen and S. B. Liu, "Citizen communications in crisis: anticipating a future of ICT-supported public participation", *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM, 2007, pp. 727-736.
- [17] L. Palen, S. Vieweg, S. B. Liu and A. L. Hughes, "Crisis in a Networked World: Features of Computer-Mediated Communication in the April 16, 2007, Virginia Tech Event", *Social Science Computer Review*, 27 (2009), pp. 467-480.
- [18] M. Price, "Oklahoma tornadoes: Social media used to warn, find information", *NewsOK*, 2013.
- [19] Y. Qu, C. Huang, P. Zhang and J. Zhang, "Microblogging after a major disaster in China: a case study of the 2010 Yushu earthquake", *Proceedings of the ACM 2011 conference on Computer supported cooperative work*, 2011, pp. 25-34.
- [20] Y. Qu, P. F. Wu and X. Wang, "Online community response to major disaster: A study of Tianya forum in the 2008 Sichuan earthquake", *Proceedings of the 42nd Annual Hawaii International Conference on System Sciences, HICSS*, 2009, pp. 1-11.
- [21] T. Sakaki, M. Okazaki and Y. Matsuo, "Earthquake shakes Twitter users: real-time event detection by social sensors", *WWW '10: Proceedings of the 19th international conference on World wide web*, 2010, pp. 851-860.
- [22] G. Schryen and F. Wex, "IS Design Thinking in Disaster Management Research", *System Science (HICSS), 2012 45th Hawaii International Conference on*, IEEE, 2012, pp. 4102-4111.
- [23] I. Shklovski, L. Palen and J. Sutton, "Finding Community Through Information and Communication Technology During Disaster Events", *Proceedings of the 2008 ACM conference on Computer supported cooperative work*, ACM, 2008, pp. 1-10.
- [24] K. Starbird, L. Palen, A. L. Hughes and S. Vieweg, "Chatter on The Red: What Hazards Threat Reveals about the Social Life of Microblogges Information", *Proceedings of the Conference on Computer Supported Cooperative Work (CSCW)*, 2010, pp. 241-250.
- [25] J. Sutton, L. Palen and I. Shklovski, "Backchannels on the front lines: Emergent uses of social media in the 2007 southern California wildfires", *Proceedings of the 5th International ISCRAM Conference*, Washington, DC, 2008, pp. 624-632.
- [26] C. Torrey, M. Burke, M. Lee, A. Dey, S. Fussell and S. Kiesler, "Connected giving: Ordinary people coordinating disaster relief on the Internet", *System Sciences, 2007. HICSS 2007. 40th Annual Hawaii International Conference on*, IEEE, 2007, pp. 179a-179a.
- [27] S. Vieweg, A. L. A. Hughes, K. Starbird and L. Palen, "Microblogging during two natural hazards events: what twitter may contribute to situational awareness", *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*, ACM, 2010, pp. 1079-1088.
- [28] J. Webster and R. T. Watson, "Analyzing the past to prepare for the future: Writing a literature review", *Management Information Systems Quarterly*, 26 (2002), pp. 3.
- [29] J. Yin, S. Karimi, B. Robinson and M. Cameron, "ESA: Emergency Situation Awareness via Microbloggers", *Proceedings of the 21st ACM international conference on Information and knowledge management - CIKM '12*, ACM, 2012, pp. 2701-2703.