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Emergency information diffusion on online social media during storm Cindy in U.S.

Jooho Kim[a], Juhee Bae[b], Makarand Hastak[a,*]

[a] Division of Construction Engineering and Management, Purdue University, 550 Stadium Mall Dr., West Lafayette, IN, 47907, USA
[b] School of Informatics, University of Skövde, Högskolevägen Box 408, 54128 Skövde, Sweden

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ABSTRACT

Social media plays a critical role in propagating emergency information during disasters. Governmental agencies have opened social media accounts for emergency communication channels. To understand the underlying mechanism of user behaviors and engagement, this study employs social network analysis to investigate information network and diffusion across news, weather agencies, governmental agencies, organizations and the public during the 2017 Storm Cindy in the U.S. This study identified certain types of Twitter users (news and weather agencies) were dominant as information sources and information diffusers (the public and organizations). However, the information flow in the network was controlled by numerous types of users including news, agency, weather agencies and the public. The results highlighted the importance of understanding the unique characteristics of social media and networks for better emergency communication system.

1. Introduction

Communication is a core component of disaster management. Given the threats to human life and property that a disaster causes, individuals need information about what has happened and what is still onging within a disaster-affected area and beyond (Rodríguez, Diaz, Santos, & Aguirre, 2007). Thus, developing an effective disaster communication system should be the top priority for relevant governmental agencies, private organizations, and communities. Social media plays a critical role in disaster management for accessing information during an emergency (Lindsay, 2011). Many studies have explored the systematic use of social media during emergency responses by extracting social media data to identify the needs of a disaster-affected community (Gao, Barbier, & Goolsby, 2011; Imran, Elbassuoni, Castillo, Diaz, & Meier, 2013; Yin et al., 2015). For example, social media data was used to develop a GIS-based real-time map during Hurricane Sandy in 2012 (Middleton, Middleton, & Modafferi, 2014). It shared critical information and community needs with emergency agencies and NGOs. Furthermore, real-time data from social media has been used to develop an early warning system for tornadoes (Knox et al., 2013; Tyshchuk, Hui, Grabowski, & Wallace, 2011). Finally, social media is used to communicate emergency information and urgent requests between emergency agencies and disaster-affected communities (Feldman et al., 2016; Kim & Hastak, 2018b). Using social media as a communication method may support emergency agencies in understanding emerging situations rapidly. However, more investigation is needed to determine how emergency agencies can effectively operate their social media during disasters to expedite the diffusion of emergency information within an affected community. For that, it is critical to understand the underlying mechanism of online user behaviors and the unique network structure. Therefore, the objective of this study is to investigate the functioning of social networks during a disaster and analyze the characteristics of an emergent online network, to improve communication strategies and facilitate the development of disaster-related social media tools.

2. Literature review

2.1. Social capital and infrastructure

Many scholars have found that social capital plays a key role in responses to disasters. Nakagawa and Shaw (2004) identified that social capital and community leadership as the core requisites for rapid disaster recovery. Aldrich (2011) concluded that the power of people (social capital) is the strongest and most robust predictor of population recovery after a catastrophe. Aldrich and Meyer (2015) examined recent literature to investigate the critical role of social capital and networks in disaster recovery. They demonstrated that disaster agencies, governmental decision makers, and NGOs need to strengthen social infrastructure at the community level to increase disaster resilience. Joshi and Aoki (2014) investigated two districts affected by the recent

* Corresponding author.
E-mail addresses: kim1282@purdue.edu (J. Kim), juhee.bae@his.se (J. Bae), hastak@purdue.edu (M. Hastak).

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tsunami in India and concluded that the strength of social networks, the commitment of residents to the community, the popularity of leaders, and various social factors influenced the disaster recovery. Grube and Storr (2014) identified local knowledge and knowledge transfer as essential to the restoration of disaster-affected communities.

Social media plays an important role in restoring community resilience after a catastrophe. Cagney et al. (2016) noted the importance of social infrastructure for community recovery from a disaster. Multiple activities by social capital (power of people) were revealed in a study of the 2016 Louisiana Flood. Kim and Hastak (2018a, 2018b) showed how disaster-affected communities and external organizations were linked via online social media (Facebook) and bonded together to improve the accuracy of emergency information during the flood. Currently, online social media are rapidly growing as emergency communication channels and have become a popular source of information.

2.2. Social media and network analysis during disasters

The importance of social media after disasters has been demonstrated by many scholars (Alexander, 2014; Houston et al., 2015; Kim & Hastak, 2017, 2018a; ; Middleton et al., 2014; Poorazizi, Hunter, & Steiniger, 2015; Reuter, Heger, & Pipek, 2013; Yin et al., 2015; Yoo, Rand, Eftekhar, & Rabinovich, 2016). Social media plays a variety of roles, from preparing and receiving disaster preparedness information and warnings, signaling and detecting disasters prior to an event, to linking community members following a disaster (Gao et al., 2011; Houston et al., 2015; Keim & Noji, 2011; Yates & Paquette, 2011). Chae et al. (2014) used spatiotemporal data from microblog to analyze public behavior response. Graham, Avery, and Park (2015) demonstrated that the extent of social media use is related to assessments of the local city's ability to deal with crisis. Yoo et al. (2016) collected Twitter data during Hurricane Sandy and applied information diffusion theory to characterize diffusion rates. They found that internal diffusion through social media networks advances at a higher speed than information in those networks that comes from external sources.

Still, the usages of social media as an information diffuser should be calibrated to expedite its effectiveness in an emergency. Keim and Noji (2011) showed that P2P communications could spread misinformation and rumor as well as commit privacy rights violations. A high volume of messages via social media makes it hard for disaster-affected communities and emergency responders to analyze the information. Imran et al. (2013) proposed a system integrated with machine learning techniques to provide actionable information from social media. Liu et al. (2014) studied disaster information channels (social media vs. traditional media) and sources (national agencies and media vs. local agencies and media) in terms of their ability to generate desired public outcomes (intentions to seek and share emergency information). They found social media users were more likely to seek further information from Twitter when the initial disaster information was in the form of a tweet than a webpage. Recently, the Federal Emergency Management Agency (FEMA) opened a new rumor control page to debunk false rumors related to Hurricanes Harvey and Irma (FEMA, 2017a, 2017b).

An online social network can be defined as a set of social entities (people, groups, organizations) and the patterns of relationships or interactions between them (Oliveira & Gama, 2012). Social Network Analysis (SNA) was designed to discover the relationships established between social entities. It includes (1) computation of metrics that provide a local (actor level) and global (network level) description of the network, (2) graphical visualization of the network, and (3) community detection for understanding the structure of complex networks and finding useful information from it (Combe, Largeron, Egyed-Zsigmond, & Géry, 2010; Oliveira & Gama, 2012). Multiple software and tools have been also developed to fulfill the increasing need for social network data mining and visualization technology such as R and the SNA library, JUNG, Guess, Prefuse, NodeXL, Gephi and FluxFlow (Luo & Zhong, 2015; Smith et al., 2009; Zhao et al., 2014).

2.3. Text analysis and semantic analysis

Text mining is becoming more popular as a means to get an overview of unstructured text information. A word cloud is used as a representative method to demonstrate the most frequently used words and provide a visual representation of text data. Nowadays, it is used in various areas with multiple purposes. Researchers and educators use text mining to report quantitative and qualitative data and to provide critical and essential information. In marketing, representatives identify the needs and plan for the future reflecting trends in consumption. Many social media sites collect and analyze unstructured information and share the trends of what is going on, while politicians and journalists use them for communication, as well as branding and informing their presence. Recently, Chen et al. (2017) introduced an overview and state-of-the-art review of analytics of social media data, along with summarizing the applications and tools used. They divided visual analytics approaches into six different categories: visual monitoring, event detection, predictive analysis, feature extraction, anomaly detection, and situation awareness.

Disaster management agencies and crisis/emergency management teams are rapidly using visualization tools to identify events of interest and to gather information for further decision making (Thom et al., 2015). It is most likely that social media messages help to convey the news, communicate needs, and analyze for better future reactions and decisions. The ScatterBlogs2 supported customized filtering and classification of a disaster (i.e. flooding) from social media sources by displaying the geospatial information on a map (Bosch et al., 2014). Moreover, anomaly detection in emerging crisis scenarios, rumor detection from public messages, and prediction are other interests in this area (Chae et al., 2014). With the help of R and its text mining packages (i.e. tm, wordcloud), we analyzed two groups (before and after the incident) of Twitter messages and visualized the keywords and their distribution (see Section 4.4.).

2.4. Storm Cindy

Storm Cindy was the first tropical cyclone to make landfall in Louisiana after the 2012 Hurricane Isaac. According to the National Hurricane Center (2017a, 2017b), Cindy was formed out of a broad area of low pressure that developed in the northwestern Caribbean Sea. The National Hurricane Center designated it as a potential tropical cyclone on June 19, and labeled it tropical storm on June 20 (National Hurricane Center, 2017b). The storm intensification was slow, due to the effects of dry air and moderate to strong wind shear. It made landfall in southwestern Louisiana on June 22. Then, it was weakened rapidly and became post-tropical by late the next day, dissipating shortly afterward (see Fig. 1).

Storm Cindy was responsible for at least three deaths along the Gulf Coast (Stokes, 2017). The storm generated heavy rainfall, up to 12 inches (300 mm) in southeastern Louisiana, leading to flash flooding. The highest rainfall amounts in the affected U.S. states are described in Table 1.

3. Objectives and methodology

This study investigated the use of Twitter's social network during the 2017 Storm Cindy in U.S. This study examined online social media networks and user behaviors during the storm through the lens of Social Network Analysis (SNA). It provides insights to understand emergent

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