

Patrick C. Shih*, Kyungsik Han and John M. Carroll

Using Social Multimedia Content to Inform Emergency Planning of Recurring and Cyclical Events in Local Communities

DOI 10.1515/jhsem-2014-0071

Abstract: Social media has been widely adopted for assisting the efforts in emergency response and recovery, but it has been underutilized for emergency planning purposes. Emergency planning in a local community context must leverage accessible and free resources such as social media, because it is largely a volunteer enterprise. We describe our fieldwork with local annual festival emergency planning teams that led to the design of the Community Incident Report (CIR). CIR is a novel emergency planning system that externalizes community knowledge on persisting issues and common mitigation strategies by integrating police reports, local crisis information, and social multimedia content to foster citizens' awareness of local emergency information and to assist emergency planners in planning for recurring and cyclical events. We provide a use case analysis of CIR and its evaluation with 20 local residents, and discuss how it could be extended to inform emergency planning for other community events and local municipalities that share similar characteristics.

Keywords: community informatics; crisis informatics; emergency planning; social media.

1 Introduction

Information and communications technology (ICT) and social media such as Twitter, Facebook, and blogs have been used to disseminate crisis information at the national scale, yet adoption of such systems in local communities where emergency planning mostly involves day-to-day incidents still have not gained

***Corresponding author: Patrick C. Shih**, Department of Information and Library Science, Indiana University, 1320 E 10th St, LI 013, Bloomington, IN 47405, USA, e-mail: patshih@indiana.edu

Kyungsik Han and John M. Carroll: College of Information Sciences and Technology, The Pennsylvania State University, University Park, PA, 16802, USA

traction. In addition, reports of social media's involvement have primarily focused on its ability to enhance the response and recovery phases of crises. We see a great opportunity of using social media to gauge citizen activities for more informed planning, especially for recurring and cyclical community events, and to provide community awareness that could result in routine community work that continue to safeguard the local neighborhood.

Existing local emergency planning rarely includes citizens in the deliberation process. In our earlier work, we reported a case study of emergency planning in our local community, a small college town where Penn State is located (Schafer et al. 2008). The top-down approach that is currently employed in the emergency planning process involves only local government and university stakeholders. Representatives from the local government units rely on regular face-to-face meetings to discuss the following five aspects of community preparedness: collaborative efforts, local area details, local culture, geographic information, and emergency plans (Schafer et al. 2008). This process does not take into account the insights that local citizens may have about the local area, and the resulting plan is neither communicated nor easily accessible to the general public. Therefore, when local incidents or crisis occur, it is difficult for civilians to know how to properly respond to or engage with the situations because of their lack of involvement in planning.

Subsequently, we engaged the local emergency planning team for the local annual arts festival, and gathered requirements that resulted in the design of the Community Incident Report (CIR), a novel emergency planning system that integrates police reports, local crisis information, and social multimedia content to foster citizens' awareness of local emergency information and to assist emergency planners in planning for recurring and cyclical events. CIR can be used by local emergency planners as a way to alert citizens of crisis, gauge citizen perception on local crisis events, and involve citizens in the deliberation and planning process. This work makes the following contributions to the emergency planning literature:

- Theoretically, we provide a well-grounded literature review on how social media is used primarily as a device for information dissemination and emergency response and coordination. We further point to the possibility of leveraging a combination of past user-generated data and archival information to inform future emergency planning of cyclical and recurring events.
- Empirically, we present a prototype of CIR that integrates multiple data streams such as police reports and social media content. We further illustrate use case scenarios of how CIR can be used in a local annual arts festival and conducted a user study to gather user feedback on the system.

Here we outline a roadmap of the paper. Section 2 summarizes current social media practices in emergency management. Section 3 describes current efforts

on supporting emergency planning. Section 4 details our engagement with local emergency planning teams that led to the design of CIR. Section 5 provides the system descriptions of CIR and a use case that illustrates scenarios in which CIR can be used as a bottom-up approach for emergency planning to complement the traditional top-down approach in the local community context. Section 6 reports our user study with 20 local residents on how they perceive the CIR system. Finally, Section 7 discusses implications, limitations, and future work on leveraging multiple data streams in future emergency planning systems.

2 Existing Use of Social Media in Emergency Management

In this section, we first review how social media is integrated into the existing emergency management practices. Current research has focused predominantly on low frequency, high-impact, unexpected events such as crippling natural disasters or war disruptions that destroy our ability to produce and distribute resources for a significant period of time. In particular, social media has been widely adopted in emergency management situations such as broadcasting crisis-related information, assessing on the ground situation, and responding and coping with the disaster aftermath, and there has been a shift to involve volunteers for identifying crisis-related social multimedia content to aid the emergency responders. However, the use of historical social multimedia content for future planning of expected, large-scale, pre-planned events is limited and underexplored. Past information could provide rich contextual information for future planning, especially for community events that are recurring and cyclical. Our literature review describes current use of social media in emergency management for the low frequency, high-impact, unexpected events, and points to the possibility of taking account of spatial, temporal, and social considerations to support expected, large-scale, pre-planned events that are recurring and cyclical.

2.1 Crisis Response

2.1.1 Information Dissemination

Microblogs such as Twitter has been found to be especially effective for disseminating information to the general public. Sutton et al. (2008) reported one of

the first instances of social media usage during the 2007 Southern California Wildfires and found that community information resources and other backchannel communications activity enabled by social media are gaining prominence. Subsequently, numerous researchers have reported the use of social media in a wide variety of natural disasters and national security events. For example, prior studies described how geographical communities utilized online forums and social networking sites for commiseration and information seeking after the 2007 Virginia Tech shootings (Palen et al. 2009) and 2008 Northern Illinois University shootings (Palen and Vieweg 2008). Hughes and Palen (2009) found that people adopt Twitter as an effective channel for information broadcasting and brokerage during emergency events such as Hurricane Gustav and Ike in 2008 and national security events like the Democratic and Republican National Conventions.

In addition to Twitter, research has also investigated the use of other social networking and knowledge sharing platforms during emergencies. White et al. (2009) found that social networking sites viable for information dissemination and communications in emergency situations. Yates and Paquette (2011) also analyzed Microsoft SharePoint usage during the 2010 Haiti Earthquake and found it to be an effective knowledge sharing mechanism that complements the traditional knowledge management systems. Bird et al. (2012) reported the use of Facebook for emergency response and recovery during the Queensland flood in 2010 and Victorian flood in 2011. They found that members of the community use Facebook to disseminate information and carry out informal communications.

Due to their effectiveness in information dissemination and brokerage, researchers and practitioners have unequivocally advocated for the adoption of social media in emergency management by official entities. Prentice and Huffman (2008) suggested an establishment of emergency incident blogs using social media by trained federal crisis communicators to ensure effective communication during crisis. Crowe (2010) proposed an extension to the National Incident Management System (NIMS) framework to include the use of social media to disseminate emergency information during crisis. As a result of integrating social media as a part of the official planning strategies, Hughes and Palen (2012) examined the work practice of the Public Information Officers (PIO), the public relations component of the NIMS framework. They found that social media expanded the information pathways between PIOs, the media, and members of the public. Starbird and Palen (2010) have also reported uses of a variety of third-party applications enhancing Twitter service on the web and mobile platforms (e.g. TweetDeck, twitterfeed, TwitterBerry, echofon, etc.). Today, broadcasting crisis-related information over

social media has become a standard practice in emergency management at the national level.

2.1.2 Situation Assessment and Coordination

While social media has been widely adopted for disseminating crisis-related information quickly to the public, it also provides an active information exchange channel that allows citizens to provide “on the ground” information back to the emergency responders during crisis. Vieweg et al. (2010) studied social media content broadcasted by people on the ground during the Oklahoma Grassfires and the Red River Floods in 2009, and identified information that may contribute to enhancing situational awareness. Latonero and Shklovski (2011) conducted an in-depth longitudinal case study of the Public Information Officers of the Los Angeles Fire Department. They found that emergency response organizers utilized social media to communicate with the public in emergencies and to collect information using the public as sources of information on the ground. Sarcevic et al. (2012) studied the use of social media by medical staff during the 2010 Haiti earthquake. They found that on the ground medical staff used microblogs for planning and coordinating equipment and personnel deployment due to the decentralized nature of medical work in disaster response.

For the purpose of enhancing communication, coordination, and situational awareness, advanced data mining algorithms and visualization systems have been developed to extract relevant crisis-related information from social media. In terms of data extraction mechanisms, Yin et al. (2012) used natural language processing and data mining techniques to extract situation awareness information from Twitter messages generated during various disasters and crises to enhance emergency situation awareness. Cameron et al. (2012) described an emergency coordination platform called Emergency Situation Awareness – Automated Web Text Mining (ESA-AWTM) that utilized Twitter to gauge the community response to an emergency warning. Pohl et al. (2012) used metadata from Flickr and Youtube during an emergency situation to detect the clustering of different sub-events in a critical situation. For visualization systems, MacEachren et al. (2011) designed SensePlace2, a visualization interface for displaying Twitter streams to support geographically-grounded situational awareness of crisis information in social media. Shih et al. (2014a) created Community Incident Chatter, a smartphone application that is designed to aggregate information reported by formal news agencies and social media surrounding local incidents. In general, emergency responders are increasingly using systems that extract, aggregate, and populate crisis-related information from social media to monitor and assess on the ground situations during emergencies.

2.1.3 Human Computation for Curation of Crisis Information

Although social media platforms are widely adopted in emergency management because of the aforementioned abilities to rapidly disseminate news to the masses and to coordinate response efforts, the massive amount of information on these platforms also cause concerns regarding information quality. First, popular social media platforms such as Twitter and Facebook are widely used for general purposes, and these general-purpose messages can distract crisis-specific information when an emergency occurs. Even when denoted by specific hashtags, it is often difficult to distinguish messages with different intentions. For example, Kavanaugh et al. (2012) examined the use of social media by government entities for managing routine and critical crisis situations. They found that the sheer volume of social data streams generated substantial noise, and future tools that could identify issues and trends in real time are necessary for effective use of Twitter by government officials. Essentially, the broadcast nature of social media platforms creates a tradeoff between information reach and information quality.

Furthermore, while the timeliness nature of the social media platforms can provide useful crisis information in real-time, the information credibility and reliability are often compromised because of the lack of time for information verification and validation. For this reason, Veil et al. (2011) suggested the need to check for information accuracy on social media in crisis situations. Twitter users during crisis have devised ways to ensure information credibility by retweeting only information distributed by credible sources and questioning those without. For example, Starbird and Palen (2010) analyzed Twitter information generated during natural hazard events and found that users are more likely to retweet information originally distributed by local media and traditional service organizations. Mendoza et al. (2010) assessed the reliability of Twitter as an information source under extreme circumstances, and found that the rumors and confirmed news propagate differently on Twitter because false rumors tend to be questioned much more than confirmed news. They proposed future systems to incorporate mechanism for filtering out false news.

More recent studies found that people outside of regions impacted by a crisis are finding ways to provide help on social media platforms by filtering, labeling, and redistributing crisis-related information to relevant emergency stakeholders. For example, Starbird et al. (2010) analyzed the flooding of the Red River Valley in 2009 and found that the production of new Twitter information during the crisis is supported through self-organized activities of directing, relaying, synthesizing, and redistributing by Twitter users. To better facilitate the efforts of digital volunteers, Starbird and Stamberger (2010) proposed Tweak the Tweet (TtT), a prescriptive, tweet-based microsyntax that can be used by people to produce parsable

and crisis-relevant information that could increase the utility of information generated during emergencies. In a later study, Starbird and Palen (2011) found that TtT was successfully adopted by some digital volunteers to organize crisis-related information in the aftermath of the 2010 Haiti earthquake. Similarly, Rogstadius et al. (2011) envisioned an architecture that utilizes a crowdsourcing mechanism to structure data collected from social media. These accounts of digital volunteers during crises show promises that human computation has the potential to be leveraged in all phases of emergency management.

2.2 Post-disaster Recovery and Resilience

Aside from information dissemination and situation assessment, civilians who live in impacted regions have also adopted social media platforms as communication channel to offer and receive social support, develop new routines and norms, and build community resilience. In the aftermath of a crisis, Mark and Semaan (2008) found that social media provides people with alternative resources to reconstruct, modify, and develop new routines, or patterns of action, for work and socializing in prolonged disruption through war. In a later study, Semaan and Mark (2012) found that people living in crisis environments use Facebook to create “safe lists”, seek help and provide assistance, reconstruct their social scaffolding, maintain and develop new social norms, and redirect their country. Taylor et al. (2012) administered a large-scale survey to explore public use of social media during natural disasters in Australia and New Zealand in 2011. They found that the public relied on a mix of formal and informal information sources to exchange timely information, promote connectedness, provide psychological first aid in the early stages of disaster, and support community resilience.

Researchers and practitioners have also advocated for the adoption of social media to aid crisis recovery and to build community resilience (Edwards 2009; Dufty 2012). However, despite the fact that social media platforms are well integrated in the emergency management process for providing support to people during and after a disaster, their usages in the earlier prevention and planning phases are less apparent and underexplored. Considerations of social media usage in earlier emergency management stages typically involve establishing a social media response infrastructure in case of emergencies (Merchant et al. 2011) and informing citizens of disaster risks with educational messages (Dufty 2012).

There exists an opportunity to utilize social multimedia content extracted from historical crisis situations to inform emergency planning in local communities that have recurring and cyclical events. The related work sections below

discuss the potential of utilizing the unique contextual and historical information of a geographic community for emergency planning.

3 Emergency Planning as Routine Community Work

Emergencies and crises are intrinsically local to a geographical region, and they are bounded by the contextual characteristics of the local resources. Emergency planning involves deep knowledge of the local area, local culture, resource allocation, and personnel rhythm and routine. This section describes the importance of contextual information in emergency planning. We first discuss how existing emergency management systems utilize geospatial and other contextual information for planning. Then we provide a review of community informatics literature that pertains to day-to-day, routine, and invisible work that is often necessary to ensure emergency preparedness in a local community setting. However, tacit knowledge such as routine and rhythm of continuous and ongoing efforts are often relegated as background work that are invisible and difficult to document. We point out how a report of historical social multimedia content could be leveraged to gauge citizen perceptions in emergency planning meetings and to make citizens more aware of the risks associated to recurring and cyclical community events.

3.1 Geospatial Emergency Management Systems

Quarantelli (2003) synthesized prior social science disaster research at the individual, organizational, community, and societal levels, and found that the great majority of disasters impact a community with existing sociotechnical support infrastructure. Context of local area such as geospatial information has been utilized extensively in existing geospatial emergency management systems. Turoff et al. (2004) developed a “Dynamic Emergency Response Management Information System” (DERMIS) framework that provides guidelines to system developers, and suggested context visibility as one of the core design principles. Cutter (2003) described constraints on the utilization of geographic information in emergency management. These challenges include: understandable user interfaces; data quantity, quality, and integration; real-time data and information.

Research has experimented with multi-user geographic information system interface that relies on multimodal input such as voice (Rauschert et al. 2002;

Sharma et al. 2003) and gesture recognition (Rauschert et al. 2002) and presents a visualization of real-time geospatial data to emergency management decision makers. Jiang et al. (2004) developed Siren, a system for supporting tacit communication of contextual data (e.g. location, temperature, etc.) between firefighters with multiple levels of redundancy in both communication and user alerts. Schafer et al. (2007) describes a geocollaboration software architecture that facilitates the development of geocollaboration solutions (e.g. emergency vehicle traffic routes and staging areas for command posts, arriving media, and personal first responders' vehicles, etc.) for the purpose of emergency planning. Overall, these earlier systems have found to be beneficial for emergency management. Given the prevalence of social media usage during emergency response and recovery, geospatial emergency management systems could integrate and overlay geotagged social multimedia content along with real-time reports to enhance the knowledge of emergency planners and responders.

3.2 Routine, Rhythm, and Local Context in Emergency Planning

Gurstein (2007) defined Community Informatics (CI) as the application of information and communications technology (ICT) to enable and empower community processes. CI is based on the assumption that geographic communities have characteristics, requirements, and opportunities that require different strategies for ICT intervention and development from the widely accepted, implied models of individual access and use. Extending this notion, Schafer et al. (2008) examined emergency planning from a local community perspective and identified five aspects that should be accounted for when planning for community preparedness: collaborative efforts, local area details, local culture, geographic information, and emergency plans. They proposed a bottom up approach that incorporated local knowledge in the emergency planning process. However, there is a dearth of effort both in research and in practice to actively incorporate citizen knowledge in the emergency planning process.

Contextual information such as local culture, routine, and temporal rhythm is situation dependent and differs across different geographic communities. For example, Pettersson et al. (2004) studied the technology to support distribution of calls and handling of cases across several Swedish emergency service centers, and they also found that the responsibilities are primarily geographically localized and the practices in the different centers are distinctively local. Based on the work of Suchman (1987), Bardram (1997) discussed how emergency plans in hospitals are made out of situated action, and in return are realized in situ. Reddy and Dourish

(2002) examined the temporal rhythms of medical staff in hospital emergency rooms. They found that medical practitioners must continually balance in situ medical and organizational information that are deeply contextualized in local settings for decision-making. Without training, these nuanced local practices are often invisible for laymen. Star and Strauss (1999) examined the relationship between visible work that has clear indicators (e.g. finished artifacts, a changed state of affairs) and individual work that often falls into the background of operations. They found that these indicators change with context, and that context becomes a negotiation that involves a complex matrix, with an ecology of its own. The subtle yet significant local context are important to day-to-day emergency planning, and it would be beneficial to externalize the community routine and rhythm in how local citizens cope and respond to crises for future planning.

Existing methods in community informatics could be applied to extract past social multimedia content that is relevant to a specific kind of incident in a local community, and the synthesized knowledge could be formulated into a report that could provide contextual knowledge on how to plan for similar future events. For example, Shih et al. (2014b) and Han et al. (2014) describe methods for extracting community opinions about local news, politics, and trending topics. Shih et al. (2015) describe a data extraction mechanism for extracting social multimedia content for real-time and past data about specific geospatial events from social media.

In general, utilization of social media for emergency planning has, until recently, observed various spatial (national scale events) and temporal (imminent threats) conventions as well as socio-political expectations (top-down communication, etc.). Analysis of past events can help inform future ones and communities are able to offer locally nuanced and timely inputs to decision-making. In the next section, we describe the design of the Community Incident Report that extracts, integrates, and synthesizes multiple data sources a report of current and past incidents in a local community that can be used to inform emergency planners for allocating community resources for similar future events and to inform the citizens of risks and mitigation strategies created from similar past events.

4 Exploratory Field Studies of Local Emergency Planning Efforts

State College, PA is a small town of approximately 42,000 local residents, with about 93,000 people in Centre Region Council of Government (COG)'s service area (www.crcog.net). The Centre Region COG is served by one fire department, two

police departments, two ambulance services, and two emergency management functions. Pennsylvania State University (Penn State) accounts for one of the EMs, ambulance services, and police departments.

To understand the challenges of emergency planning in our local community, we conducted several field studies with local emergency management entities including the Centre County Office of Emergency Services, the Centre Region Office of Emergency Management, and Penn State's Emergency Management Office. Our earlier study focused on the collaboration involved in emergency planning at the local University Park Airport over a period of 9 months. The result of that study was reported in Schafer et al. (2008).

Subsequently, we studied emergency planning for the Central Pennsylvania Festival of the Arts (ArtsFest) in the months preceding the festival. ArtsFest is one of the most popular summer events in Central Pennsylvania. It is a 5-day event that begins on the second Wednesday of July and ends on Sunday. It is located in downtown and on the adjacent Penn State University campus. ArtsFest celebrates the arts with a sidewalk sale and juried gallery exhibition involving around 1000 artists, as well as music, dance, theatrical performances, and several workshops and events for children. Approximately 100,000 people visit the festival each year (www.arts-festival.com).

The emergency planning process for the University Park Airport and ArtsFest involve personnel from local emergency response centers such as the 911/Emergency Communications Center, on-property airport Aircraft Rescue and Fire Fighting (ARFF), Penn State's Department of Public Information, Penn State's Hazardous Materials Team, the Bellefonte Fire Department (two companies), the Alpha Fire Company in State College, University Police, University Ambulance Service, and the local FBI office. Larger incidents call for additional resources from surrounding fire companies in the adjacent areas. The emergency management function in the Centre County is staffed by 5 local emergency management coordinators (LEMCs) – one at the County Level, and two each at the Centre Region COG and Penn State (www.emergency.psu.edu). There are two full-time employees at Centre Region COG and two at Penn State (www.emergency.psu.edu). A typical planning meeting involves approximately 10–20 people representing a variety of aforementioned roles and functions. Over a course of several months, we participated in the regular planning meetings of local festivals, collected meeting documents and archival records, and conducted informal interviews.

A salient finding from our exploratory fieldwork is that contrasting with the top-down approach such as the Department of Homeland Security, the Federal Emergency Management Agency (FEMA), and the state-level Pennsylvania Emergency Management Agency (PEMA) guidelines, the local emergency planning discussions focus primarily on local area details, local culture, and geographic

information. However, while planning and decision-making depend highly on the familiarity with local knowledge, these conversations, rationales, insights, and background work are often forgotten between meetings. The continuity of knowledge also depends highly on the specific individuals attending the meeting. Crucial information is sometimes lost during transition when personnel turnovers occur. In general, meetings serve as a mechanism for planners to revisit and negotiate local resources and priorities.

From our observations, we recognize that planning for recurring and cyclical community events such as an annual festival involves many discussions of knowledge of prior incidents. However, these incidents tend not to be well documented and the archives often contain outdated information. There is an opportunity to leverage existing information such as the police reports and statistics, weather reports, news archives, and social multimedia to create a context repository to assist planners in emergency planning meetings.

In the next section, we describe the design of the Community Incident Report (CIR) system, a system that extracts and visualizes relevant contextual information from multiple official sources and public social media data streams to support evidence-based emergency planning. One novel feature of the system is that it monitors social media streams for issues and coping strategies reported collectively by citizens in recurring and cyclical events. Such information could inform emergency planners of persisting issues and common mitigation approaches taken by the citizens.

5 The Community Incident Report (CIR) System

5.1 CIR Implementation

Figure 1 shows the overview of CIR, which consists of two main phases: (1) data aggregation and integration which are processed on backend, and (2) data access and visualization which present corresponding results to users.

Based on a list of the emergency or incident related tags obtained from the police department, our algorithm was designed to collect four different types of reports, namely, police reports, local news articles, local tweets, and local photos. Police reports are available on the local police website, formal local news articles are retrieved from local news channels, local tweets from Twitter, and local photos from Flickr. More specifically, for police reports, CIR crawls the police report data available on the web page of the Borough of State College. Each report contains an incident type, a reported date and time, an address, a detailed description of the

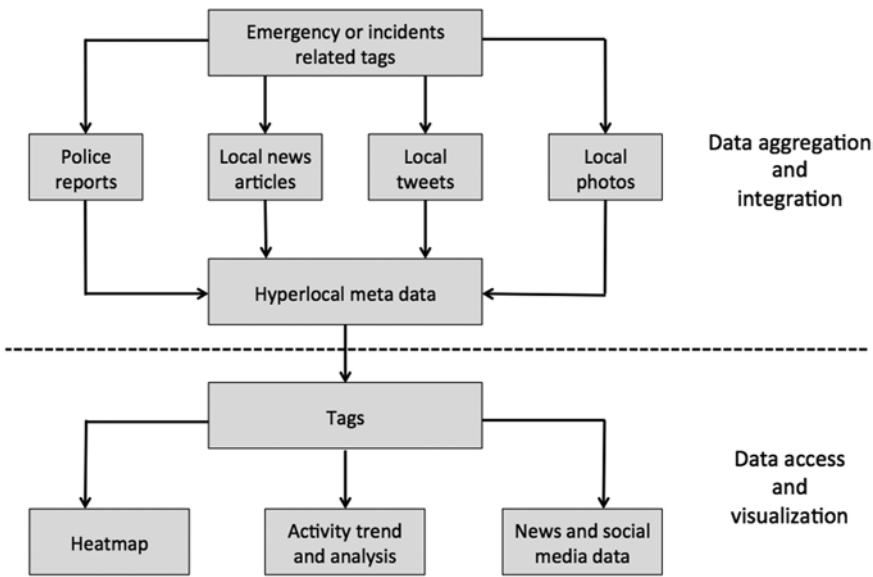


Figure 1: Architectural Overview of CIR.

incident, and the responding emergency agency. We utilize Google’s reverse geo-coding method to convert addresses into geo-coordinates. For the news articles, it collects RSS news article feeds from local news sites. We leverage only news feeds that provide locally relevant news content (e.g. ones that end with “.../local”). Each news item contains a set of metadata, including a title, description, source URL, and created date and time. For tweets, CIR requests the data by passing three parameters (i.e. location, radius, and tags) to Twitter Search API and receives a set of tweets that are pertinent to the provided tag and location. Similarly, for local photos, we used Flickr and Instagram Search APIs that take geo-coordinates and tag to collect tag-based local photos. The data are parsed and collected from different data streams and stored in the local server database on an hourly basis.

We then present these hyperlocal metadata in three different fashions. First, the data that contain a geo-coordinate are presented on the map view. Here we not only present pushpins to locate the data, but also render a graphical representation of data where individual values are represented as colors to add an additional component implying noticeable areas in the community. We also show a trend of the tag based on the overall volume of police reports, local news articles, tweets, and photos over the specified time period. Lastly, we show social media data (i.e. local news articles, tweets, and photos) that are related to the tag.

Our design rationale is to present those different types of the reports in an integrated view. Figure 2 illustrates the CIR interface, which is a web-based

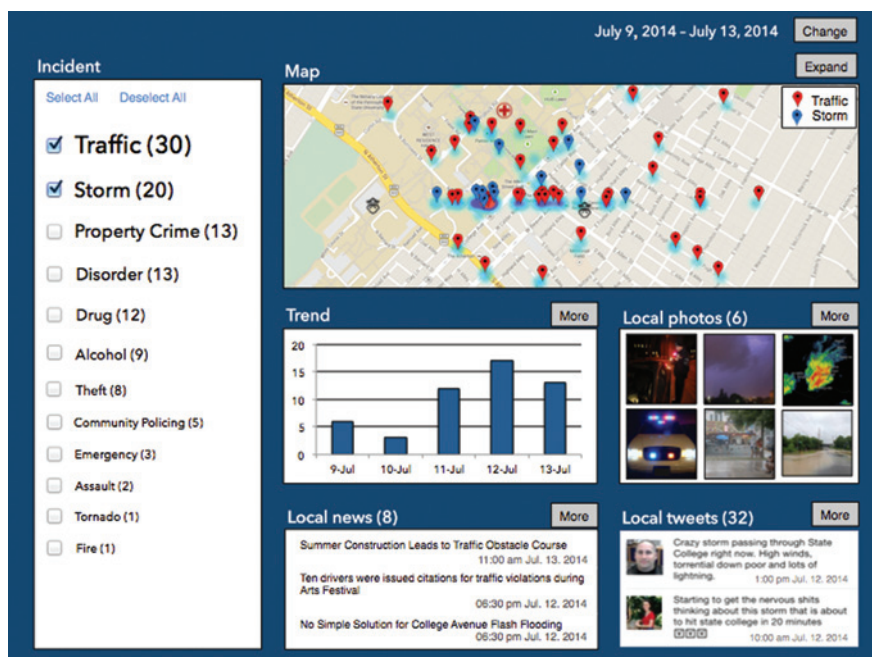


Figure 2: The CIR Interface.

dashboard design. When a user specifies dates (e.g. July 9, 2014 – July 13, 2014), CIR calculates the number of all data sources available for each incident tag. The incident tags are then presented in a list sorted by the total number. The sizes of the tags also vary according to the data volume so that the emergency planners could quickly visualize the severity and prevalence of the incident type. A user can also pick the tags that s/he is interested via a checkbox interface. Then CIR retrieves police reports, local news articles, tweets, and photos during that timeframe and for the selected tags. CIR shows geo-tagged data on the map with pushpins and a heatmap view, which allows users to quickly check which areas have more incident reports and incident-related activities. The locations of the police station, hospital, and on-campus medical clinic are also presented on the map so that the emergency planners could easily estimate the response time to the incidents. Users can also check the detailed information of the report by clicking the pushpin. CIR displays a trend of the incidents (based on the total number of all sources for the incidents) by the date specified in a timeline. Lastly, CIR presents a list of local news articles, tweets, and photos in chronological order as well as a link to a detailed view for those who want to access the information in more detail.

Overall, by using a list of incidents that best represent local incidents, we expect that community members and emergency planners will be able to quickly access the most relevant and prevalent community events as well as gauging citizen activities using CIR.

5.2 CIR Use Case

To illustrate how CIR can inform emergency planning, we describe a use case that generates insights for evidence-based planning by taking social media mentions as proxies for incipient or hidden emergencies drivers. The use case involves the incidents identified by CIR during the 2014 ArtsFest in State College, PA that took place between July 9 and July 13, 2014 (Figure 2). As previously mentioned, ArtsFest is one of the most popular summer events in State College, PA that attracts more than 100,000 visitors every year in mid-July. We found that traffic-related incidents (30 police reports and social media mentions) received the most mentioned in the police reports and the social media. The use case discusses how CIR allows emergency planners to filter police reports and social media data sources to identify possible causes and potential ways of mitigation of future traffic incidents surrounding the ArtsFest.

When we checked the data to see the number of reports, news articles, and social media data for the “traffic” tag over past 6 months (see Figure 3), we found an important insight. We compared the number of traffic incidents during the 2 weeks of ArtsFest with other 2-week periods using one-sample t-test, and found that traffic incidents occurred the most during ArtsFest in this 6-month period [$t(11)=6.85, p<0.0001$]. A possible and perhaps the most obvious explanation one might immediately observe was the presence of more than 100,000 visitors coming from outside of this community to attend the festival. More people and more cars could lead to a higher rate of traffic-related incidents.

A closer examination of the data revealed a lesser obvious connection between traffic- and storm-related incidents that would otherwise have been overlooked without CIR. Apparently, a storm (22 police reports and social media mentions) that brought a lot of rain and flooding into the area was another cause of traffic-related incidents in addition to the high number of visitors. CIR presented a high number of local news articles as well as tweets and photos contained the information about rain and storm during the festival. Local news articles described possibility of rain (e.g. “Both Saturday and Sunday have a chance of afternoon thunderstorms ...”) and flash flooding (e.g. “Significant flooding occurred Tuesday during a heavy rainstorm ...”) in the community (Figure 4).

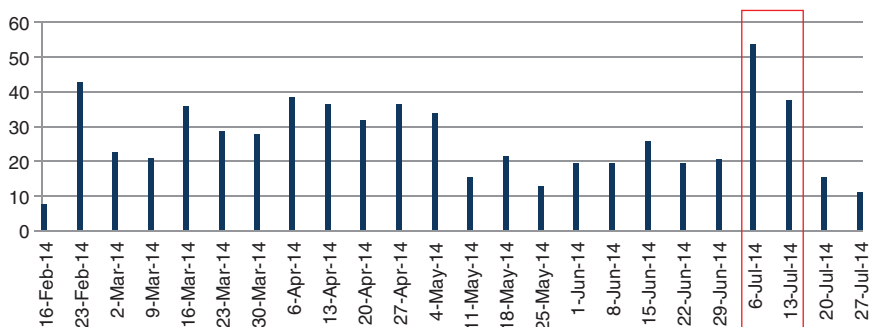


Figure 3: Weekly Volume of Police Reports and Social Media Mentions for the “traffic” Incident. Red box indicates the ArtsFest period, which has statistically higher number of traffic incidents than other periods.

Chance of Storms Through Arts Fest, 'Polar Vortex' to Bring Cooler Days

Follow @MichaelMGarrett

by Michael Martin Garrett on July 12, 2014 7:00 AM

Print

Comments(0)

Email

ShareThis

8+1 0

f Like 15

Though State College can expect a hot – and maybe rainy – Arts Fest weekend, next week will see the return of last winter's polar vortex, bringing with it several days of cooler temperatures.

Accuweather meteorologist Paul Walker says that Saturday and Sunday both have expected highs of about 84 degrees. Though Saturday will mostly be a dry heat, the final day of this year's Arts Fest will be a bit more



No Simple Solution for College Avenue Flash Flooding

Follow @RprtrJennMiller

by Jennifer Miller on July 10, 2014 6:30 AM

Print

Comments(2)

Email

ShareThis

8+1 2

f Like 66

There isn't a simple solution to the dangerous flash flooding seen on College Avenue a few times each summer.

The flooding occurs in the 1000 block of East College Avenue near the Blaise Alexander car dealership and Your Building Center.

Significant flooding occurred Tuesday during a heavy rainstorm. Watch video of Tuesday's flooding below:



Click photo for gallery

Figure 4: Local News Articles about Rain and Flooding Presented by CIR.

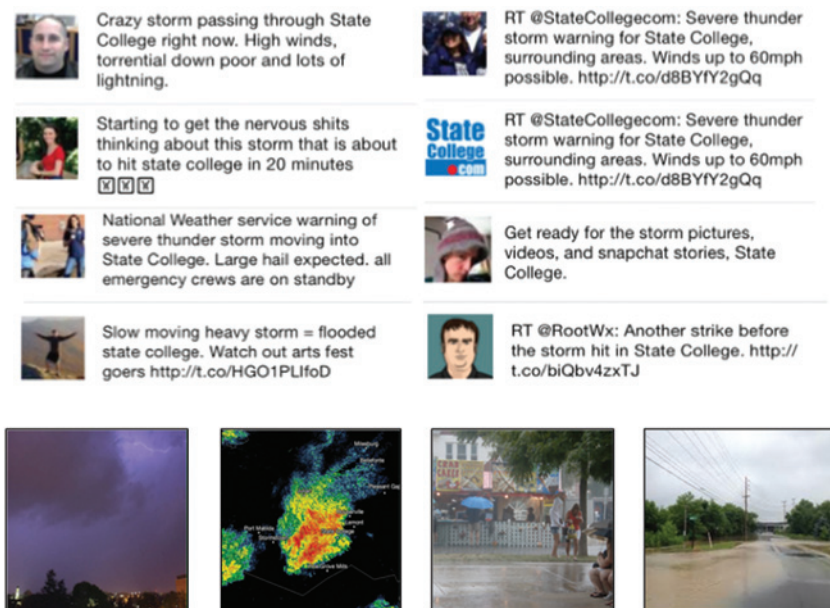


Figure 5: Social Media Data about Rain and Flooding Presented by CIR.

Figure 5 shows social media data (tweets and photos) shared by local citizens. We found that people showed different motivations or intentions when posting tweets; for example, broadcasting upcoming storm (e.g. “*Slow moving heavy storm=flooded state college. Watch out arts fest goers*”), sharing their personal thoughts about the storm (e.g. “*Get ready for the storm pictures ...*”, or “*... thinking about this storm that is about to hit state college in 20 minutes*”), and reporting what they see now (e.g. “*Crazy storm passing through State College right now. High winds, torrential down pour and lots of lightning*”). In terms of photos, people shared ones that showed additional storm-relevant information; for example, a weather radar report, storm-related damages and flooding during the festival, and so on. Together with local news articles, these additional social media contents shared by local citizens provided additional context about the incident in the local area.

While news articles and social media data are useful for providing rich context of local incidents, a heatmap is especially helpful for emergency planning because planners can see where both police reports and people’s social media activities are located on the map. For example, Figure 6 shows the locations of the reported incidents and social media activities related to traffic and

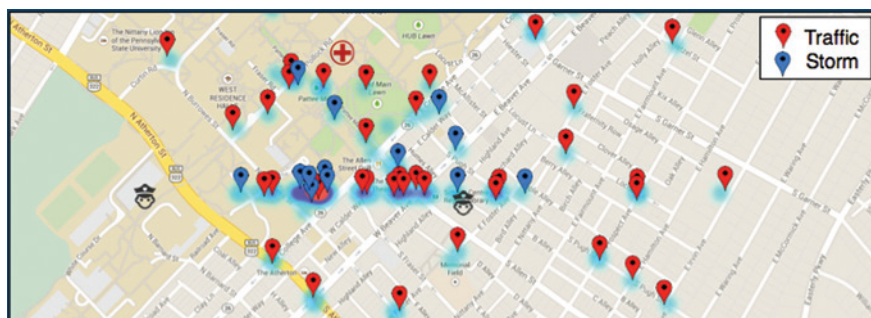


Figure 6: Map View of Rain and Flooding Incidents Presented in CIR.

storm. A high density of pushpins indicates high traffic areas and regions that are severely impacted by storm and flood. With this information, emergency planners could plan evacuation routes that avoid those areas until they can be made more flood-proof in future ArtsFests.

Based on the connection drawn from CIR, we investigated historical weather data provided by Weather Underground (www.wunderground.com) and extracted the number of rainy or stormy days during the 5 days of festival in the last 10 years, from 2004 to 2014. We found that it either stormed or rained at least 2 days every year with an average of 50% (25 out of 50 days) chance of bad weather. Given this fact, it is paramount for emergency planners to consider any possible emergency situations (e.g. flood, traffic, car accident, etc.) caused by heavy rain or storm during the festival. In the case of flooding, for example, it would be helpful to know where impacted areas are based on the historical and current incident reports and social activities for planning evacuation routes for pedestrians, drivers, emergency vehicles, etc. Given the high number of occurrences of traffic and storm-related incidents each year, emergency planners could also suggest more efficient parking options and shuttle services for transporting ArtsFest visitors in and out of town.

In summary, this use case of CIR to investigate incidents that occurred during ArtsFest shows that CIR could be used to enhance emergency planners' awareness of local emergency information and to assist them in planning for recurring and cyclical events. Neither police reports nor social media alone is able to fully capture the rich context surrounding all the local incidents during a large festival of this scale. Other types of incidents such as drug and alcohol use, proper crimes, theft, assaults, and other incidents that occurred during the ArtsFest could all be analyzed more fully by emergency planners using CIR to gain additional insights on how to best plan for future festivals.

6 User Study

We conducted a user study to explore the potential opportunities, usability, and feasibility of how local residents and emergency planners can leverage CIR. We recruited 20 local residents via a university research website and word-of-mouth. We first asked participants to come to our laboratory. We introduced the motivation and design of CIR and answered the questions that they had. We then asked them to complete the survey that consisted of their current practices and awareness of local incidents as well as evaluation on CIR. All questions were based on a 5-point Likert scale. The survey questions covered four main aspects: capability, engagement, emergency planning, and target audience. We also asked participants to evaluate the usability of CIR based on System Usability Scale (SUS, Brooke 1996), a widely adopted industry standard that evaluates the usability of a system. After participants completed the survey, we had a debriefing interview to collect additional feedback on their general perception of CIR. The study took about 30 min.

6.1 Participants

Participants consisted of five males and 15 females. Twelve participants are in their 20s and eight are in their 30s. The average length of residency in the local community is between 3 and 4 years. We first asked about the way they are informed of local crime or incidents. Table 1 shows a summary of participants' existing practice of getting local crime or incident news. Social media, news websites, and word of mouth were the most used sources, indicating that participants are quite used to or perhaps dependent on using digital channels to receive local crime or incident information. Their familiarity to digital media might lower the barriers of using and interacting with CIR. Interestingly, the use of a police department website was very low. Since not all local crimes or incidents are covered by news websites or social media, it is likely that local residents tend not to be fully aware of incidents in their local community.

6.2 User Perception of CIR

Table 2 shows a summary of participants' perception of CIR. Overall, participants were quite positive about all aspects of CIR (average results for all questions were above 4.0). They agreed the potential of CIR in terms of providing and receiving more diverse current and historical local crime and incidents news (*capability*).

Table 1: Existing Practice of Getting Local Crime/Incident News (1=Never; 5=Always).

Source	Mean	SD
Social media	3.95	1.24
News websites	3.80	1.12
Word of mouth	3.70	1.10
News mobile application	3.10	1.18
Newspapers	2.35	1.06
Radio	1.85	0.79
Police department website	1.45	0.59

Table 2: User Perception of CIR (1=Strongly Disagree; 5=Strongly Agree).

Question	Mean (SD)
Capability	
CIR provides richer and more dynamic local crime/incident news than other current methods	4.35 (0.65)
CIR allows users to easily navigate and receive relevant local crime/incident news	4.30 (0.56)
CIR allows users to easily access historical crime/incident news	4.25 (0.70)
Engagement	
CIR positively influences one's awareness of local crime/incident news	4.50 (0.50)
CIR positively influences one's participation in sharing local crime/incident news through social media	4.20 (0.75)
Management and Planning	
CIR can be useful for managing local crime/incident situations	4.05 (0.86)
CIR can be useful for making emergency plans to prepare for future incidents	4.00 (1.05)
Target	
CIR can be useful for local residents	4.45 (0.50)
CIR can be useful for local police and emergency teams	4.40 (0.58)

They thought that CIR positively influences their local awareness of crime and incident news and participation in sharing relevant information through social media (*engagement*). Because social media is one of the main data sources extracted by CIR, newly added content will be updated and displayed in CIR instantaneously. Participants also thought that CIR can be useful for managing and planning current or future incidents in the community (*management and planning*). Having a customized filtering (e.g. date or tag selection) feature provides users a way to browse relevant local incident information. Lastly, regarding potential users who might benefit from CIR, participants answered that CIR

can be useful for different community members and stakeholders including local police and emergency teams as well as local residents. We further tested some statistical comparison analyses based on participants' age, gender, and length of residency but could not find any significant differences. As rule of thumb, a SUS score above 68 is considered above average (Brooke 1996). The SUS score from our study results was 69.6, which indicates that participants' perceived usability is generally positive.

Overall, our preliminary user study results show that participants were positive about the design idea of integrating local incident information from official sources and social media as well as the possibility of receiving and contributing relevant local crime/incident information. Participants believed that CIR will positively influence civic awareness and participation, help to manage and plan emergency situations, and can be used by many different local crisis and emergency planning stakeholders and local residents.

7 Conclusions and Future Work

Although emergency planning typically follow a top-down approach, the process itself is intrinsically very local and specific to a geographic community and very routine. Emergency planning requires deep knowledge of local context and nuanced details of past occurrences of recurring incidents related to community events. However, this knowledge is also difficult to document and preserve. Social media is widely adopted for emergency response and recovery, but has been underutilized by emergency planners to support planning. In this work, we discuss our exploratory fieldwork that led to the design of the Community Incident Report (CIR) system. CIR extracts and visualizes contextual information relevant to specific community incidents from multiple official and public data streams. In particular, the goal of CIR is to construct a collective knowledgebase of incidents surrounding recurring and cyclical events. CIR externalizes community knowledge on persisting issues and common mitigation strategies, and the emergency planners could utilize that knowledge to formulate best practices and improve planning of future events. We provided a case study of how CIR could inform emergency planners at a popular local arts festival that takes place annually. Our user study with 20 local residents showed that CIR provides more dynamic and diverse local incidents and crime information, which can be used by local residents, police, and emergency groups. Participants agreed that CIR is a platform for the local community that increases civic awareness of local incident information and participation in providing relevant information.

In this paper, we argue that planning in a community context *must* leverage accessible and free resources, because it is largely a volunteer enterprise. A common misconception by the public is that small towns are disappearing, and that the population is migrating to bigger metropolitan cities. According to the 2000 census, slightly more than one-half of the nation's population lived in jurisdictions – cities, towns, boroughs, villages, and townships – with fewer than 25,000 people or in rural areas (Cox 2008). Emergency planners might see regions as mega-units, but in fact, they are usually composed of many small towns and a far smaller number of larger cities. In contrast to the larger cities, leveraging social multimedia content is more essential to a local community such as ours, and a system such CIR that focuses on supporting local geographic communities has the potential of benefiting many other smaller communities that share many of the same characteristics overall.

As future work, we plan to incorporate feedback from local residents and deploy the system and use it to support the planning of other community events and engage the emergency planning stakeholders in our community on CIR's usage so that we could iteratively improve the system. Recurring community events, such as the Memorial Day festival, July 4th festival, football weekends, etc., that are slightly smaller in scale but still draw plenty of visitors into the local area could all learn from the lessons at ArtsFest. Other contextual factors such as weather (snow vs. thunderstorms), school in session, year-to-year comparison data, and others also differ across events, and CIR can be leveraged to extract, filter, and synthesize incident-related information from police reports, local news, and social media to generate insights that would not have been found when examining these data sources separately. CIR could also be used as a way to alert citizens, increase citizens' awareness, and involve citizens in the deliberation and emergency planning process of local incidents.

Although CIR shows initial promises of using social media and other data streams for the purpose of emergency planning, there exist some limitations in its current design. For example, social media is known to contain noisy, irrelevant, and misinformation (Shih et al. 2014b). While we do not observe many instances of misinformation in our local area because of the relatively small population in this region, future systems that leverage past social media information for the purpose of emergency planning in more densely populated urban areas will need to address the information overload and misinformation issues. Currently, CIR utilizes Twitter, Instagram, and Flickr to gather user-generated content. Future implementations that integrate information gathered from other popular platforms (e.g. Facebook, YouTube, etc.) and insights generated from other reporting channels (e.g. online questionnaires, complaint portals, call center data, etc.) will make the visualization richer and more informative for

emergency planners. In addition, the current CIR utilizes public information that is provided on State College Police Department's website. However, other data streams such as information from the University Police Department, Bellefonte Fire Department, Alpha Fire Company, ambulance service reports, historical and predicted weather data, and event schedule information can be further integrated into the system in order to make CIR more effective. Establishing data and information sharing partnerships across the local public service sectors in the future will be necessary to fulfill this vision. This study motivates the possibilities and benefits of leveraging these data streams for public safety and emergency planning, and could be a good starting point of more fruitful future collaborations.

References

- Bardram, J. E. (1997) "Plans as Situated Action: An Activity Theory Approach to Workflow Systems." In: *Proceedings of the Fifth European Conference on Computer Supported Cooperative Work*. Lancaster, UK: Springer, pp. 17–32.
- Bird, D., M. Ling and K. Haynes (2012) "Flooding Facebook-the use of social media during the Queensland and Victorian floods," *The Australian Journal of Emergency Management*, 27(1):27–33.
- Brooke, J. (1996) *SUS: A "quick and dirty" usability scale. Usability Evaluation in Industry*. London: Taylor and Francis, pp. 189–194.
- Cameron, M. A., R. Power, B. Robinson and J. Yin (2012) "Emergency Situation Awareness from Twitter for Crisis Management." In: *Proceedings of the 21st International Conference on World Wide Web*. Lyon, France: ACM, pp. 695–698.
- Cox, W. (2008) "America is More Small Town Than We Think." *New Geography*. Available at: <http://www.newgeography.com/content/00242-america-more-small-town-we-think>, 2008 (accessed July 1, 2014).
- Crowe, A. (2010) "The Elephant in the JIC: The Fundamental Flaw of Emergency Public Information within the NIMS Framework," *Journal of Homeland Security and Emergency Management*, 7(1). DOI: 10.2202/1547-7355.1662.
- Cutter, S. L. (2003) "GI Science, Disasters, and Emergency Management," *Transactions in GIS*, 7(4):439–446.
- Dufty, N. (2012) "Using Social Media to Build Community Disaster Resilience," *The Australian Journal of Emergency Management*, 27(1):40–45.
- Edwards, C. (2009) *Resilient Nation*. London, UK: Demos.
- Gurstein, M. (2007) *What is Community Informatics:(and why Does it Matter)?* Hershey, PA, USA: Idea Group (IGI).
- Han, K., P. C. Shih and J. M. Carroll (2014) "Local News Chatter: Augmenting Community News by Aggregating Hyperlocal Microblog Content in a Tag Cloud," *International Journal of Human-Computer Interaction*, 30(12):1003–1014.
- Hughes, A. L. and L. Palen (2009) "Twitter Adoption and Use in Mass Convergence and Emergency Events," *International Journal of Emergency Management*, 6(3):248–260.

- Hughes, A. L. and L. Palen (2012) "The Evolving Role of the Public Information Officer: An Examination of Social Media in Emergency Management," *Journal of Homeland Security and Emergency Management*, 9(1), Article 22.
- Jiang, X., N. Y. Chen, J. I. Hong, K. Wang, L. Takayama and J. A. Landay (2004) *Siren: Context-Aware Computing for Firefighting*. Berlin Heidelberg: Springer, pp. 87–105.
- Kavanaugh, A. L., E. A. Fox, S. D. Sheetz, S. Yang, L. T. Li, D. J. Shoemaker, A. Natsev and L. Xie (2012) "Social Media Use by Government: From the Routine to the Critical," *Government Information Quarterly*, 29(4):480–491.
- Latonero, M. and I. Shklovski (2011) "Emergency Management, Twitter, and Social Media Evangelism," *International Journal of Information Systems for Crisis Response and Management*, 3(4):1–16.
- MacEachren, A. M., A. R. Jaiswal, A. C. Robinson, S. Pezanowski, A. Savelyev, P. Mitra, X. Zhang and J. Blanford (2011) "Senseplace2: Geotwitter Analytics Support for Situational Awareness." In: *Visual Analytics Science and Technology*. Providence, RI, USA: IEEE, pp. 181–190.
- Mark, G. and B. Semaan (2008) "Resilience in Collaboration: Technology as a Resource for New Patterns of Action." In: *Proceedings of the International Conference on Computer Supported Cooperative Work*. San Diego, CA, USA: ACM, pp. 137–146.
- Mendoza, M., B. Poblete and C. Castillo (2010) "Twitter Under Crisis: Can We Trust What We RT?" In: *Proceedings of the First Workshop on Social Media Analytics*. Washington, DC, USA: ACM, pp. 71–79.
- Merchant, R. M., S. Elmer and N. Lurie (2011) "Integrating Social Media into Emergency-Preparedness Efforts," *New England Journal of Medicine*, 365(4):289–291.
- Palen, L. and S. Vieweg (2008) "The Emergence of Online Widescale Interaction in Unexpected Events: Assistance, Alliance & Retreat." In: *Proceedings of the International Conference on Computer Supported Cooperative Work*. San Diego, CA, USA: ACM, pp. 117–126.
- Palen, L., S. Vieweg, S. B. Liu and A. L. Hughes (2009) "Crisis in a Networked World Features of Computer-Mediated Communication in the April 16, 2007, Virginia Tech Event," *Social Science Computer Review*, 27(4):467–480.
- Pettersson, M., D. Randall and B. Helgeson (2004): "Ambiguities, Awareness and Economy: A Study of Emergency Service Work," *Computer Supported Cooperative Work*, 13(2): 125–154.
- Pohl, D., A. Bouchachia and H. Hellwagner (2012) "Automatic Sub-Event Detection in Emergency Management Using Social Media." In: *Proceedings of the 21st International Conference on World Wide Web*. Lyon, France: ACM, pp. 683–686.
- Prentice, S. and E. Huffman (2008) *Social Medias New Role in Emergency Management*. Emergency Management and Robotics for Hazardous Environments. Idaho National Laboratory, Albuquerque, NM, USA, pp. 1–5. <http://www.osti.gov/scitech/biblio/927635>.
- Quarantelli, E. L. (2003) *A Half Century of Social Science Disaster Research: Selected Major Findings and their Applicability*. Newark, DE, USA: Disaster Research Center.
- Rauschert, I., P. Agrawal, R. Sharma, S. Fuhrmann, I. Brewer and A. MacEachren (2002) "Designing A Human-Centered, Multimodal GIS Interface to Support Emergency Management." In: *Proceedings of the 10th ACM International Symposium on Advances in Geographic Information Systems*. McLean, VA, USA: ACM, pp. 119–124.
- Reddy, M. and P. Dourish (2002) "A Finger On the Pulse: Temporal Rhythms and Information Seeking in Medical Work." In: *Proceedings of the International Conference on Computer Supported Cooperative Work*. Chicago, IL, USA: ACM, pp. 344–353.

- Rogstadius, J., V. Kostakos, J. Laredo and M. Vukovic (2011) "Towards Real-Time Emergency Response Using Crowd Supported Analysis of Social Media." In: *Proceedings of CHI Workshop on Crowdsourcing and Human Computation, Systems, Studies and Platforms*. Vancouver, BC, Canada: ACM.
- Sarcevic, A., L. Palen, J. White, K. Starbird, M. Bagdouri and K. Anderson (2012) "Beacons of Hope in Decentralized Coordination: Learning from On-the-Ground Medical Twitterers during the 2010 Haiti Earthquake." In: *Proceedings of the International Conference on Computer Supported Cooperative Work*. Seattle, WA, USA: ACM, pp. 47–56.
- Schafer, W. A., C. H. Ganoë and J. M. Carroll (2007) "Supporting Community Emergency Management Planning through a Geocollaboration Software Architecture," *Journal of Computer Supported Cooperative Work*, 16(4–5):501–537.
- Schafer, W. A., J. M. Carroll, S. R. Haynes and S. Abrams (2008) "Emergency Management Planning as Collaborative Community Work," *Journal of Homeland Security and Emergency Management*, 5(1). DOI: 10.2202/1547-7355.1396.
- Semaan, B. and G. Mark (2012) "'Facebooking' Towards Crisis Recovery and Beyond: Disruption as an Opportunity." In: *Proceedings of the International Conference on Computer Supported Cooperative Work*. Seattle, WA, USA: ACM, pp. 27–36.
- Sharma, R., M. Yeasin, N. Krahnstoeve, I. Rauschert, G. Cai, I. Brewer, A. M. MacEachren and K. Sengupta (2003) "Speech-Gesture Driven Multimodal Interfaces for Crisis Management," *Proceedings of the IEEE*, 91(9):1327–1354.
- Shih, P. C., K. Han and J. M. Carroll (2014a) "Community Incident Chatter: Informing Local Incidents by Aggregating Local News and Social Media Content." In: *Proceedings of the International Conference on Information Systems for Crisis Response and Management*. University Park, PA, USA: Scopus.
- Shih, P. C., K. Han and J. M. Carroll (2014b) "Community Poll: Externalizing Public Sentiments in Social Media in a Local Community Context." In: *Proceedings of the AAAI Conference on Human Computation & Crowdsourcing*. Pittsburgh, PA, USA: AAAI.
- Shih, P. C., K. Han, U. Heo and J. M. Carroll (2015) "Engaging Community Members with Digitally Curated Social Multimedia Content at an Arts Festival," *ACM Journal on Computing and Cultural Heritage*, Under Review.
- Star, S. L. and A. Strauss (1999) "Layers of Silence, Arenas of Voice: The Ecology of Visible and Invisible Work," *Computer Supported Cooperative Work*, 8(1–2):9–30.
- Starbird, K. and L. Palen (2010) "Pass it on?: Retweeting in Mass Emergency." In: *Proceedings of International Conference on Information Systems for Crisis Response and Management*. Seattle, WA, USA: Scopus.
- Starbird, K. and L. Palen (2011) "Voluntweeters: Self-Organizing by Digital Volunteers in Times of Crisis." In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Vancouver, BC, Canada: ACM, pp. 1071–1080.
- Starbird, K. and J. Stamberger (2010) "Tweak the Tweet: Leveraging Microblogging Proliferation with a Prescriptive Syntax to Support Citizen Reporting." In: *Proceedings of the International Conference on Information Systems for Crisis Response and Management*. Seattle, WA, USA: Scopus.
- Starbird, K., L. Palen, A. L. Hughes and S. Vieweg (2010) "Chatter on the red: What Hazards Threat Reveals about the Social Life of Microblogged Information." In: *Proceedings of the International conference on Computer Supported Cooperative Work*. Savannah, GA, USA: ACM, pp. 241–250.
- Suchman, L. A. (1987) *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge, England: Cambridge University Press.

- Sutton, J., L. Palen and I. Shklovski (2008) "Backchannels on the Front Lines: Emergent Uses of Social Media in the 2007 Southern California Wildfires." In: *Proceedings of International Conference on Information Systems for Crisis Response and Management*. Washington, DC, USA: Scopus, pp. 624–632.
- Taylor, M., G. Wells, G. Howell and B. Raphael (2012) "The Role of Social Media as Psychological First Aid as a Support to Community Resilience Building," *The Australian Journal of Emergency Management*, 27(1):20–26.
- Turoff, M., M. Chumer, B. V. de Walle and X. Yao (2004) "The Design of a Dynamic Emergency Response Management Information System (DERMIS)," *Journal of Information Technology Theory and Application*, 5(4):1–35.
- Veil, S. R., T. Buehner and M. J. Palenchar (2011) "A Work-In-Process Literature Review: Incorporating Social Media in Risk and Crisis Communication," *Journal of Contingencies and Crisis Management*, 19(2):110–122.
- Vieweg, S., A. L. Hughes, K. Starbird and L. Palen (2010) "Microblogging During Two Natural Hazards Events: What Twitter May contribute to Situational Awareness." In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Atlanta, GA, USA: ACM, pp. 1079–1088.
- White, C., L. Plotnick, J. Kushma and S. R. Hiltz (2009) "An Online Social network for Emergency Management," *International Journal of Emergency Management*, 6(3):369–382.
- Yates, D. and S. Paquette (2011) "Emergency Knowledge Management and Social Media Technologies: A Case Study of the 2010 Haitian Earthquake," *International Journal of Information Management*, 31(1):6–13.
- Yin, J., A. Lampert, M. Cameron, B. Robinson and R. Power (2012) "Using Social Media to Enhance Emergency Situation Awareness," *IEEE Intelligent Systems*, 27(6):52–59.