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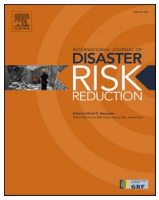

# Use of social media in crisis management: A survey

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ABSTRACT

Emergency situations arising out of natural disasters like tsunami, earthquakes, floods, hurricanes or man-made ones like terror strikes, riots, accidents, etc. cause tremendous social and economic loss and badly affect the poor in low-income economies, in particular. In this paper, we attempt to see and analyze the relationship between emergencies and online social media, especially Twitter, Facebook, and Youtube. Specifically, we look at three important issues. First, we try to see the effect of occurrence of emergencies on social media. Second, when there is a sudden surge of posts in social media due to the occurrence, how that deluge of data can be effectively extracted and processed to create situational awareness and minimize the damage due to the disaster. Third, how different social media posts can help different government and other agencies to get prepared and to take necessary steps to manage emergencies in order to minimize the loss. In this survey, the papers centered around emergencies and its effect on social media and different organizations related to crisis management are considered that are published in the past decade.

## 1. Introduction

Today social media plays an important role in our life. Social media services, such as Facebook, Twitter, LinkedIn, FourSquare, YouTube or Flickr, provide a forum for connecting people and creating online communities to share information and voice their opinion on any topic that affects their life. A study by Jin et al. (2014) [50] showed that people, especially young adults, are connected to social media all the time to very frequently in their daily lives.

During the time of disasters (natural or man-made), this use increases manifold. People try to communicate with their family and friends in the area of disasters and enquire about the safety and security of their lives. They seek or share information about food, shelter, transportation, medical and other needs. While many phone networks are unable to deal with sudden surge in calls (thousands of people trying to call simultaneously) or text immediately after a disastrous event, online social media like Facebook and Twitter can serve the people. These media have the ability to deal with large traffic, can stay online and serve as a medium of communication. It can also overcome the barrier of one-way communication of television and radio. In fact, in case of natural calamities, when electricity is cut-off or gets disconnected, these channels of communication (radio/television) can also be disrupted. Even then, through smart phones, tablets and other devices, people can reach to social media for real-time information exchange [24]. They can share their well being and location with friends and family. In an emergency, everyone is a potential source of important information that collects and distributes content [43]. Online social media, thus, can play an all-important role during crisis and emergency situations and it is, in fact, on the rise [67].

Increased use of smart phones has been recognized as an important factor which enables access to social media. In recent years, Twitter has been used to spread the number of casualties and damage, donation efforts and alerts, including multimedia information like video and photos [8,12]. Recent incidents of natural disasters have seen the network of humanitarian organizations and volunteers setting up web-based manual crisis mapping sites like the Haiti 2010 Earthquake, the Russian 2010 Wildfire, 2012 Hurricane Sandy of New York and Oklahoma for the 2013 Tornado [66].

Information ceaselessly flows in social media and it can be used to benefit emergency managers [42,83,107]. With the spread of network technologies, researchers have started focusing on the elements of network components, as well as reducing the impact of network elements on the effects and accelerating recovery from extreme events [62,63,99,102]. Social media, as an emerging and evolving communication technology offers the possibility of better emergency communication for its capacity, dependence and interactivity [48].

Although a few surveys on the topic of disaster and/or crisis management exist in literature, they mostly focus on some specific domain of

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administration or management like public health [59], use of social media by public during disasters [30,61,106], or case studies related to a particular event ([26,44]) etc. These papers cover very little technicalities involved in use of social media data as far as information processing is concerned. Some of these surveys are also little old, dating back to 2007 or earlier [3].

Among the recent surveys, Kankanamge et al. (2019) [53] discussed data collection through volunteer crowdsourcing from disaster domain along with from other domains like marketing and communications. Another survey by Chaves et al. (2019) [17] looked at how an urban emergency management infrastructure can be designed and built through crowdsourcing involving people in a participatory mode. Both the surveys look the problem from the point of view of policy administration and management with little or no discussion on computational techniques or methodologies involved therein.

We, therefore, attempt to study and do a systematic review (Linnenluecke et al., 2019 [64]) to provide a comprehensive account on the use of social media in different disasters worldwide, mainly from the technical point of view. The methodological approach we used was according to the one by Kankanamge et al. (2019) [53] and Yigitcanlar et al. (2019) [114].

In this survey, we focus on the use of social media during disasters (man-made and/or natural) as reported in the literature during the period of 2007–2019. We find Twitter as the most used social media platform compared to others like Facebook, YouTube, Instagram, LinkedIn etc. Twitter is preferred due to its simple usability, ability to make a short and quick communication instantly and most importantly, easy access to the content through its APIs without privacy and/or authorization issues. We include papers from both theory and practice covering the techniques and methodologies of using social media data. We explore the domain from three different angles and include the papers from each such perspective. Other than research papers, some software tools and relevant webpages are also considered.

The rest of the paper is organized as follows. In Sec 3, we describe the methodology of the article selection. In Sec 4, we describe the effect of different disasters and emergency situations on the social media. How the number of posts increase in the social media, what kind of information people share are looked at here. Next, how this flood of data can be used effectively to extract useful information is seen in Sec 5. The information can be helpful to the general users who seek specific information, or different emergency handling agencies for crisis management. In Sec 6 we try to describe how various social media posts can help different government and administrative agencies to take stock of the situations and necessary steps to reduce the emergency situation. We summarise and critically analyze different works in Sec 7. Finally we conclude in Sec 8.

## 2. Methodology

We conduct a systematic review of the literature reported and available in the public domain on the use of social media centered around disasters. The methodology followed is largely inspired by the work of Kankanamge et al. and Yigitcanlar et al. [53,114].

The keywords such as “earthquakes and social media”, “floods and social media”, “floods and social media”, “Tsunamis and social media”, “landslides floods and social media”, “wildfires and social media”, “cyclones and social media”, “natural disasters and social media”, “volcanic eruptions and social media”, “Natural hazard and social media”, “man-made disaster and social media” etc. were used on different academic search engines (ScienceDirect, Scopus, Web of Science, Google Scholar and Sci-hub).

The search included books-chapters, conference proceedings, peer-reviewed and non-refereed full-text journal articles. Our research aim is to see use of social media during disasters by different stakeholders with a focus on use of different computational techniques and methodologies from both theory and practice. We therefore excluded government or industry reports and non-academic studies.

Fig. 1 shows the procedure for collecting and then sorting the articles. Based on the keyword search we collected a total of 270 ($p = 270$) articles from different academic search engines. We explored the domain from three different angles and thus classified the papers from such perspectives after going through the titles and abstracts. The papers included here represent the development of the field in the last decade, specifically 2007 to 2019.

In the first category, we found a total 98 papers or articles related to the effect of emergency situations on social media. Based on title and abstract, the full text of each article was also seen to verify the scope against our research questions. All 98 articles were reviewed and analyzed. We again classified under five primary information categories: location prediction ($p = 4$), emotion analysis ($p = 4$), rescue or relief assistance ($p = 2$), time information ($p = 4$), and loss & casualty ($p = 8$).

For the second category (information processing techniques), number of articles found were 82. We classified the articles under four categories based on methodologies like: extraction ($p = 8$), summarization ($p = 3$), event detection ($p = 4$) and, classification ($p = 3$).

For the third category (effect or use of SM on disaster management), 90 articles were identified. We classified the articles under four categories: Apps for emergency management ($p = 5$), Police & Fire Department ($p = 6$), Civic Administration ($p = 9$) and, NGOs ($p = 3$).

A few additional articles were also consulted, though they did not meet the selection criteria, mainly to provide necessary research background. Thus total number of reviewed, cited, and quoted references increased to little over 110 papers.

## 3. The effect of emergency situation on social media

Social media is a platform where people emote and react instantly. A lot of posts are generally observed on social media whenever any major event occurs. In this section, we try a look at how social media get affected in emergency situations due to occurrence of any natural or man-made disasters. We classify papers detailing the effect of different aspects on social media into a number of categories.

### 3.1. Location prediction

During the time of disaster events, or immediately after it, people in general get curious to know the location of the event. For crisis managers, it is more imperative to learn the exact location, in some cases, even the longitude and latitude of the same with good amount of precision. We can find location information of the events from Facebook or Twitter data. Location can be classified into approximately three groups based on the techniques used in geographical assessment: content analysis with words in the gazetteer, material analysis with possible language model, and guess through social relations. Many studies attempt to estimate the location of web content using content analysis based on geo-related conditions in a particular external knowledge base [18]. Addresses, postal codes, and other information listed in the geographic gazette from web content to identify relevant geographic scope of web pages and blogs [4,31,37].

Table 1 summarizes the techniques used to find or estimate location.

#### 3.1.1. Markov chain based prediction

Singh et al. (2017) [94] proposed a tweet classification and location detection system to identify tweets from disaster victims asking for help and their location. The location was estimated using Markov Chain Stochastic model from their old tweets, if the location in the existing tweets is not mentioned.

#### 3.1.2. Event extraction from multimodal data

Adam et al. (2012) [1] discussed a US Govt initiative to provide location-based and context-aware personalized services to a wide user base through smartphones and other powerful smart devices equipped

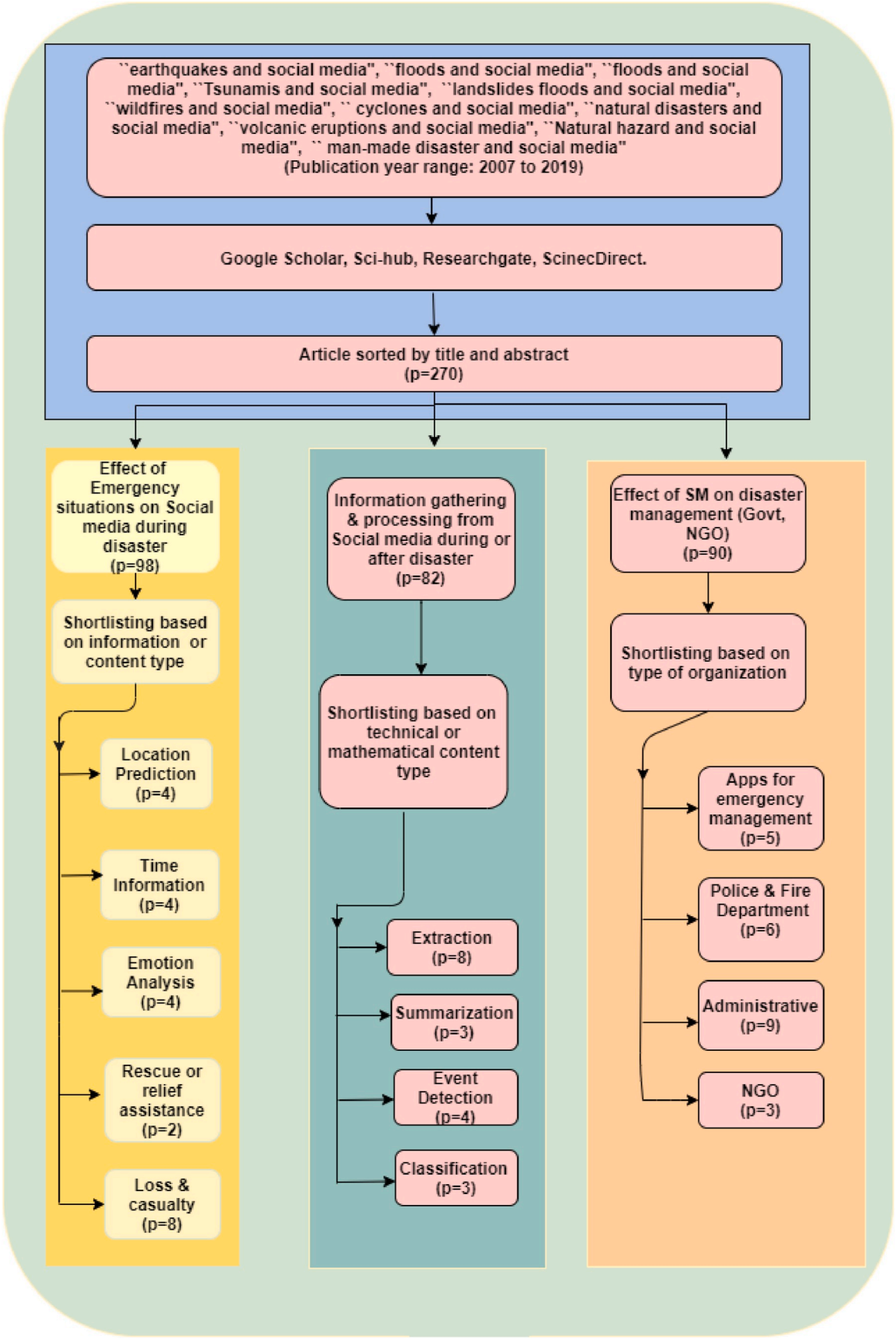


**Fig. 1.** Process of the article selection.

**Table 1**
Location prediction Techniques.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| location prediction | Markov chain | [94] | 32,400 tweets | prediction based on past location | 87% accuracy |
| Survey | Event extraction from multimodal data | [1] | SMART-C System | Geo-location data avialable | 80% users want SM monitoring and 30% expect help during disaster |
| Geo-location(GL) and location referencing(LR) | Extraction of geo-location from content | [107] | 4,592,466 tweets for Red River Floods(RR) and 1,986,091 tweets for the Oklahoma Grassfires(OK) | Based on user's specific address | 78% OK, 86% RR(GL) and 8% OK,6% RR(LR) |
| Location Estimation | Particle filtering | [90] | Real-time data | Each tweet is associated with a time and location, and each user treated as a sensor | prediction accuracy in terms of Euclidean distance error from actual location for earthquake = 3.01% and for typhoon trajectory = 3.58% |

with GPS and sensors, spatial computing applications and technologies. These smart devices enable users to remain always connected and interacting with various systems and information sources.

#### 3.1.3. Geo-location based identification

Vieweg et al. (2010) [107] analyzed the micro-blog posts generated during two concurrent emergency events, via Twitter in North America. Focussed on the communication broadcast by those who were,"On the ground" Oklahoma Grassfires of March and April 2009 during the flood of the Red River the authors identified the information that can contribute to the increase in situational awareness (SA). Carefully studying the tweets during the events followed by choosing a set of potential users and their tweets they built a sizeable collection of tweets for the analysis. The authors then manually categorized the tweets into three major groups: tweets having geo-location, location-referencing and situational updates.

#### 3.1.4. Particle filtering based prediction

Sakaki et al. (2013) [90] first classified tweets based on features like keywords, number of words, and their references in tweets. Then each Twitter user was treated as a sensor in a spatio-temporal model and then event was detected from the sensory observations. Location estimation was done using particle filtering technique. Their system was able to detect earthquake much earlier and disseminated the information much before notification from meteorological authority.

### 3.2. Time information

When a disaster happens or the news of its occurrence surfaces, people also get curious about the time of its occurrence, its duration etc. If that information is not readily available on the social media, then time of first post reporting such incident can work to approximately guess such time of occurrence. Also how much time it takes to broadcast the news of the disaster - how quickly it spreads in the social media so that people can be situationally aware of it and get prepared. If the post comes from an authentic source, it can get viral very quickly. In this section, we attempt to study different time-related aspects of communication in social media. A summary of time-related papers are summarized in Table 2.

#### 3.2.1. Role-based approach

Barley (1990) [9] discussed a role-based approach to the study of technology and functions, which differentiates between relational and non-relational properties of roles. However, Barley concluded that it is difficult to classify roles in particular relational and non-relational types, to explain that all roles are "bundles of non-relational and relational elements" [71].

Ehnis et al. (2014) [69] followed Barley's role approach to analyze the network role of the Berlin Police, and in its eventual relationship with other network roles in different crisis such as 1 May 2014 Labor Day events in Germany. The analysis provides evidence that, the Berlin Police did not broadcast many tweets, but had very high re-tweets of their tweets, by other media and political organizations. The study showed that the police had great influence and visibility in the social media communications network because of trustworthiness of the organization. Very low time to re-tweets (few seconds or minutes) indicated a high speed of information flow and a belief in the communications authenticity.

#### 3.2.2. Rule based classification

Kongthon et al. (2012) [55] did a case study on 2011 Thai flood. During the serious flood situation in Thailand, Twitter showed the ability to become an effective tool for Thai citizens, where minute information were obtained and broadcast. With its real time-enabled platform, Twitter allowed traditional journalists, as well as "citizen journalists" to provide an immediate status report. Twitter messages were classified based on keyword analysis and rule based approaches. People used Twitter for real-time and practical information that conventional media could not provide during the natural disaster period. However one needs to be cautious about the false, outdated, or

**Table 2**
Time information Techniques.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Time to first re-tweets | Barley's role approach | [69] | 13,511 Tweets | Retweet analysis with time | 52 s |
| Time-series analysis and tweet category | Rule based classification | [55] | 175,551 Tweets of Thaiflood | Five different categories of tweets | Situational announcement and alerts are dominant type, Twitter activities decreases over time and becomes negligible after one and half month |
| Time-series analysis | Trend analysis | [85] | 94,101 Microblog posts | Type of messages and re-posting behaviors in respect to different types of information(five major categories) | 1540 (35%) opinion-related messages, 1151 (26%) situated update messages, 811 (18%) general Yushu Earthquake related messages, 729 (17%) emotion-related messages |
| Survey (1146 respondents) | Uncontrolled sampling technique | [101] | FB users of Aus & NZ during disaster | Based on 27 survey questions | 70% responses (800) within 36 h; mostly from age-group 25–44 (51%); most important online activity information seeking (83% general, 55% specific) |

inaccurate information that could complicate situational awareness of a crisis and hence slow down relief efforts.

#### 3.2.3. Trend analysis

Trend analysis reveals attention and activity shift during various stages of emergency response [85]. Qu et al. (2011) studied posts on Sina-Weibo, a popular Chinese micro-blogging site, during 2010 Yushu Earthquake. The authors examined trends of different types of messages and the re-posting patterns. They observed that people used the micro-blogging system for four major objectives during and after the disaster: calling for status updates, feedback, emotional support, and action. While situational updates flood the microblog site immediately and spread faster, they are mostly second-hand information and therefore used cautiously. Action related posts take time to grow as people need time to understand the situation and plan accordingly. Emotion and opinion related posts, although are not directly of help in rescue and relief, are helpful in understanding societal concern and need.

#### 3.2.4. Uncontrolled sampling technique

The authors use snowball sampling technique with an online survey [36]. Taylor et al. (2012) [101] revisit a survey to explore public use of social media during a series of natural disasters in Australia and New Zealand, during 2011. The study indicated that public relied on a mix of formal and informal information sources, often using re-post or re-tweet of government messages or information that they felt to be of use to communities. The role of social media is not to change face-to-face contact, or to alter the official warning services, but it can expand the ability to provide information, extend access to official messages, and limit the psychological damage caused by rumors and sensational media reporting. The paper discusses how social media, specifically their core strengths of timely information exchange and promotion of connectedness, were able to act as sources of psychological first aid in the early stages of disaster and assist in supporting aspects of community resilience.

### 3.3. Emotion analysis

Social media websites are used by users to express their opinion online. The primary working theory of emotion analysis is to classify the text in terms of positive, negative and neutral [103]. Emotion analysis is also called sentiment analysis or opinion mining. Based on the techniques applied, emotion analysis can be broadly categorized into two main classes [111]:

- lexicon-based methods
- Machine-learning based methods

Table 3 provides a summary of different techniques.

#### 3.3.1. Lexicon-based approaches

Lexicon-based approaches include calculation of orientation for documents from the meaning orientation of words or phrases in the document [104]. It calculates the degree to which people use different categories of words in a wide range of texts, including emails, speeches, poems, or everyday daily speeches. Wang et al. (2014) [110] used a lexicon-based classifier, where first a lexicon dictionary is built. With the help of Linguistic Inquiry and Word Count (LIWC) [100] the authors developed an advanced sense classification method to detect anomaly in social media sentiment pattern. They first categorized the tweets into four classes independently by 8 annotators who agreed in 80% cases. The authors then did automatic classification using their technique.

#### 3.3.2. ML-based approaches

Machine-learning based methods use the known properties obtained from training data to classify new information. There is a wide variety of machine-learning-based methods, such as naive Bayes classifier, maximum entropy classifier support vector machine, etc. Machine-learning-based methods generally require a large training dataset. This approach can achieve a good classification accuracy compared to a simple lexicon-based approach, and therefore, is widely used [40,79].

#### 3.3.3. Hierarchical classification

Qu et al. (2009) [86] studied Tianya, an online forum to demonstrate how Chinese netizens faced the 2008 Sichuan earthquake and used discussion forums for emergency response and recovery. By analyzing the earthquake-related discussions on Tianya, they first manually identified 16 non-exclusive classes of threads. Then they applied mix (bottom-up and top-down) classification approach to have 8 middle level classes which were finally categorized into four major classes. These four significant ways are, namely, information related threads, opinion related threads, action related threads and emotion related threads. The panel responded quickly and relatively efficiently to the disaster, for information and opinion roles.

**Table 3**
Emotion analysis techniques.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Anomaly detection in sentiments | Lexicon-based classifiers | [110] | Twitter data from users of a service company in Singapore | Users are located in Singapore | Mean agreement between proposed method and 8 annotators = 80% |
| Community response after 2008 Sichuan earthquake | mixed (top-down &bottom-up) categorization | [86] | 2266 threads from Tianya forum (within 7 days) | 16 non-exclusive classes, 8 middle level and 4 top-level classes | Qualitative analysis. Information seeking, sharing, gathering and integrating were major activity. Other major classes of threads: opinions (32.1%), emotion (14%) criticizing (12%). |
| A survey of SM use by a minority community in crisis | Hierarchical regression analysis | [81] | 1018 African American travelers | travelers have taken at least one trip in the past 12 month i.e 50+ miles away from home and persons having origins in any of the Black racial groups of Africa | largest % of respondents were female (59.3%) and in the age group 50–59 (30%), well educated (35.9% college educated, 24.5% Bachelor's degree) and full time employed (43.3%). Younger African Americans are more likely to seek info about a crisis while traveling and perceptions of crime and financial crisis are high via SM than older groups |
| Case study on gas shortage in New Yark city after 2012 Hurrican Sandy | Autoregr-essive-moving-average model | [72] | 2 data set,1. Ground truth data of gas availability in region collected,2.711 tweets collected over 22 days with negative sentiment | Relation between the Twitter social response and actual damage can be predicted | Social sentiment shows non linear behavior, closely follows actual damage initially but puts more importance on its past value gradually. Current damage is best approximated by a combination of past damage and current social response |

#### 3.3.4. Hierarchical regression analysis

A study by Pennington-Gray et al. (2013) [81] examines the minorities and tourists as at-risk populations and their relationship with social media in the event of crisis. The study based on a survey on African American tourists in USA specifically explores three questions: the influence of age, risk perception, level and type of prior use of social media on the use social media during crisis. The authors conclude that young participants use social media more than their older counterparts and perception of crime and financial loss make them seeking information on social media.

#### 3.3.5. Auto-regressive-moving-average (ARMA) model

A linear ARMA model attempts to predict today's social response using the history of real damage and the history of past response values. Nguyen et al. (2014) [72] did a study on the problem of event modeling using information from social networks. In the aftermath of hurricane Sandy in 2012, the authors studied social sentiment and actual gas shortage in New York and New Jersey. Through time-series analysis they showed that social sentiment exhibits non-linear behavior following actual damage during initial stage of the event, but gradually puts more importance on its own past values.

### 3.4. Rescue or relief assistance

Many people suffer injury and trauma when/after they encounter a disaster and, therefore, need medical help. There is tremendous potential for further improvement in the delivery of medical and healthcare practices in the development and advancement of medical and healthcare information technologies [32,60,80] during disasters. With social media tools becoming ubiquitous, physicians are finding a role for them in their medical and healthcare practices [5,20] using social media. It actually provides an ideal platform for practicing physicians to share real-time collaboration and new ideas, past experiences, and current medical and health care research [5]. Two survey works were prominent here (Table 4) that are discussed below.

#### 3.4.1. Scoping review

Arksey and O'Malley [6] first created a framework for scoping review and followed by lot many other in recent years [21,57,82]. Finch et al. (2016) [30] conducted an extensive literature review on the use of social media in the domain of public health and environment. And concluded that social media data can help in better planning and delivery of service by public health professionals.

#### 3.4.2. Commentary approaches

Lim (2016) [59] discussed the opportunities and challenges of using social media in medical and health care situation in general, and during emergency in particular. The author opined that the success of public health emergency systems relies on routine attention to preparedness, timeliness in responding to catastrophes, adopting and utilizing social media can help emergency management medical and health care communities (i.e. medical and public health professionals) to respond to and make informed decisions about medical and health catastrophes.

### 3.5. Loss & casualty

Crisis management is the process by which an organization handles a disruptive and unpredictable event that threatens to cause harm to the organization or its stakeholders [13]. Crisis management studies started in the 1980s, largely due to industrial and environmental disasters [93]. Plenty of literature exist in the field, some of which are summarized here (Tables 5 and 6).

#### 3.5.1. Overview of natural disasters

Velev and Zlateva (2012) [106] studied the use of social media during natural calamities. They identified characteristics of social media that attract people to use them during disasters, specifically when conventional mode of communication become non-functional. The authors categorized how people communicate in social media during crisis and then suggested how it can help crisis managers in amplifying information dissemination, increasing preparedness and crisis mitigation.

#### 3.5.2. Literature review

A group led by Palen works in the field of crisis informatics that studies how critical information on losses and casualties can be accurately obtained during crisis. They analyzed information flow in both informal and formal channels during 2007 Virginia Tech Campus shooting and 2007 Southern California Wildfires. In the shooting incidence, they did face-to-face interviews of students and staffs, and followed different informal communication among students and general public and formal official communications from the University authorities [78,108]. In another paper [77] Palen described how people engaged in social media to get more local and focused information of the wildfire over the formal channel which were more general and inaccurate.

#### 3.5.3. Use of social media in different disasters worldwide

Lindsay (2011) [61] studied the use of various "social media", ranked as the fourth most popular source to access emergency information. The author categorized its use in two broad categories. One, passive use to disseminate information, and receive user feedback through incoming messages, posts and polls. However, recently, the second category seems prominent with more pro-active involvement and engagement by the users for early warnings, timely notification,

**Table 4**
Rescue or relief assistance.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Literature review | Scoping review (Arksey and O'Malley framework) | [30] | 34 articles from Web of Science, EBSCOhost Academic Search Complete, and PubMed databases | examine how social media is used during natural disasters & environmental concerns etc, determine what the implications are for public health officials, and identify research gaps | SM disseminate information, give early warnings, predict where and when a disaster will occur, raise environmental awareness, promote health, and measure public participation during natural disasters and Public health officials can use this information to provide more timely responses, gauge the overall health of the public, and spread messages and awareness |
| survey | Commentary approaches | [59] | Public Health (Data size N/A) | Opportunities and challenges of using social media in medical and health care | Three prospects that social media can offer to medical and health care practices, namely, enhancement in participatory medicine, quality of care, and emergency management & preparedness. Defamation, privacy, accuracy of info, are some of the challenges for the progressionals. |

**Table 5**
Loss & casualty.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Literature review | Survey | [3] | Social Media Data | Seven ways in which social media are put to use for disaster response, recovery and risk reduction | Social media support the influence of the existing public-side information production and distribution |
| Use of Social Media in different disasters worldwide | Survey | [61] | Social Media Data | How social media have been used by emergency managers and agencies and its potential benefits, implications in the context of emergencies and disasters | SM can be used passively to disseminate information and receive user feedback via incoming messages, wall posts, and polls. Two categories: 1. Systematic use involves the medium to make emergency communications and issue warnings; 2. Use of SM to receive victims' requests for assistance; Monitor user activities to establish situational awareness; and using uploaded images to create damage estimates. |
| Literature review on Twitter in emergency management over the past ten years in Australia and overseas | Literature survey | [26] | Twitter Data (data size NR) | 75 papers are used for Literature review | Twitter in emergency management are as an additional means of communication, for crisis mapping for response, for understanding the sentiment of those affected, and in sharing real-time information between the community and emergency managers |
| Case study of users in Japan during earthquake and tsunami (2011) | Social mobile media & Mobile intimacy | [44] | Mobile media data (Twitter, MobaGe, Mixi) during earthquake & tsunami and face-to-face conversation with Tokyo residents (20–30 years) | Study on<br>1 whether OSN helps in maintaining relationship during crisis<br>2 Similarity & dissimilarity with old methods | 1 OSN provides new channels for affective of mobile intimacy<br>2 This is an extension old media practices and rituals like postcard |
| Case study of social media use in 2011 Thailand flood | Social media-based crisis management framework and the structuration theory | [51] | Social media data during Thailand flood between July 2011 and January 2012 | Use of social media before, during, and after its occurrence in three communications: agencies-to-agencies, agencies-to-communities and community-to-community | Five important project management lessons learnt: 1) Risk assessment should be done and communicated to people before disaster 2) Effective team development is necessary for social media followed by action from government agencies. 3) Absence of Govt effort spurred rapid adoption of social media among the public 4) Risk control should take precedence to risk analysis 5) Govt should actively interact with public even after the crisis to announce different rehabilitation schemes |

update relief and recovery information, to listen to victims' requests and address them, using uploaded images to estimate damages etc.

### *3.5.4. Literature review on twitter in emergency management over the past ten years in Australia and overseas*

Dufty et al. (2016) [26] studied the current literature in Australia and abroad for identifying the main uses of Twitter in emergency management for the last ten years. The main use of Twitter in emergency management is in the form of an additional medium of communication, for mapping the crisis for feedback, to understand the spirit of the affected people and to share real time information between the community and emergency management.

### *3.5.5. Social mobile media*

Hjorth et al. (2011) [44] discussed the deployment of social media spreading civic engagement and methods of the press. Based on a case study with participants living in Tokyo on the date of the terrible events surrounding Japan earthquake and tsunami disaster on March 11, 2011 (3.11), this article gave a good account of the role of new media in helping, if, at all, and managing distress and grief.

### *3.5.6. Crisis management framework and the structuration theory*

Kaewkitipong et al. (2012) [51] discussed a case study of heavy floods occurred between July 2011 and January 2012 in Thailand, affecting more than 13.6 lakh people. The study provides a greater understanding of the use of social media before, during and after the occurrence of a disaster. The authors here focused on the management of crises in the immediate, complex, and long projects from a structural and theoretical perspective. They studied each of pre-crisis preparedness and mitigation, during-crisis response and post-crisis recovery phases from three angles: communication between agencies to agencies, agencies to communities and communities to communities.

### *3.5.7. Sociological theory about collective behavior in disaster*

Hughes et al. (2008) [45] discussed seven types of social convergence: the anxious, the returnees, the curious, the helpers, the exploiters, the mourners, and the supporters. The authors gave an example of each type through online activities. The first five of these types were originally defined by Fritz and Mathewson (1957) [34], while the last two–the mourners and the supporters–were newly identified by Kendra and Wachtendorf (2003) [54]. By seeing these activities as important parts of the disaster social sector, the authors commented that types of these activities and communications in the public sector are not only relevant to the disaster response - in many cases, they are necessary. Next step to these activities could be to prepare for on-line environments, equipment, and specific types of convergence activity. For example, the government bodies can support the activities of mourning with digital environments that make users easily, customize and maintain your monuments, etc.

**Table 6**
Loss & casualty (contd …).

| Study type | Tech-niques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Overview of natural disasters | Survey | [106] | Social Media Data | guidelines for organizing information exchange by social media | Functions and components of social media and communication types between participants during natural disasters |
| Case study | Over-arching Approach | [108] | Virginia Tech Shooting Data in a Facebook group | The "informal" public-side communications within a close community of the University | Contrary to popular belief that social media spread rumors, the group communicated with authentic figures of casualties in a manner of matured citizenry |
| Study on crisis informatics | Case study | [78] | Media Reports of Virginia Tech on April 16, 2007 | Challenge of studying citizenside information generation and dissemination activities during the April 16, 2007 crisis at Virginia Tech, investigated both on-site and on-line features of the large-scale social interaction | There are roughly 8 socio-temporal stages of a disaster. Crisis informatics involving socialy and behaviourally conscious ICT development and deployment is needed with a united perspective of information, disaster and technology. |
| Case study | Twitter and the Great East Japan Earthquake | [52] | Social media data | Social media mid-level disruptions by natural disaster the case of the city of Tsukuba in Ibaraki prefecture during the Great East Japan Earthquake of March 2011 | Twitter was found to be most effective for quickly spreading information whether good or bad. |
| Examina-tion of social convergence behavior in the 2001 World Trade Center Disaster | Sociologi-cal theory about collective behavior in disaster | [45] | Empirical data of four events World Trade Center Disaster, Hurricane Katrina, Virginia Tech Shooting and Southern California Wildfires of 2007 | To check different categories of social convergence theory and their nature during crisis in digital world | Seven types of social convergence: the anxious, the returnees, the curious, the helpers, the exploiters, the mourners, and the supporters. |

### *3.5.8. Twitter and the great east Japan earthquake*

Muneo Kaigo (2012) [52] conducted a study on the use of Twitter during the March 2011 Great East Japan earthquake in Tsukuba city. Tsukuba city was relatively unharmed in comparison to much of the devastation of northeastern Japan, but lost electricity, water immediately. Telephone and internet communication and also stopped web-enabled phones and smartphones became the primary device for communication through VoIP, SMS, email and social media. Facebook

**Table 7**
Extraction techniques.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Improving situational awareness | Information Extraction techniques | [107] | 4,592,466 tweets for Red River Floods (RR) and 1,986,091 tweets for the Oklahoma Grassfires (OK) | extracting useful, relevant information during emergencies | The events identify the characteristics of the information generated during the emergency and lead to the development of a working framework to inform the design and implementation of software systems that employ information extraction strategies. |
| Extracting Information Nuggets from Disaster | Naïve Bayesian classifiers | [47] | 206,764 tweets | A system to automatically extract information nuggets from microblogging messages during disaster times(7 Extractor) | The precision of all the extractors are above 0.7 except for the Damaged Object Extractor(0.47) |
| Preliminary study | Spectral clustering | [39] | England riots = 1,165,628, hurricane Irene = 90,237 and earthquake in Virginia = 277,604 tweets | identify and characterize communities from a set of users who post messages on Twitter during crisis events | 81% accuracy |
| Analysis of public behavior | Visual Analytics Approach | [15] | Real-time tweets, collect about 2.2 million geo-tagged Tweets with in the United States per day | How people prepare and respond to disasters, plays an important role in crisis management, disaster response, and evacuation planning | Demonstrated an integrated visualization that allows spatial and temporal aspects with in a single view |
| Compares the capabilities of two popular systems-Project Epic's Tweak the Tweet (TtT) and Ushahidi | Geospatial Technology | [65] | Twitter Data or SMS Text | Earthquake data | Both provide rudimentary situational awareness and visualization features |
| Case studies | Counter-disaster systems | [105] | events of the disaster in order to show the state of the country after March 11 | comprehensive survey of Counter-disaster systems | Future disasters: i) authorities are advised to disclose statistical information as quickly as possible, ii) coordination among developers must be provided, iii) interconnection of databases is essential for efficiency |
| Real-Time Crisis Mapping | Geospatial data-extraction tools & OpenStreetMap to access street-level | [68] | 877,527 tweets in 5 days | Compare street-level Twitterbased crisis maps to a verified ground truth based on post-event expert assessment | 90% precision |

and Twitter became the most effective medium for disseminating information. Tsukuba's municipal authority was using Twitter for communication with its citizens after the earthquake, and this forum played an important role in the spread of important information during the disaster and thus building a social capital. Life-lines of the city were out of service, yet social media functioned to spread information very fast to the public as well as among different disaster management agencies. However, there was potential of spreading rumors and unverified information.

## 4. Information gathering and processing from social media during emergency

In the last section we saw how activities in the social media gets a surge during emergency situation. Getting useful information out of this huge data in real-time is critical, at the same time, an increasingly difficult problem. How this sudden influx of information can be mined to get what one actually requires, what are the effective and efficient techniques to achieve this – are explored in this section. We cover the papers that primarily focus on different information accumulation techniques from microblogging sites. We classify papers focusing on the techniques into a number of categories. Table 7 summarizes the techniques.

### 4.1. Extraction

In text mining, information extraction is an important task. The general goal of information extraction is to find structured information with in uncontrolled or semi-structured text. Two basic functions of information extraction have been named entity recognition and relation extraction [49]. Some of the extraction techniques are summarized below (Table 7).

#### 4.1.1. Information extraction techniques

Vieweg et al. (2010) [107] discussed the manual identification of relevant information during emergency situations: specifically, through identifying geo-locations, location referencing and situational updates. Through a comprehensive study of two emergency events they came up with a number of features that can be used to identify useful tweets in any information extraction (IE) techniques.

#### 4.1.2. Naïve Bayesian classifiers

Imran et al. (2013) [47] described a method of machine learning based extraction of information nuggets from Twitter data on Joplin tornado 2011 data. For a filtering task, they first manually created training data through crowdsourcing and labeled the raw tweets into five categories: personal, informative (direct), informative (indirect), informative (direct or indirect) and other. They found 60% of the training data belonging to informative. Next they trained a Naive Bayes multi-class classifier to automatically classify informative tweets into further sub-categories based on a set of binary, scalar and text features. They also extracted information nuggets of different categories: caution & advice, casualty & damage, donation & offer etc with reasonable accuracy. The experiments established application of machine learning based filtering and extraction of structured information nuggets in crisis informatics with acceptable performance.

#### 4.1.3. Spectral clustering

Gupta et al. (2012) [39] identified, extracted and characterized prominent components of topics and opinions that people share during crisis events on Twitter. The aim of the study was to identify different user community based on the topic of discussion and mark them by top central users based on Twitter data during England Riots, Hurricane Irene and Earthquake in Virginia, occurring in 2011. To detect communities, first user-user similarity calculation was done using content-similarity (common words, hashtags, URLs), link similarity (based on # retweets, mentions, replies between two users) and meta-data similarity (common location). Spectral clustering was then applied to find clusters. All the users were thus divided into clusters. Degree centrality was used to find top users in each cluster. The experiments suggested that the top users represent the topics and opinions of an entire community with an average 81% accuracy.

#### 4.1.4. Visual analytics approach

Chae et al. (2014) [15] developed a tool for visual analysis of spatio-temporal distribution of tweets to identify public behavior patterns during natural disasters. The authors collected geo-temporal information of the Twitter users and plotted them on a map using different colors based on posting time. On a single frame, the tool offered visualization of both location and time. The main features of this approach are spatial analysis and decision support, temporal pattern analysis and spatio-temporal visualization. All methods are tightly integrated based on a user-centered design in order to enhance the ability to analyze huge social media data. The system provides effective analysis for exploring and examining the spatial distribution of Twitter users and supporting spatial decision making using a large volume of geo-located tweets and multiple types of supplementary information during specific time periods. Using user movement data of two emergency events: hurricane Sandy of 2012 in New York city and Moore tornado of 2013 they showed how the visualization tool can help understand public movement from normal time to time of crisis. Also it can help in understanding the effect of public warnings, design evacuation plan and disaster management.

#### 4.1.5. Geospatial technology

McClendon et al. (2013) [65] compared capabilities of Project Epic's Tweak the Tweet (TtT) and Ushahidi, both of which collect and visualize crowd-sourced information. TtT system takes the tweets from Twitter streaming API with content is mapped to locations using Google map. Ushahidi can be configured to work with Twitter API and provides APIs for data exchange in XML and JSON. The raw data can be saved in Google spreadsheet and integrated with Googlemap. Both the software are comparable in their capability of creating crisis maps and provide rudimentary situational awareness and visualization features.

#### 4.1.6. Counter-disaster systems

Middleton et al. (2014) [68] came up with a social media crisis mapping system in real-time for natural disasters. They collected disaster-prone areas or locations from the gazetteer, road map and voluntary geographical information (VGI) sources and matched them with real-time tweets. GoogleGeoCoding API is used for necessary geo-coding. With case studies on hurricane Sandy and Oklahoma tornado, they demonstrated more than 90% precision in geo-parsing from real-time tweets.

#### 4.1.7. Machine learning methods

Utani et al. (2011) [105] did a comprehensive survey on a plethora of systems developed during the Japan earthquake 2011 triggered by real world needs of victims and survivors and shared by Twitter, Facebook and Mixi (a Japanese networking service). The authors identified 162 counter-disaster systems use Google Person Finder (a database service with details of missing persons and identified persons), Traffic/Road information service based on car-navigation data and Google map, Electric Power information tool to forecast power outages, radioactivity monitoring systems.

### 4.2. Event detection

An event is an arbitrary classification of the space-time zone. An event can be a actively participating agent, idle factor, products, and a location in space/time [87]. Events such as earthquakes, typhoons, traffic jams, and flood are visible through tweets. A target event is extracted from tweets with the help of hashtags and keywords. For

example, the rapid and massive influx of tweets coming soon after the earthquake prompted many blog postings and articles, which use Twitter as a tool for earthquake detection [27,58,73,89,91]. Some of the reported event detection techniques are summarized in Table 8.

#### 4.2.1. Short and long-term-average algorithm

Earle et al. (2012) [28] ran an experiment to check whether Twitter can detect an earthquake and to what extent. They checked rapid increase in the number of tweets containing the word "earthquake" or similar in other languages. Rapid increase was detected using short-term-average over long-term average (STA/LTA) algorithm popularly used in seismic study. Although the technique missed vast majority of the earthquake events (48 detected out 5175 occurred), it detected the major ones within tens of seconds of occurrence.

#### 4.2.2. GNOME model through event detection

Aulov and Halem (2012) [7] used social media (SM) as a human sensor network in oil spill prediction. SM was included in the geophysical model, with satellite observations and sensor measurements. Along with the use of a special software GNOME that is used to predict oil spill, the authors collected tweets, Flickr images, with their geo-tags to compare and verify the oil-spill trajectory of GNOME. The longitude, latitude, timestamp of SM data were taken as ground truths and GNOME forecasts were compared with them.

#### 4.2.3. Transaction-Based Rule Change Mining

Olowe et al. (2016) [2] studied event detection and tracking for three events in Twitter: from two different domains; Sports (English FA Cup 2012) and Politics (US Presidential Elections 2012 and Super Tuesday 2012). They applied Transaction-Based Rule Change Mining (TRCM), motivated by Association Rule mining on the tweets. Since a football game is of 90 min–120 min event, whereas election is of much longer duration, they applied different datatype to different time-windows and update rates for their study (Football 2000 tweets per 1 min slot; President election 20,000 tweets/10min slots; 10,000 tweets per 1 h update rate). TRCM was able to correctly detect 54 out of 59 events for FA Cup data and for election detection accuracy was 45%.

### 4.3. Summarization

With a summary, we can make effective decisions in a short time. Although some tools are already available, with increasing volume of online information, it is becoming difficult to generate meaningful and timely summaries [41]. Some of the reported summarization techniques are summarized in Table 9.

#### 4.3.1. Content analysis

Yates et al. (2011) [113] did a case study on Haiti Earthquake (2010) response that was a large effort co-ordinated by three major agencies involving Govt of Haiti, UN and a number of countries. The authors detailed how a social media tool SharePoint was used to share, reuse, different information in the real time and cut down time in decision making. The paper discussed in detail how knowledge from different agencies were captured and shared without redundancy/duplicacy, discussed and then decision was communicated across them with the use of SharePoint and Wiki. The authors also pointed out potential loopholes in using such systems and suggested how to plug them.

Vis (2013) [109] studied the use of Twitter as a tool for reporting breaking news during UK riots 2011. The author mainly focused on the Twitter activity of two journalists of mainstream news media and analyzed their ways of data collection as well as sharing of mainstream news content with links, images and videos. Both the journalists use Twitter for real-time reporting. While one journalist restricted himself in expressing personal opinion (5.2%), the other was more expressive (22.4%).

#### 4.3.2. Incremental clustering algorithm

In a study of microblog use by Qu et al. (2011) [85], the authors looked at three different questions:

1 What people post during disaster?
2 How the posting pattern changes over time during different stages of a disaster?
3 How information spreads in microblog-sphere?

For Question 1, they iteratively developed a classification and coding scheme based on manual checking of few sample tweets randomly. For trend analysis, they looked at distribution of different types of post categories (done in categorization) over time. To understand information spread, they saw the frequency distribution of re-posts of different message categories followed by regression analysis to identify factors of reposits.

### 4.4. Classification

Classification is the process of analyzing a particular input and assigning it to (one or more) category. Some of the reported classification techniques are summarized in Table 10.

#### 4.4.1. Naive Bayes classifiers

Yin et al. (2015) [115] discussed the relevant approaches for burst detection, tweet filtering and classification, online clustering and geotagging. Burst detection focused on monitoring a feed of Twitter messages and raising an alert for immediate attention when an unexpected event was detected. When Twitter was monitored for a specific incident, then every other published tweets was considered to be largely

**Table 8**
Event detection techniques.

| Study type | Techniques | References | Dataset | Assumption | Observation |
|---|---|---|---|---|---|
| Earthquakes detection | Short and Long-term-average algorithm | [28] | real-time earthquake & tweets containing the words "earthquake", "gempa", "temblor", "terremoto", or "sismo" | categories of alert dissemination, situational awareness, and event detection | 75% occur within 2 min of the origin time |
| satellite observations and sensor measurements | GNOME model | [7] | NOAA/NOS medium resolution coastline data designed for 1 : 70,000 scales. | GNOME trajectory forecasts | oil trajectories, indicating the need for realistic quantitative mapping of the thickness of inferred oil spill images |
| Event Detection | Gradient boosting and Random forest | [94] | 32,400 tweets | tweets in English and Hindi languages | 81% accuracy |
| Event detection and tracking | Transaction-based Rule Change Mining (Association rule mining) | [2] | Twitter dataset from: FA Cup final (444,291 tweets), US Elections 2012 (3,837,291 tweets) and Super Tuesday 2012 (474,109 tweets) | Dataset divided into different tweets/time slots (FA: 2000 tweets/time slot of 1min; Election: 20,000 tweets/slot of 10min; SuperT-day: 10,000 tweets/slot of 1hr) | FA cup(Prec - 96.6%, F-score 76.9%), US elections(Prec - 53.8%, F-score 60%), Super Tuesday (Prec - 62.5%, F-score 58.79%) |

**Table 9**
Summarization techniques.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Case study | Content Analysis | [85] | 94,101 microblog posts and 41,817 re-posts | five major categories | 1540 (35%) opinion-related messages, 1151 (26%) situated update messages, 811 (18%) general Yushu Earthquake related messages, 729 (17%) emotion-related messages, and 177 (4%) action-related messages |
| Twitter as a reporting tool | Content Analysis | [109] | Two datasets:<br>1 The Guardian/Twitter database of 2.6 million tweets, uploaded by 700,000 individual users<br>2 731 tweets by two journalists | To study evolving nature of use of Twitter by instinctive journalists | Both journalists took to Twitter predominantly for eye-witness reporting (30%) with huge use of hastags (59% and 78%), also expressed personal opinion (5% and 22% respectively). |
| Australian Government to detect, assess, summarise, and report messages of interest for CC published by Twitter | Incre-mental clustering algorithm | [14] | Real-time data of Twitter | Cluster summaries with font size and colour used to indicate the relative number of tweets | Evaluation of this algorithm and approach is the subject of ongoing work. |

**Table 10**
Classification techniques.

| Study type | Techniques | References | Dataset | Assumption | Observation |
|---|---|---|---|---|---|
| Burst detection, tweet filtering and classification, online clustering, and geotagging | Support Vector Machines (SVM) and Naive Bayes classifiers | [115] | annotated dataset of 450 tweets | classification features:word unigrams, word bigrams, word length, the number of hashtags, the number of user mentions | Naive Bayes and SVM achieve classification accuracy of 86.2% and 87.5% |
| Classify and Review High-Value Messagesn | Support Vector Machines | [14] | near-real-time information from Twitter during February 2011 earthquake. | Classify and review high-value messages during an incident (e.g. messages describing infrastructure damage or cries for help) | Watch officers with a more targeted view of information during an incident. |

irrelevant. The authors used two classification algorithms Support Vector Machines (SVM) and Naïve Bayes classifiers, with the latter being the most effective for text classification. These features were used for architecture classification: word unigarm, word bigram, word length, number of hashtags, user number, whether the tweet has been retweeted, and other users have responded to a tweet.

#### 4.4.2. Support Vector Machines

Cameron et al. (2012) [14] described a work with the Australian Government to identify, evaluate, summarise, and report tweets of interest for crisis coordination. The developed platform and devices, collectively termed as the Emergency Situation Awareness - Automated Web Text Mining (ESA-AWTM) system. Crisis coordinators required the tools and services that the social media needs to meet the following requirements:

- Find unexpected or unusual events, possibly beyond official communication;
- Provide messages and summaries about an incident to keep awareness of the content collected without reading individual messages;
- Classify and review high-value messages during an event (for example, message describing the infrastructure or cry for help), classification was done based on Support Vector Machines;
- Identify, track, and manage problems that arise in an event;
- Perform forensic analysis of events by analyzing social media content in advance during and after an incident.

#### 4.4.3. Crowd-sourcing

Gao et al. (2011) [35] described the advantages and disadvantages of the crowd-sourcing application used for disaster relief coordination and challenges rumors, false information, baseless speculations, inaccurate geo-tags etc. Security is another problem which should be considered especially in the design of a crowdsourcing system in the Disaster Relief Management Plan. When making data publicly available, such systems should protect the privacy of NGOs and ensure the safety of their workers. Crowd-sourcing integrated with the map of crisis has been a powerful tool in the form of humanitarian aid and disaster. Future crowding applications should provide capabilities to better manage untested messages and improve streaming data.

6. Effect of social media on government and non-government policies and initiatives

Social media get sudden increase in the number of posts during crisis. There have been matching efforts to tap that data to understand and visualize the crisis, provide alerts, warnings, preparedness and plan rescue and relief measures through different computational techniques. In this section we focus on the use of social media by different government and non-government organizations in crisis management.

### 4.5. Apps for emergency management

In the recent past, along with different academic research, there has been a number of initiatives to develop applications to report, track, monitor and share information related to emergency situations. Most of these applications are smartphone apps as these devices are handy and easy to use. Some of the apps are already commercialized while others are prototypes at different stages of development in Table 11.

#### 4.5.1. uRep

Goncalves et al. (2014) [38] discussed the design and development of “uRep”, which allows civilians to use their smartphones to report problems during emergency. The app allows the user to snap a picture and geo-tag it using GPS. Emergency managers can get real-time update and plan for its mitigation. The app also helps one to get an idea of time-to-repair (TTR) for utility services, establishes a connection between the people and the utility providers, allowing people to report issues and companies to update their progress.

**Table 11**
Apps for emergency management during disasters.

| Study type | Techniques | References | Dataset | Assumption | Observation |
|---|---|---|---|---|---|
| Crowd-sourcing for Public Safety | "uRep", a mobile application developed at Kean University | [38] | Social Media Data | "uRep" needs civilians to use their smartphones to report problems | Users can upload images with geotagging using GPS to report incidents and get updates on its present status in real-time |
| Crisis mapping and management | "Ushahidi", an open-source s/w platform | [29,76, 112] | collects multi-media data from sms, emails, tweets, etc.) | Android and iOS app supports offline survey creation | In-bound data can be verified, and then disseminated with visualization using map, timeline, activity views having easy search, filter and clustering features |
| Crowd-sourced e-Health and medical informatics applications | "CrowdHelp", an app based on ML, cyber-physical systems, and crowdsourcing | [10] | Crowd-sourced data from victims or bystanders in real-time | ML algorithms for clarifying, deciphering, summarizing, and clustering all inputs into easily comprehensible visual images representing the geographical location, urgency | Helps users with real-time patient assessment and support with symptoms, causes, list of nearby health centers. Also helps disaster managers with patient details and geo-info. |

#### 4.5.2. *Ushahidi*

Ushahidi (means "witness" [29,76]) is a crisis mapping software that enables organizations around the world to collect, manage, visualize, and respond to information from their stakeholders. Based on open-source software, the platform is now deployed over 125,000 times in over 160 countries, collecting over 7 million reports cumulatively. It leverages Web 2.0 technologies to integrate data from multiple sources phones, Web applications, email, and social media sites such as Twitter and Facebook to provide an up-to-date, publicly available crisis map that is in turn available to relief organizations. This platform uses crowdsourcing for social activism and public accountability to collectively contribute information, visualize incidents, and enable cooperation among various organizations [35]. Use of Ushahidi has been reported in humanitarian crises in Kenya violence(2007–08), Haiti earthquake (2010), Chile earthequake(2010), Nepal earthquake (2015) etc. [112] (Fig. 2).

#### 4.5.3. *CrowdHelp*

Besaleva et al. (2013) [10] demonstrated a system CrowdHelp for real-time patient assessment which uses mobile electronic triaging (assess, sort and count) accomplished via crowdsourced information. With the help of CrowdHelp, emergency management professionals receive information needed for preparing themselves to provide timely and accurate treatments of their patients even before dispatching a response team to the site. CrowdHelp is a smartphone app that is lightweight, works with low battery power and weak service signal. It has a user end for ordinary users and victims and a server end for disaster management personnels. Through an easy-to-use and helpful interface an user can enter her problems and symptoms. Emergency professional can have data analysis from the back-end using machine learning techniques. Clarifying, deciphering, summarizing and clustering all inputs into easily comprehensible visual images representing the geographical location, urgency and association of each entry to a specific cluster, Crowdhelp helps in meeting the needs of disaster management (see Fig. 2).

### 4.6. *Police and fire departments*

During a disaster, police officers not only have to continue to keep the community safe from possible looting, destruction of property, and theft that may occur, they also have to be prepared to evacuate citizens, render advanced life saving techniques, and keep points of dispensing sites secure. Additional duties also include delivery of food, water, and blankets to those who have been displaced by the disaster. Police officers must be prepared with proper equipments that go far beyond a gun and a badge. Officers now are encouraged to carry preparedness kits that include food and water [33]. Table 12 summarizes the roles played by Police and Fire departments as reported in literature.

#### 4.6.1. *Exploratory case study method*

Latonero et al. (2011) [56] discussed the emergency management organizations such as police and fire departments that are trained in emergency situations. They use social media technologies available to interact with the public in emergencies and to collect potentially important information as a source of information on the basis of the public. An understanding of adoption of organizational innovation, risk communication and technology by emergency management is essential for effective interaction with the public. In the case study of the Public Information Officers (PIO) of the Los Angeles Fire Department, the importance of information evangelist has been highlighted within the emergency management organizations and social media and Twitter.

#### 4.6.2. *Qualitative text-based analysis*

Denef et al. (2013) [22] analyzed police crisis communication during the UK Riot on Twitter. London Metropolitan Police (MET) got the formal choice, depersonalized style which emphasized the difference

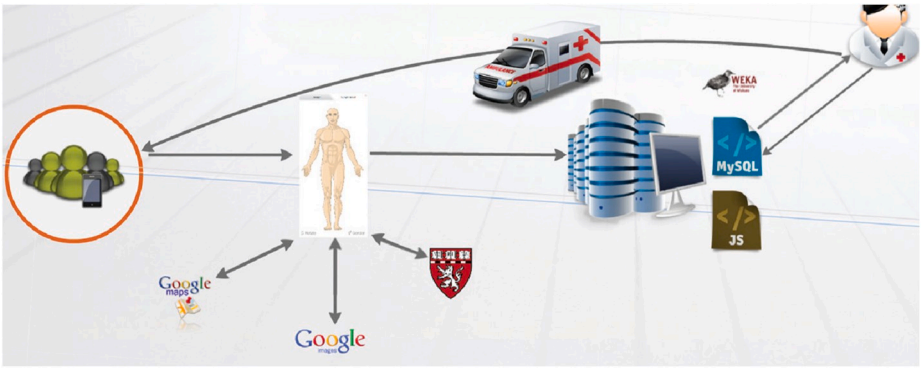


**Fig. 2.** Schematic Presentation of CrowdHelp Forum Workflow. An application layer serves as a gateway to platform's functionalities, and a server layer provides back-end facilities for disaster management professionals [10].

**Table 12**
Efforts of Police & Fire Departments during disasters.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Case study | Exploratory case study method | [56] | Social Media Data | case study of Public Information Officers (PIO) of the Los Angeles Fire Department (LAFD) | LAFD utilized Twitter as a tool for emergency management both for sending one-way messages to the public and for monitoring and responding to Twitter posts |
| Comparative study of Twitter communications by the London Metropolitan Police (MET) and the Greater Manchester Police (GMP) during August 2011 riots | Qualitative text-based analysis (Between Instrumental approach and Expressive approach) | [22] | 547 tweets posted by MET and GMP police forces from August 2nd to August 13th | Reporting Police Performance | Intrumental approach has low maintenance with low interaction with public and low potential to harness resources. Expressive approach has high cost but greater public tolerance of police mistakes. |
| Case study on Police and Fire departments during Hurricane Sandy (2012) | Content and Statistical Analysis | [46] | Communic-ation from 4 channels (website, Nixle, Facebook and Twitter) of 840 fire and police departments | Emergency management agencies have websites and social media accounts | Most depts have websites (81%) and/or FB accounts (66%) but very less Twitter accounts (13%). During hurricance, Few depts (246 departments, 29.3%) were in Sandy Active Group, 24.6% in non-Sandy active groups and the rest in inactive group. |
| Network role of an EMA like the Berlin police and its relationships with other network roles in an extreme event | Barley's role approach | [69] | 70 tweets over 2 distinct operational phases | Network behavior and perception of the police role during the 1st of May event | High number of retweets of police tweets (by 149 accounts) because of its trustworthiness. Police tweets were mostly (12 out of 14) for information braodcast, 1 broadcast warning and 1 influencing behavior. |
| Case study | Online Social Networks | [88] | Facebook page of Bangalore City Police, India, over a period of one month. | Victimization theory can be applied to find actionable items in residents' OSN communication to police. | Out of 255 posts, police replied to 172 posts. Most responses were related to safety issues (11.48%) and suggestions (9.02%). Responses were mostly to complaints (43.44%), acknowledgements (21.31%), follow-up (10%). Avg police response time is 30.53 h with SD 41.26 h. |
| Empirical Study of the 2015 Nepal Earthquake Police Twitter Project | An online field-study method called Netnography | [96] | Nepal Police tweets in April (231 tweets) and May (1241 tweets) | Situation Crisis Communication Theory (SCCT) and typology of convergence behaviors in emergency response (ER) can be used to categorize the public interaction with social media platforms | Curiosity (42%), detectives (22%) and help (18%) were major tweets in April 2015. But in May 2015, Support is the main convergent type followed by Curiosity. |

between Police and the public - that is called as *Instrumental* approach. Messages were largely helpful, either request or provide information or display Police display (e.g., number of arrests, officers On the road, or request for information). Greater Manchester Police (GMP), on the contrary, developed a very personal, informal style of direct conversation with individual followers (called the *Expressive* approach). Both the forces used the same communication medium Twitter. Intrumental approach is seen to have low maintenance cost but it does not inspire good interaction with public. Also it risks of having low potential to harness resources in short or long-term. Expressive approach, on the other hand, has high maintenance cost, but greater public tolerance of police mistakes.

#### 4.6.3. Content and statistical analysis

Hughes et al. (2014) [46] studied the use of internet and social media by US Police and Fire departments during Hurrican Sandy. Data were collected from four types of online communication media (Departmental website, Nixle, Twitter, Facebook) involving 840 Fire and police departments. It was observed that although most of the departments have websites (81%) and/or Facebook accounts (66%), only a few had Twitter (13%) account. Between the two, Police have better presence in online media than their Fire counterparts except in terms of Facebook accounts. Absence of policies regarding disaster communication used as a deterrent to adoption of widespread online or social media, the activities of active groups can work as useful precedents for formulating such a policy.

#### 4.6.4. Network role of an EMA

Ehnis et al. (2014) [69] discussed the use of social media platforms like Twitter affects the network role of an emergency management agency (EMA) like the Berlin Police, and in its eventual relationship with other network roles such as 1 May Labor Day. Twitter analysis of the May 1 incident provides evidence that the Berlin Police did broadcast only a few tweets, but they had great influence and visibility in the social media communications network.

#### 4.6.5. An online field-study method called netnography

Subba et al. (2017) [96] used the Situation Crisis Communication Theory (SCCT) to analyze crisis communication practices by the National Police Headquarters in the result of the 2015 Nepal earthquake. Twitter, as a popular social media platform, was used as an effective communication and collaboration platform between public authority and the general public. Help in creating a collaborative relationship between information on the situation of road conditions, casualties, landslide, relief and rescue operations, contacts and the disappearance of missing people were the major topics of communication between police department and followers. The OSN helped police often to reconsider its planning activities in handling situation and responses.

#### 4.6.6. Online social networks

Sachdeva et al. (2015) [88] studied the interaction between police and public through one month Facebook data from the account of Bangalore City Police. Safety and security for most urban communities is a concern. The results show that information about various crimes (information including location), information about neighboring issues

(alcoholic, illegal construction), financial fraud, property crime and theft, are known to the residents. The response of the police to the post of residents varies in ignore, accept, answer and follow-up. The police responds to the post of most residents and helps the residents reach the authority that can help solve the problem. The police adopt a formal communication style to communicate with the residents. OSN offers an opportunity for public accountability of police. This transparency can help increase accountability and to foster trust in the police and to generate a feeling of being protected in public.

### 4.7. Administration

Government agencies play an important role during any disaster, but the exact role of the government is often ambiguous to disaster victims. It is sometimes difficult to understand the complex relationships among different government programs at local, regional and national levels [74].

Types of Assistance: A state government may request three types of federal assistance as given below [74].

- Individual Assistance: For individuals, families, farmers and businesses in the form of loans, grants, emergency housing, tax relief and unemployment assistance.
- Public Assistance: Funds for states, local communities and non-profit groups to restore public systems and facilities.
- Matching Mitigation Funds: For states and local communities, for projects which eliminate or reduce an area's vulnerability to a hazard.

The following important works are summarized in Tables 13 and 14.

#### 4.7.1. Community response grids

Jaeger et al. (2007) [48] introduced the concept of developing a Community Reaction Grid (CRG) for community emergency response and discussed related policy implications of such a system. CRGs are designed to use internet and mobile communication devices, allow residents and respondents to share information, coordinating activities in response to a major disaster. Through mobile communication technologies and the web with e-government, response systems need to help communities before, during, and after a major disaster, provide channels to contact residents and respondents, upload information, coordinate information distribution, social network responses, and provide residential support to residents.

#### 4.7.2. Virtual socio-cultural analysis

Sutton et al. (2010) [97] discussed the use of Twitter after a technical disaster of coal fly-ash spill at Tennessee in 2008. The paper studied the social networking, collaboration and online convergence of distributed environmental activists. It also pointed out in contrast the lack of participation of local people, public officials and industry representatives. Network communication during disaster support distributed and coordinated activities, which can have a direct benefit to the local community, however penetration of the online media needs to be taken into consideration during information dissemination related to disaster management.

**Table 13**
Administration's use of social media during disasters.

| Study type | Techniques | References | Dataset | Assumption | Observation |
|---|---|---|---|---|---|
| Exploring and Viability study | Policy proposal for development of community response grid (CRG) | [48] | Empirical data of Hurricane Katrina, 9/11 terror attack, Kobe earthquake, tsunami etc. | Integrating mobile communication, Internet, e-Government and community through CRG can provide effective mechanism in crisis management | Estblishes the viability of using mobile communication technologies and the Web, including e-government and CRGs to enhance coordination of policies related to effective crisis management |
| Case study of a Technology Disaster | Virtual socio-cultural analysis (study on networked Twitter users and their content linked to a specific incident) | [97] | More than 1000 tweets (collected with incident-specific keywords) | Twitter can facilitate communication and collaboration both locally and among distributed networks | Distributed individuals broadcast information of a local disaster and its long-term effects inspite of lack of local participation and authoratative under-reporting |
| Social network analysis of tweets during the 2010–2011 Australian floods | Statistical and Visual analysis | [19] | Tweets extracted using search terms of hashtags: Queensland floods (6014 tweets) &New South Wales(384 tweets) & Victorian floods (1122 tweets) | Two types of network: a "users" network and a "users-resources" network were studied | Active and effective users: police, politicians, volunteers and NGOs. Important resources; webpages, blogs of general nature of floods. Twitter activity very low in NSW and Victorian floods than Queensland. |
| A study-cum-survey of floods in Queensland and Victoria, Australia (2010–11) | Online surveying (SurveyMonkey tool) | [11] | Facebook pages of local police, administration and communities; online survey of 432 users | Usefulness of social media related to the emergency services | Govt FB pages topped in accuracy and trustworthiness over community pages while the latter was more up-to-date and useful over the first; media websites and their FB pages were less impactful. |
| Policy paper | Proposing a Strategic framework of emergency management | [25] | Few references to use of social media in disasters | Analysis of different actions required for community disaster resilience and identification of three major fields:<br>1 Disaster Risk Reduction<br>2 Emergency Management<br>3 Community Development | 1 Sharing info, discussing and planning reduces risks<br>2 Through crowdsourcing help others prepare for disasters, co-ordinating relief and recovery<br>3 Learning from past and building resources (social capital) for future |
| Case study on 2011 US Shadow Lake Fire | OSN monitoring and virtual content management | [23] | Online data (Twitter, FB, Google, Dropbox etc.) | Interview questions, Interviews were conducted over the phone or Skype | A team of trusted online volunteers can help monitor, collect, share and coordinate emergency management alongwith responsible emergency managers |
| Disaster early warning system for Indonesian tsunami (2012) | Case study research for theory building & social network analysis | [16] | 6223 tweets by Govt agency & 6383 retweets by civic network in 16 days | Answering research questions<br>1 How govt used social media in alerting public<br>2 How govt engage public in spreading warning | Tsunami warnings reached as many as 4,115,164 Twitter followers within 6 min 7 s of earthquake (much within 15min acceptable time) |

**Table 14**
Administration's use of social media during disasters.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Case study of 2013 Colorado Floods | Mixed method approach of interviews and social media content analysis | [95] | Two data set<br>1 2013 Jefferson County Flood Data Set includes 115 blog posts, 361 tweets, 157 FB posts.<br>2 2013 Jefferson County Public Engagement Data Set included 5125 FB likes, 1027 FB comments, 169 Jefferson County Sheriff's Office FB comments, 54 tweets and 49 retweets from the Jefferson County Sheriff's Office account | 1 To find answers to How social media is used<br>2 Motivations for use<br>3 Effect of social media in mass media and public communication<br>4 Integration of social media into formal procedures etc. | 1 Twitter is used for real-time notification<br>2 Facebook for community engagement<br>3 Blogs for details serving as info backbone |
| Studying the role of social media intelligence analyst | Case Study | [84] | Different social media channels (Facebook, Instagram, Twitter, TweetDeck, SocialMention, FotoForensics, TinEye, Storify, Pipl, YouTube etc) and social media monitoring tools | face to face interviews with subject matter expert to understand the role | The job is 24 × 7 in different shifts. Daily job consists of active monitoring of SM channels, identifying priority events and tracking its developments, listening for new incidents, verification and corroboration of identified facts using other sources. |

#### 4.7.3. Statistical and visual analysis

Cheong et al. (2011) [19] studied that tweets extracted from Twitter during the Australian floods of the 2010–2011. The paper attempts to understand the social interactions of online communities for Queensland, New South Wales and Victorian floods. During the flood of Queensland, important and effective players were Local officials (mainly Queensland Police Service), political personality (Queensland Premier, Prime Minister, opposition leader, parliament member), social media volunteers, traditional media correspondents, and people nonprofit, Human, and community associations. New South Wales and the Victorian flood did have almost negligible evidence of twitter activity by local authorities and government. Most of the active players during the NSW and Victorian floods were volunteers who were active during the flood of Queensland. The paper argued that, increasing the adoption of Twitter for emergencies by local and federal authorities is needed for disseminating critical information to all stakeholders.

#### 4.7.4. Survey of floods in queensland and victoria using SurveyMonkey tool

Bird et al. (2012) [11] studied the use of Facebook by local communities and administrative agencies during floods in Queensland and Victoria of Australia in 2010-11. First they reported their observations on very fast and steady rise in 'likes' of FB pages of Queensland Police Service. Administrators of the groups collected their data from agencies like Meteorological Bureau, State Emergency Service, Queensland and the Victorian Police Department, Local Councils and News Media. However, trust in the information available in social media is a concern where government institutions have a big role to play. Despite that community Fb pages help people get information on the incidence of threats; Clearance centers and road closure; Fundraising opportunities; self service; and, assure people about the safety of family and friends much before traditional media can cater.

#### 4.7.5. Strategic framework

Dufty et al. (2012) [25] discussed about framing a policy and mechanism for emergency management in Australia. The authors first identified a strategic framework to "provide high-level guidance on disaster management in federal, state, regional and local governments, business and community leaders and non-profit sector". The paper also explored how social media can be effectively used in the framework and discussed issues faced by different emergency management agencies in using social media for education, communication and engagement activities.

#### 4.7.6. OSN monitoring and virtual content management

Denis et al. (2012) [23] discussed the formation and working of a team of trusted digital volunteers during 2011 Shadow Lake Fire in the US Pacific Northwest. The team was built and coordinated by a emergency manager who knew the members personally with their expertise in emergency management and social media communication. The members of the Virtual Operational Support Team (VOST) being located remotely, and, therefore, free from the issue of power outages and other issues of the disaster site, were in a better position to monitor the social media, share documents and other study materials online, and guide effectively the emergency managers on the ground.

#### 4.7.7. Case study for theory building

Chatfield et al. (2013) [16] discussed two central research questions on the utility of social media in government warning and information dissemination service and enabling the role of citizens in co-production of public information services, under extreme events (EEs). As a case study of Tsunami early warning system by Indonesian agency for meteorology, climate science and geophysics (BMKG), the paper observed that the agency quite effectively alerted citizens of ensuing tsunami within minutes of earthquake in Indonesia (April 2012) in Twitter reached millions of citizens due to huge retweets by net-savvy individuals, organizations through active participation in their civic network.

#### 4.7.8. Mixed method approach of interviews and social media content analysis

Denis et al. (2014) [95] did a case study on the social media communications and work practices of the Jefferson County Type III Incident Management Team during the September 2013 Colorado Floods. The authors examined flood-related communication across three platforms: Facebook, Twitter, and the team's blog for insight into how this innovative team coordinated their communications to meet the information needs of a community outside of the media spotlight and also interviewed the team of the Jefferson County Type III Incident Management Team (IMT) to understand the reason behind use pattern of different social media.

#### 4.7.9. Monitoring SM for emergency management

Power and Kibell (2017) [84] studied the role of social media intelligence analyst as a new operational role within a State Control Center in Victoria, Australia dedicated to obtain situational awareness from social media to support decision making for emergency management. They also analyzed how the role fits within a command and control organization's structure, described the requirements for such a situation and expand the required operational activities during an emergency event.

### 4.8. NGOs

NGOs are organizations that are non-profit making, voluntary and independent of the government, engage in activities related to various social and developmental issues. The role of NGOs during a disaster is to have a quick response and to save as many lives as possible with their resources. NGOs have a faster response to situations because they have less formalities and need less paperwork [70]. Some of the reported work from NGOs are summarized below in Table 15.

#### 4.8.1. Qualitative methods

Shklovski et al. (2008) [92] discussed the use of ICT during the wild fire of Southern California in October 2007. The study showed that ICT use provides a means for communication of community-relevant information, especially when members are geographically dispersed and may be away from, take advantage of community resources and even build community resources locally. The paper also showed how traditional media like television, radio or newspaper provided outdated information or news of general nature while people were looking for focused local updates catered by local communities through social media.

#### 4.8.2. Friedman's non-parametric ANOVA

Oh et al. (2010) [75] studied the collective behavior of human psychology around information during crisis. Based on the Haiti Earthquake Twitter data of 2010, the paper reports both quantitative and qualitative results that validate that "concern" and "informational opacity" are the primary variables to create rumors. Lack of credible information increases 'anxiety' which adds fuel to the rumor mill. The study suggests that anxiety can be controlled at the early stage through feeds of credible and accurate information through websites of the emergency response center or authenticating governmental organizations, RSS, streaming videos, photos, text messages, retweets etc. This is important as part of disaster management strategy in Web 2.0 era when many people are interconnected with social media.

#### 4.8.3. Deductive & inductive approach

Tapia et al. (2011) [98] studied microblog and other short text data and functioning of 13 international humanitarian relief organizations during a crisis. Most of the NGOs have not adopted use of social media in a supportive fashion. While microblog data, the authors observe, is not trustworthy, and therefore, is a bottleneck to be used by NGOs during emergencies. For public relations and disseminating their activities, NGOs use social media but not for emergency response. Also, some organizations focus on immediate emergency while others in post-disaster long-term recovery. For the first category, due to organizational apathy and lack of mechanism to verify facts, people take less input from social media. Moreover, NGOs seriously lack staff and mechanism to track, monitor and verify social media streams. However, NGOs can use bounded microblogging (following only a few trusted Twitter handles), microblogged data as contextual data (an additional source of information in context), and/or use of computational solutions involving event extraction, categorization and other machine learning techniques.

## 5. Discussion

We did a systematic literature survey on disaster management through social media. We collected papers from keywords-based web search using a set of hand-crafted disaster-related keywords. We divided the papers into following three broad categories based on their contents.

- The effect of emergency situation on social media
- Information gathering and processing from social media during emergency
- Effect of social media on government and non-government policies and initiatives.

In the first category we did the study of social media uses before and after the crises. We further categorize this section into subsections based on the uses and findings of social media. We observe that there are four types of information that people share or look for: location and time information of the disaster, emotion or sentiments and medical/material help. Some of these are observed during or after the disaster. We observe that at the time of disaster incidents, or soon after, generally, people become anxious to know the location of the incident. Affected people or victims mostly ask for help (food, water, medicine, shelter) and their location during disaster or immediately after disaster. On the other hand, different voluntary organizations ask for locations for reaching out to victims. For crisis managers, the exact location and time of the event are very important and also how many victims need medical help right now. With the passage of days pass after the crisis, activity in social media declines and people focus more on reconstruction and recovery mechanisms.

The second category of paper focus more on techniques that are used for information extraction, information summarization of different events, and locating the source and then tracking the propagation of disastrous events like cyclones, earthquakes, tsunami, floods, etc, and then classify the events. Here, we discuss different data processing techniques that have been used so far for extracting social media data.

**Table 15**
NGO's use of social media during disasters.

| Study type | Techniques | References | Dataset | Assumptions | Observations |
|---|---|---|---|---|---|
| Southern California wildfires (October 2007) | Qualitative methods | [92] | Empirical data | The use of ICT to find communities post-disaster | Via ICT, members of communities not only derive immediate benefits, they improvise its use and also establish emergent practices that prepare for future |
| Case study of Haiti Earthquake 2010 | Both Qualitative and Quantitative study: Friedman's non-parametric ANOVA, Rumor Interaction Analysis Systems (RIAS) | [75] | 10 days' Twitter data extracted using search terms (962 tweets); data belonged to 4 stages of communication (each stage has 240 tweets) | To study and understand rumor theory in extreme emergencies and their possible control | It is important to<br>1. Monitor social media to assess the level of social tension (genesis and spread of rumor), and<br>2. Reliable information with credible sources' feed at the early stage to reduce anxiety and contain rumor. |
| Case study of 13 NGOs on adoption of microblog data | Deductive (Long interviews) Inductive (qualitative data analysis) approach | [98] | Microblog Data & audio-taped and transcribed interviews from thirteen distinct international NGOs | To explore how NGOs use microblog in general and during disasters | Reasons behind low use of microblog data by NGOs are:<br>1. Untrustworthiness of microblogged data<br>2. Three structural mismatches, namely: public relations vs emergency response, emergency response vs post-disaster recovery, and missing organizational support for IT |

We primarily focus on various information accumulation techniques from microblogging sites, especially during the crisis, whether natural or man-made disaster. The most useful techniques we found are: information extraction techniques, geospatial technologies like GPS, spectral clustering, short and long-term-average algorithm, GNOME model, Gradient Boosting and Random Forest for classification, Transaction-based Rule Change Mining (Association rule mining), content analysis, incremental clustering algorithm etc. However, more work is needed in summarization and data classification from social media data.

In the third category we study the role of government and non-government agencies in different parts of the world during and after crises. Specifically we look at how different crisis management agencies use social media for information collection and dissemination from and to the citizens. We study the role of Police and Fire department, and NGOs, and civil administration after the disaster. Although different government and non-government agencies have started using social media, the use is very limited. We find only a few agencies played important role during crises like health, fire, police department and relief organizations. They primarily use it for information dissemination and spreading awareness among public. However, they rarely use it to gauge and/or listen to public. Some agencies inform the institutional policies are not mature enough to track social media feeds as often the news there are not factual or authentic. Of late, very few initiatives have started where government agencies have noticed this lacunae on their part and investing time, money and human resources to keep track of social media updates and events occurring there.

## 6. Conclusion

Due to Web 2.0, people engage in social media more intensely than ever before. People share emotions, thoughts, images, audio and video to their near and dear ones as well as to wider public in general. During crisis, this trend becomes overwhelming. Often the first-hand experience first comes in the social media before any other media reaches and reports from the spot. Although the information available in the social media may have inaccurate and false information, including rumors, the instant and wide reach of social media is over-empowering, especially during crisis. Natural disasters like flood, cyclones, tsunami earthquake cause havoc and disrupt all form of traditional communication. But social media remain mostly unaffected and often serve as the only source of communication. Government and other crisis management agencies have already taken note of this powerful tool and started using it in dissemination of warnings, alerts, status updates as well as for collection of ground information. In this paper, we studied the use of social media and its effect on government and non-governmental agencies in disasters. Our literature review was divided into three major sections. First we attempted to see and analyze the effect of emergency situations in the social media, especially Twitter, Facebook and Youtube. Second, we discussed different techniques that have been reported in the last decade to effectively and efficiently extract, summarise and/or visualize the data so that effective emergency measures can be taken. Third, we discuss some case studies how different social media posts can help different government and other agencies to get prepared and to take necessary steps to mitigate emergency situations. Social media is an evolving field with lot of innovations happening across the globe and is poised to certainly play an increasing role in disaster management in the future. To this end, future research should be directed to ensure synergy and speed in communication among different stakeholders of disaster management. Problem of credibility can be solved to some extent when official social media accounts of government offices and reputed and reliable NGOs are used for faster communication among themselves as well as to the public in general in real-time or near real-time. Also, research should be directed to verify the authenticity of an actionable news item in social media. The paper underlines the importance of social media in disaster management and hopes to serve as a ready reference to the community encompassing social, technical and organizational aspects surrounding disasters.

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