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Introduction

When faced with a sudden crisis, people quickly try to gather as much information as they can from the sources most immediately available to them: those in their immediate vicinity, friends and acquaintances via phone and texts, governments, nongovernment organizations, mass media such as radio and television, the Internet, and social media (Gao et al., 2014). Based on this information, they quickly take cover, flee, or act in a way that keeps them away from danger (Dynes, 1994).

Popular depictions of human response to crisis in movies and TV series tend to show widespread mayhem and panic. These scenes in "disaster movies" are plot devices, not very different from typical scenes in horror movies in which people irrationally run straight into danger (Mitchell et al., 2000). They are part of a long-standing myth that understands emergency management from a managerial perspective (Calhoun, 2004), and perpetuates the idea that disasters need to be policed because otherwise people will panic and riot.

As Palen (2014) emphasizes, an agenda of research about social media on disasters can uncover fascinating points if it avoids these misconceptions, and pays attention to the pro-social behavior of people during an emergency. Most people do not panic, but instead rapidly and effectively collect information, make decisions, and coordinate with others through a variety of channels. People affected by a disaster are the first to respond to it, often improvising complex rescue operations that save lives.

During a crisis, everybody involved – the public, the media, the government, emergency services, relief organizations, and others – try to quickly gain *situational awareness*. This is a complex process, which involves perceiving, comprehending, and being able to make predictions about the near future (Endsley, 1995; Vieweg, 2012). Gaining situational awareness is essentially a collective intelligence process that involves many actors interacting with a combination of various sources of information (Hutchins, 1995; Palen et al., 2010). Social

media can contribute to situational awareness during a crisis, but handling its volume and complexity makes it impractical to be directly used by analysts.

This book is about how to use computing to help bridge this gap. This chapter explains what is the importance of social media for crisis management, exemplifying through recent crisis situations (§1.1). It provides some key concepts (§1.2) and describes information flows happening in social media during disasters (§1.3). Next, it summarizes the main problems when dealing with crisis-related social media (§1.4), as well as the expectations and needs of formal emergency response and humanitarian agencies (§1.5), and their organizational challenges with respect to social media (§1.6). This introduction also presents an overview of the remaining chapters (§1.7) and pointers to background readings on disaster research (§1.8).

1.1 "Sirens going off now!! Take cover . . . be safe!"

In times of crisis and disaster, "people tend to gravitate towards the systems and networks that are more relevant to them" (Potts, 2013). Internet users, particularly those who rely and trust more on the Internet, are prone to go online when faced with a disaster (Lu et al., 2007).

The Internet and social media are now key information channels through which people collectively build awareness about a crisis situation. Compared to other types of media, the main advantages of the Internet as an information source is that it is distributed, far-reaching, and instantaneous. Before emergency services, fire fighters, police, and filming crews from TV stations arrive at the scene of a disaster – indeed, very often before they even leave their base – firsthand witnesses are already broadcasting status updates, photos, and videos through the Internet.

As with everything on the Internet, messages during a disaster are extremely varied. The specific class of messages that is often the focus of computing efforts are those that contribute to situation awareness, that is, the messages that can expand our understanding of the situation on the ground. Examples cited in recent work include:

- "*OMG! The fire seems out of control: It's running down the hills!*" (bush fire near Marseilles, France, in 2009, quoted from Twitter by de Longueville et al., 2009).
- "*Red River at East Grand Forks is* 48.70 *feet,* +20.7 *feet of flood stage,* −5.65 *feet of 1997 crest. #flood09*" (automatically generated tweet during Red River Valley floods in 2009, quoted from Twitter by Starbird et al., 2010).

- "*My moms backyard in Hatteras. That dock is usually about 3 feet above water [photo]*" (Hurricane Sandy 2013, quoted from Reddit by Leavitt and Clark, 2014)
- "*Sirens going off now!! Take cover ... be safe!*" (Moore Tornado 2013, quoted from Twitter by Blanford et al., 2014).
- "*There is shooting at Utøya, my little sister is there and just called home!*" (2011 attacks in Norway, quoted from Twitter by Perng et al., 2013).

Unlike these selected examples, most social media posts do not include new and useful information. Many repeat information that is already available through other channels. Many include personal impressions and/or messages that are only relevant for the user who posted them and perhaps a small circle of family and friends. However, some really interesting and important messages do get posted, sometimes providing information that is not available through other channels.

Social media information is often irreplaceable immediately after a sudden-onset emergency or disaster. It plays a role not only in the immediate aftermath of a disaster, but during its entire life cycle, for instance, to coordinate donations and volunteering, or to propagate messages of safety from authorities:

- "*Anyone know of volunteer opportunities for hurricane Sandy? Would like to try and help in any way possible*" (Hurricane Sandy 2013, quoted from Twitter by Purohit et al., 2014a).
- "*We have taken control of the ground floor and we urge you to be patient*" (police during the attack in Westgate Mall, Kenya in 2013, quoted from Twitter by Simon et al., 2014).

Many other types of information, including photos and videos, are posted in huge amounts during large-scale crises. They all contribute to get a more accurate picture of a developing situation.

1.2 What Is a Disaster?

Sociologists of disasters have been working toward a definition of disaster for decades. There is a broad consensus that *disasters are social phenomena*, characterized by a disruption of routine and of social structure, norms, and/or values (Perry, 2006). This definition implies that the severity of a disaster is more related to the extent of the disruption of social life (e.g., the extent of its disruption of processes and capacities of governments, business, and individuals), than to the measurable physical magnitude of the hazard that may

Table 1.1 *Hazard categories and sub-categories, adapted from Olteanu et al. (2015).*

Category	Subcategory	Examples
Natural	• Meteorological • Hydrological • Geophysical • Climatological • Biological	• tornado, hurricane • flood, landslide • earthquake, volcano • wildfire, heat/cold wave • epidemic, infestation
Anthropogenic (Human-Induced)	• Sociological (intentional) • Technological (accidental)	• shooting, bombing • derailment, building collapse

have triggered the disaster. The emphasis on disruption also implies that long-duration situations or conflicts that redefine what is "normal," may not match a strict version of this definition.

Not all crises are disasters: *a crisis is an unstable situation* that may or may not lead to a disaster. Not all emergencies are disasters: a serious situation, even a life-threatening one affecting a group of people, such as a traffic accident involving multiple vehicles, would be considered a disaster only to the extent to which it disrupts social routines and/or social order.

In this book, we focus on evolving, time-critical situations, which means that we can often adopt a broad definition of our subject of study. For instance, a police raid on a marginalized neighborhood may be met by violence that can escalate into riots. This would match the definition of disaster in the later stages where social order is disrupted, but not in the earlier stages. For our purposes, we would consider a possible response of social media to the police raid as a signal of a potential disaster precursor, even if it is not certain that it will become one.

Disasters have many characteristics; one of the most obvious ones is the *type of hazard*. Olteanu et al. (2015) consider two taxonomies used in Europe[1] and the United States,[2] as well as the traditional hazard categories listed by Fischer (1998). The resulting list is reproduced in Table 1.1. These are to some extent idealized categories (Calhoun, 2004); for instance, global warming implies that some meteorological phenomena can be traced back to human causes;

[1] EM-DAT, The International Disaster Database. http://www.emdat.be/classification.
[2] "Ready" campaign by U.S. Department of Homeland Security (DHS) and US Federal Emergency Management Agency (FEMA). http://www.ready.gov/be-informed.

similarly, some hydrological phenomena such as floods are sometimes the consequence of intentional deforestation.

Different hazard types affect human populations differently and are expressed differently on social media. To a large extent, the focus of research in social media during crises have been natural hazards. Floods are the more common type of disaster in the world (UN OCHA, 2014b), and, indeed, many case studies on social media usage during disasters are related to floods. In addition to natural hazards, research on social media during crises is sometimes about large-scale industrial accidents, and occasionally intentional violent acts such as shootings and bombings. "Complex emergencies" such as war present significant challenges because of issues such as accessing data, maintaining neutrality, and being responsible for the safety of all involved, which make them a much more difficult context to do research on.

Other categorizations for a disaster are possible, particularly in the dimensions of time and space. With respect to time, we considered that a disaster is *instantaneous* if it "does not allow pre-disaster mobilization of workers or pre-impact evacuation of those in danger," and, it is *progressive* if it is "preceded by a warning period" (Adams, 1970). With respect to space, a disaster is *focalized* when it affects and mobilizes response in a small area (e.g., a train accident) or *diffused* when it impacts a large geographic area and/or mobilizes national or international response (e.g., a large earthquake) (Adams, 1970; Prelog, 2010).

These categorizations are important because, among other reasons, the type of disaster influences the volume of the different classes of information that are shared in social media (Olteanu et al., 2015).

1.3 Information Flows in Social Media

Social media comprises a variety of social software platforms in which people can create, share, and exchange user-generated content. *Social software* are computer systems and applications that serve as an intermediary or a focus for social relationships (Schuler, 1994). *User-Generated Content* (UGC) is content published online in a publicly accessible manner or to a group of people, containing a certain amount of creative work, and created outside of professional routines and practices (Vickery and Wunsch-Vincent, 2007).

Social media is used intensely by people affected by a disaster for a variety of ends, including getting updates about the crisis, personal updates from family and friends, emergency contacts, and information about relief efforts (Vieweg, 2012; Olteanu et al., 2015). Disasters also bring a response in social media from people around the world, many without a direct connection with the incident,

but that feel touched or somehow affected by a developing situation (Fraustino et al., 2012; Kogan et al., 2015).

Reuter et al. (2011, 2012) classify the different uses of social media during disaster according to their role with respect to organizations. From their perspective, social media information flows from citizen to citizen, citizen to organizations, organizations to citizens, and organizations to organizations. The last type of communication is not frequently observed at present, because organizations often have other ways of communicating and coordinating with each other (Sutton et al., 2012; Sarcevic et al., 2012). The remaining three are the basis of the prototypical flows we describe next.

Social media for interpersonal communications. From the perspective of many social media users, social media platforms are essentially tools for staying in touch with friends and family (Whiting and Williams, 2013). From this perspective, people use social media during a crisis to signal to those in their social circle that they are safe, or that they need help. This is the motivation behind Facebook's Safety Check[3] and similar systems. Social media, with its one-to-many capabilities, has advantages over voice calls or text messages for this type of activity. Indeed during the 2012 Sandy hurricane in the United States, the Federal Emergency Management Administration (FEMA) asked residents to use social media for personal status updates, to avoid overloading other channels (Ludwig et al., 2015b).

Interestingly, the fact that communications are interpersonal, but occur in a public space in certain types of social media (but not in all of them), presents an opportunity for learning from those communications. For instance, a message describing a relatively mundane situation, for example, a person posting that she is staying at home with fever, can be used in conjunction with similar messages to identify a global phenomenon, such as an emerging epidemic.

Social media for citizen sensing. Social media can be understood as a form of *distributed cognition*, a mechanism for understanding a situation using information spread across many minds (Hutchins, 1995). The interactions among people in social media are a form of collective intelligence, as they allow people to collectively make sense of a developing situation (Palen et al., 2009, 2010). Social media during a crisis generates a wealth of data conducive to better *situational awareness* (Farnham et al., 2006; Vieweg, 2012).

During a crisis, social media users can become "social sensors" or "citizen sensors" (Sheth, 2009; Nagarajan et al., 2011; Corley et al., 2013;

[3] Introducing Safety Check. *Facebook Newsroom*, October 2014. https://newsroom.fb.com/news/2014/10/introducing-safety-check/.

Hermida, 2014) – other terms are "participatory sensing," or "crowdsensors/crowdsensing" (Salfinger et al., 2015a) – whose postings are a response to the conditions they are experiencing as the crisis unfolds. For instance, information about areas where people are seeing or smelling smoke can be used as clues to locate a wildfire. An officer from the Los Angeles Fire Department explains this using an analogy with military operations: "The military has a model that every soldier is a sensor. Every soldier – we like to say that every citizen is a contributor" (Latonero and Shklovski, 2011).

Social media platforms may sometimes be sufficient to enable this form of cognition without any extra functionality or processing. Wilensky (2014) describes communications between stranded commuters after the Great East Japan Earthquake in 2011, where people used social media to determine how to get home or how to get shelter. However, social media platforms may not provide the functionality of summarizing information in a way that is useful for the public and for emergency response organizations (Vieweg et al., 2014). That is the task of computer scientists and other technologists working on this field (Palen et al., 2010).

Social media for official communications. Although some formal emergency response organizations do "listen" to the public through social media, the dominant view in many organizations remains that social media is essentially a one-way, "write-only" channel to push information to the public (Latonero and Shklovski, 2011; Díaz et al., 2014; Plotnick et al., 2015). These messages are written, among other reasons, for communicating risks, providing advice, countering rumors, or issuing calls to action, such as evacuation orders, alerts, and requests for donations or volunteers.

Social media users, however, are not entirely passive with respect to these messages. They filter and amplify them through the mechanisms already in place in these platforms, such as "liking," "favoriting," or "reposting" a message. They also have expectations of immediacy that need to be balanced with policies seeking to control the flow of information. Policies that are too strict may slow down public communications to a point where they are no longer useful by the public. Asking an incident commander to approve every social media message is impractical (Crowe, 2012). Instead, using social media for official communications effectively requires trust and "a more flexible organization within the command and control structure, with more autonomy for the public information team" (St. Denis et al., 2014).

In general, unidirectional communications in social media between the public and established organizations are problematic. The public can experience

from disappointment to disempowerment when realizing that they are expected to listen but are not being listened at all, or that they are being solicited input, but not receiving any response (Crawford and Finn, 2014).

Over time, organizations go through several stages with respect to social media. They start with no social media presence or interactions at all. Then, many organizations enter an initial phase involving a limited presence and one-directional usage of social media (either only for sensing, or only to make announcements). Finally, some organizations reach a phase in which they are actually present in social media, and using it as an effective bidirectional communication channel in ways that positively impact their activities (Crowe, 2012, ch. 4).

1.4 The Data Deluge

Social media is a rich and chaotic environment in normal times as much as it is during crises. Many organizations tasked with emergency response are not prepared to deal with a "deluge" of unverified, sometimes incomplete reports arriving at a fast pace from a variety of previously unknown sources. The amount of unverified information arriving in real-time through social media channels can be overwhelming (Bressler et al., 2012). At the same time, people who work at these organizations cannot ignore the wealth of information present in social media, or avoid engaging with members of the public who are providing critical information to them through these channels (St. Denis et al., 2014).

Emergency managers and public information officers have expressed that most messages they see in social media do not contain new, useful information for them (see, e.g., Ludwig et al., 2015b; Vieweg et al., 2014). For instance, during a storm, most photos posted by Internet users may simply depict the storm, bringing nothing valuable that is not available through weather reports. In this scenario, many organizations indicate that they simply do not have enough people to monitor social media: "100 teenagers take loads of photos each, and five people are expected to assess them all" (Ludwig et al., 2015b).

Emergency managers often use the phrase "information overload" (Toffler, 1990) to describe this problem, as reported in interviews by Plotnick et al. (2015), among others. Indeed, during a disaster information overload affects both physical systems as well as people (Fritz and Mathewson, 1957). However, we need to be precise. If an organization receives more requests for help than what they can handle, it is their capacity to respond that has been exceeded, not necessarily their capacity to process information. By contrast, if an organization retrieves from a data source more data than what they can handle, it might be

more appropriate to say that this is *filter failure*.[4] Filter failure can occur due to many causes, for instance because the information need is not expressed correctly (something that might be very difficult to do at the onset of a disaster), or because the methods used to retrieve and process the data are too naive or simplistic. For instance, trying to find critical actionable information by simply following a real-time feed of social media messages containing a given hashtag can be a frustrating experience, because the tool used (the standard interface of a social media site) is not appropriate for the task.

Incidentally, people who contribute content in social media during a disaster face similar difficulties with the standard interfaces of social media. "Familiar sites for sharing photos of weddings become locations for sharing breaking news ... collaborative writing tools become locations to transcribe hospital faxes to confirm the injured. Participants are using social web tools in ways the designers of such systems have neither anticipated nor considered" (Potts, 2013).

1.5 Requirements: "Big Picture" Versus "Actionable Insights"

The users of the systems we describe in this book are an heterogeneous group of people that includes all those who have a stake in a developing crisis, particularly the people directly and indirectly affected, and the people tasked with response and relief operations. Software tools do not exist in isolation, nor operate on an empty informational context (Potts, 2013, ch. 6). Instead, social media is one of many information sources available. The information needs of users are almost never answered by social media alone, but only in combination ("triangulation") with information gathered from other sources. Indeed, social media and other types of "big data" can be used for augmenting and complementing existing informational products in which organizations already rely on, instead of for creating new informational products.[5]

Understanding user requirements is not merely asking "what data do you need?" Humanitarian organizations often request data but do not actually use it into their operations or decision making. Avoiding this situation requires to

[4] "It's not information overload. It's filter failure." Clay Shirky, keynote at *Web 2.0 Expo* in New York, USA, 2008. http://blip.tv/web2expo/web-2-0-expo-ny-clay-shirky-shirky-com-it-s-not-information-overload-it-s-filter-failure-1283699.

[5] "Guidance for incorporating big data into humanitarian operations." Blog post announcing Whipkey and Verity (2015) by Andrej Verity, September 2015. http://blog.verity think.com/post/130055206939/guidance-for-incorporating-big-data-into.

clearly identify what is the problem or gap that social media data will be used to address (Whipkey and Verity, 2015).

User needs may not be fully defined at the onset of a crisis, and they may change as a crisis evolve. At the onset of a crisis the priority might be understanding the context and scope of the event, then it might shift to assessing affected populations and damage, determining specific goods and services that need to be provided, identifying which other organizations are operating on the ground, and so on, as the situation develops (Tapia and Moore, 2014).

The very set of people that we define as "users" may change as a crisis progresses and new people are affected or the scope of the response changes. Even within a single emergency response organization, different people may have different information needs. Mittelstadt et al. (2015) note that the needs of a first responder (e.g., a police or fire fighter) differ from the needs of a site commander (who handles a set of missions in a specific area), which in turn differ from the needs of a crisis manager (who oversees the response to a crisis).

Some users may have very concrete information needs, such as identifying resources on the ground, targeting humanitarian efforts, or identifying specific groups of volunteers or victims, while others may have more generic information needs, such as gaining better situational awareness or detecting events of interest (Morrow et al., 2011; McCreadie et al., 2015b). Indeed, we can sketch broadly two prototypical categories of information needs during a crisis. These are not necessarily comprehensive nor mutually exclusive.

Strategic information: capturing the "big picture." This is the prototypical need of a large humanitarian organization, or a government branch doing resource allocation and mobilization at the onset of a disaster. Preliminary assessment and resource allocation is often done based on incomplete and often contradicting pieces of evidence. Background knowledge, such as census data or historical data from similar situations in the past, usually forms the basis for this preliminary assessment.

A data gathering exercise aimed at understanding the "big picture" uses social media messages as a basis to create high-level summaries that speak about the situation as a whole, and not about specific requests for help or other individual messages. What is needed in this case is a way of seeing beyond individual messages, which are like the proverbial trees, that prevent us from seeing the forest.

Typical "big picture" questions include estimations of the area in which the effects of a disaster are felt, estimations of the number of people affected by a disaster, injured, dead, or displaced, and estimations of the damage to