Towards a realtime Twitter analysis during crises for operational crisis management

Conference Paper · April 2012

CITATIONS
47

READS
1,338

1 author:

Teun Terpstra
HZ University of Applied Sciences
31 PUBLICATIONS **1,427** CITATIONS

SEE PROFILE

Towards a realtime Twitter analysis during crises for operational crisis management

Teun Terpstra
HKV Consultants
t.Terpstra@hkv.nl

A. de Vries
TNO
arnout.devries@tno.nl

R. Stronkman
Twitcident
richardstronkman@gmail.com

G.L. Paradies
TNO
geerte.paradies@tno.nl

ABSTRACT

Today's crises attract great attention on social media, from local and distant citizens as well as from news media. This study investigates the possibilities of real-time and automated analysis of Twitter messages during crises. The analysis was performed through application of an information extraction tool to nearly 97,000 tweets that were published shortly before, during and after a storm hit the Pukkelpop 2011 festival in Belgium. As soon as the storm hit the festival tweet activity increased exponentially, peaking at 576 tweets per minute. The extraction tool enabled analyzing tweets through predefined (geo)graphical displays, message content filters (damage, casualties) and tweet type filters (e.g., retweets). Important topics that emerged were 'early warning tweets', 'rumors' and the 'self-organization of disaster relief' on Twitter. Results indicate that automated filtering of information provides valuable information for operational response and crisis communication. Steps for further research are discussed.

Keywords

Crisis management, Social media, Twitter, Monitoring, Information extraction, Natural hazard

INTRODUCTION

Crises all over the world are continuously showing that citizens, media and organizations use social media such as Twitter, Facebook and YouTube extensively to express their feelings and to share opinions and information. Due to the introduction of Internet access on smart phones and also other devices that are equipped with camera, video and social media applications, the amount of available crisis information has increased enormously. Recently, researchers have begun studying the use of social media during crises. These studies focused especially on the use of Twitter in relation to natural hazards, including hurricanes (Hughes and Palen, 2009), flooding and wildfires (Starbird and Palen, 2010) and the 2010 Haiti earthquake (Starbird and Palen, 2011). These studies indicated that citizens use Twitter to share information about the crisis, to express their opinions and feelings, and to help those in need of aid. The information that is being shared on social media during crises is potentially valuable to crisis managers, because they can use this information to update their situational awareness and to improve their operational response to the crisis. However, during crises filtering and understanding the information content of messages is highly challenging. For example, Vieweg, Hughes, Starbird and Palen (2010) hand-analyzed tweets about the Red River Floods (nearly 20,000 tweets) and the Oklahoma wildfires (nearly 3,000 tweets). Such an analysis is extremely labor intensive and time consuming. Utilizing Twitter's potential for operational crisis management therefore requires information extraction tools that digest the information content in realtime, and in a reliable fashion.

This study aims to explore the technological opportunities (information extraction tools) of social media. In particular, we focus on the opportunities of Twitter in crisis management. Twitter users can publish short messages with a maximum of 140 characters, so-called tweets, which are visible publicly or semi-publicly (e.g. restricted to the user's designated contacts) on a message board of the website or through third-party applications (e.g., Tweetdeck). The next sections report on the progress that is being made in the real-time and automated analysis of Twitter messages during a crisis. This is done by

analyzing tweets that were published during a recent storm event that hit a pop festival in Belgium (Pukkelpop 2011).

TWITTER ANALYSIS OF PUKKELPOP 2011

To investigate what relevant information is shared on Twitter during incidents, we collected and analyzed tweets published before and during the Pukkelpop 2011 incident by using the Twitcident system. This section introduces the Pukkelpop incident, the Twitcident system and presents our Twitter analyses and results.

Pukkelpop 2011 incident

On August 18 at 6:15 PM a storm hit the Pukkelpop festival area in Kiewit (Belgium)[1]. Within a few minutes the meadow was flooded and trees were blown down. Visitors took shelter in festival tents, but due to heavy rainfall, hail and wind the Chateau tent collapsed, causing many casualties. Among the 60,000 visitors 5 people died, 10 were heavily injured and more than 100 had minor injuries[2]. Almost 80,000 tweets were published within the first four hours after the incident.

Twitcident system

Twitcident is a recently developed framework and Web-based system that automatically filters, searches and analyzes tweets regarding incidents (Stronkman, 2011). The system contains three components. The first component maintains a list of incidents happening in the Netherlands by real-time parsing public paging messages[3] sent to emergency services and extracting references to an incident's location, start time and type of incident. Given this set of information, the second component generates a Twitter search query, which includes the city name and the most typical words people use to refer to a particular incident type (e.g. "fire" when it is a fire incident). Subsequently the system uses the Search API to retrieve tweets from the past, and the Streaming API to retrieve a current stream of tweets. The third component contains analysis and visualization features. The analysis features enable filtering of tweets on keywords, type of tweets (i.e., retweet, mention, reply, singleton; Kwak, Lee, Park and Moon, 2010), topics of interest (i.e., tweets that report about damage or casualties), tweets from authority users (i.e., accounts from trusted news media or emergency services), and date-time ranges. The tool supports different views of the filtered data, such as a tweet list, statistics charts and tweets plotted on a geographical map, and a gallery of pictures and videos extracted from URLs.

Data collection and analysis

Because the Pukkelpop festival is situated in Belgium, and Twitcident receives only input from Dutch incidents, Twitcident could not automatically identify the storm incident at Pukkelpop. Therefore we manually created a search query including the terms that reference the festival (i.e., pukkelpop, ppop, pp11) as well as terms that emerged during emergency response and recovery (i.e., hasselthelpt, genthelpt, antwerpenhelpt, brusselhelpt, ppok). Next to these terms, the Twitter search query also included all hashtags containing these terms, separated by a logical OR operator. The query retrieved 156,157 tweets published between August 18 at 12 AM and August 20 at 12 AM. For the purpose of this paper, we only analyzed tweets that were published prior to, during and shortly after the storm hit the festival; i.e., 96,957 tweets that were published on August 18 between noon (12:00 PM) and midnight (12:00 AM).

VISUAL ANALYSIS USING TWITCIDENT

In this section we illustrate the information that is generated by applying Twitcident's graphical and mapping functionalities in order to provide a quick overview of the data. During crises these overviews help to identify abnormalities in the twitterverse that may be worth analyzing.

[1] http://www.nrc.nl/nieuws/2011/08/18/pukkelpop-stilgelegd-na-noodweer/

[2] http://www.deredactie.be/cm/vrtnieuws/drama op Pukkelpop/110820_Pukkelpop_doden

[3] http://www.p2000.nl/

Graphical display

Twitcident displays the number of published tweets identified by the search query per minute. Figure 1 presents these tweets three hours before and five hours after the incident started. The graphical display functionality serves an important purpose; sudden increases in tweets are a clearly visible sign that something has attracted people's attention that might be worth monitoring. Figure 1 shows a first small glitch of 41 tweets per minute at 5:44 PM, and an exponential growth shortly after the storm impacts the festival at 6:15 PM. The exponential growth reveals an erratic pattern and peaks at 9:01 PM (576 tweets per minute), and then follows a downward trend. At midnight the number of tweets has fallen near zero, but on the subsequent day new tweets appear although at a much lower rate than during and shortly after the storm impacted on Pukkelpop.

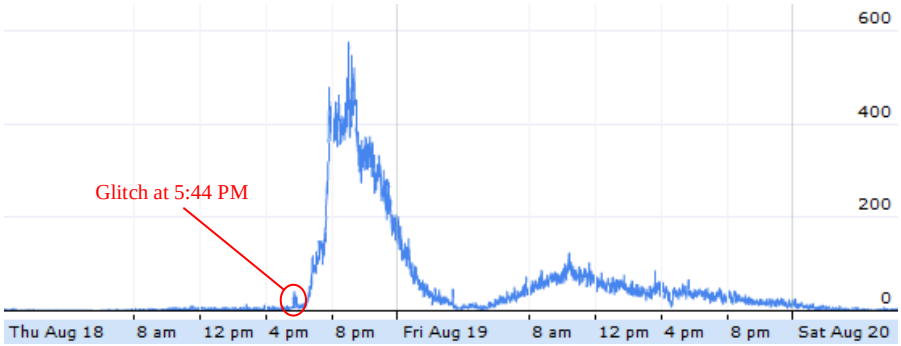

Figure 1: Showing number of tweets per minute

Mapping geo-annotated tweets

In total 1,500 tweets were annotated with a geo-location, which is approximately 1% of the total collection of tweets. Figure 2 shows the distribution of these tweets on a map of Belgium and the Netherlands in four time slots. The first map plots the tweets published two hours before impact. In this period 79% of the tweets originated from the festival site. The latter three maps display tweets published in the two hours following the start of the incident. These maps show that as time elapses the news spreads across Belgium and the Netherlands (and beyond). In the first quarter after the incident 77% of the geo-annotated tweets originated from the incident site. This percentage decreases to 15% and 4% for the third and fourth time period, respectively.

INTERPRETATIVE ANALYSIS OF TWEET CONTENTS

We will present the content analysis and interpretation of tweets for two separate time intervals. The first set contains all (2,848) tweets published prior to the incident (until 6:15 PM) and the second set includes all 94,109 tweets published during and after the incident (between 6:15 PM and 12:00 AM). Specifically, the analysis of tweets prior to the incident focuses on the question whether sudden increases in tweets provide information that could signal an approaching threat (early warning). The analysis of tweets that were published after impact focuses on the filtering of damage- and casualties-related tweets and rumor propagation.

Period I: 4:15 – 6:15 PM *Period II: 6:15 – 6:30 PM* *Period III: 6:30 – 7:15 PM* *Period IV: 7:15 – 8:15 PM*

Figure 2: Geo-annotated tweets plotted on Google maps

Before the incident started (until 6:15 PM)

As previously discussed, Figure 1 shows a small peak in the tweet rate at 5.44 PM, about 30 minutes before the storm hits the festival. Previous studies of Twitter use during crises have shown that twitterers often respond to information they deem important or relevant by retweeting other's tweets (RT @username) or by mentioning other twitterers (@username) in their own tweets. Retweets seem important because these tweets identify and thereby informally recommend the original author as an important source (Starbird and Palen, 2010; Vieweg, Hughes, Starbird and Palen, 2010).

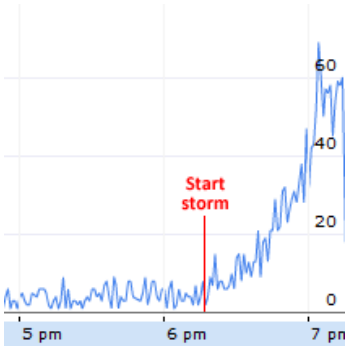

Figure 3: Showing number of tweets (without retweets) per minute

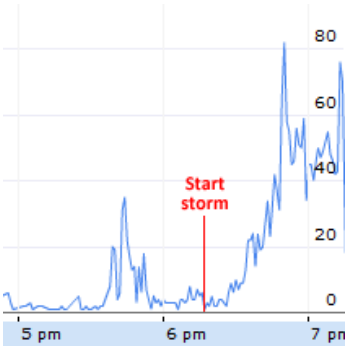

Figure 4: Showing number of retweets per minute

We therefore analyzed the tweets published around 5:44 PM by looking at their properties; i.e., whether there were irregularities in the patterns of singletons, mentions and reply tweets (@username), and retweets (RT @username). Figure 3 displays the number of tweets per minute (excluding retweets), and reveals only minor irregularities until the storm starts at 6:15 PM. However, Figure 4 reveals various glitches in the number of retweets around 5:45 PM. Exploring the contents of the retweets showed that many retweets originated from one tweet published by one of the artists (@ShannonLeto) at 5:38 PM: *"You ready Pukkelpop?! Might be a wet one out there! Slip-n-slide-an-dog-an-you!! Remember that one @jaredleto".* Specifically, 277 of the 311 (89%) retweets published between 5:38 PM and 6:15 PM were retweets on this particular tweet. Although this tweet communicates environmental cues (i.e., rain approaching Pukkelpop) the tweet is framed in an amusing fashion. Likely few people have interpreted this tweet as an early warning.

However, a manual search of tweets did identify some tweets that reflected a high threat perception, mostly from people that were located upwind along the storm track. We analyzed all 343 tweets (excluding retweets) published between 4:45 and 6:15 PM (i.e., during the 90 minutes before impact) using the Twitcident search tool. In total we marked 56 tweets (16%) that related to the changing weather conditions. Closer inspection showed that 35 (10%) of the tweets contained observations of extreme weather conditions (e.g. people see cloud-bursts, hail, storm and lightning in nearby places like Brussels, Leuven, and Hasselt). Furthermore, 22 of 56 tweets (39%) reflected concerns from Twitter users, worrying that the storm might hit on Pukkelpop. Table 1 shows a small selection of these tweets.

User	Tweet	Time
JonathanBadisco	The sky is pitch-black in Brussel... I wish you all the best at Pukkelpop! #pp11	4:54 PM
DenysJan	I hope the storm does not burst on the Pukkelpop pasture. #PP11	5:00 PM
Matthiiii	I feel pity with #pukkelpop! Here, the sky was pitch black for 15 minutes! And there was cloud-burst, lightning, thunder... ai ai!	5:27 PM
Maartentibau	Serious thunderstorm in Hasselt. I hope for a happy end at Pukkelpop.	6:03 PM

Table 1: Concerns from Twitter users regarding the heavy weather approaching Pukkelpop

An important question is to what extent it would be feasible to detect these 'high threat perception' tweets automatically. Content analyzing the 22 tweets showed that Twitter users often mentioned environmental cues (i.e., the extreme weather conditions) and expressed their high threat perceptions by using affect-laden adjectives in their tweets. Keywords that referred to the extreme weather conditions included 'storm', 'thunder', 'lightning', 'cloud burst', 'rain burst', 'hail', 'downpour', and 'black sky'. Affect-laden adjectives and expressions included 'heavy', 'intense', 'serious', 'enormous', 'threatening', 'severe', 'significant', 'massive', 'dangerous', as well as 'help', 'crazy', 'oh no', 'oh

my', 'hell', 'drama' or the exclamation mark. Moreover, 15 out of 22 tweets (68%) contained both observations of environmental cues and affect-laden adjectives or expressions.

During and after the storm (from 6:15 onwards)

In this section we conduct an interpretative analysis of the tweets published from the moment that the storm hit the festival at 6:15 PM until 12 AM (midnight). The search query identified 94.109 tweets that were published within this period. In the subsequent sections we will analyze the tweets that were identified by applying two of Twitcident's topic-filters: damage and casualty reporting. These topics are important because both damage and casualty reports can serve indicators for the impact of an incident. Such information can support crisis managers to allocate resources based on an estimated demand. In addition, we will discuss tweets about two other topics that turned out to be important at Pukkelpop, but that are currently not automatically filtered by Twitcident: rumor propagation and initiatives that stimulated disaster relief.

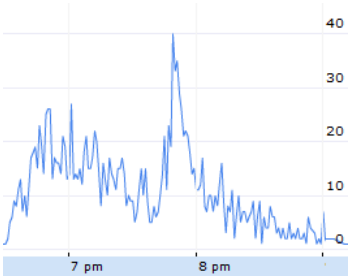

Figure 5: Damage reporting (tweets/minute)

Figure 6: Casualties reporting (tweets/minute)

Figure 7: First picture of collapsed Chateau tent[4]

Damage reporting

Twitcident identifies damage-related tweets by filtering tweets on keywords: 'damage', 'devastate', 'collapse', 'destroy', 'ravage' and conjugations of these terms. Figure 5 shows that the number of damage-related tweets per minute increased in the 30 minutes after 6:15 PM, peaked at 7:50 PM when damage and casualty reports were officially disseminated by national news media, and subsequently decreased. Table 2 lists a selection of the first damage reports published shortly after one of the festival tents (the Chateau tent) collapsed.

User	Tweet	Time
Simonvrebos	The camping tents are blowing away #pp11.	6:22 PM
TommyPorte	Heavy storm at pukkelpop. Chateau tent is blown away. There is panic. I am sheltering in a toilet. #pp11	6:25 PM
Michlr	I just escaped a completely ragged festival tent. #pp11 #storm	6:27 PM
c_concepts	In the meanwhile, a call to the newsroom: "The chateau tent has collapsed, mass casualties, ..." #PP11 #pukkelpop	6:31 PM

Table 2: Damage reported by Twitter users regarding tents blown away

In the first hour after the start of the incident at 6:15 PM 674 tweets report on damage, of which 64% are retweets of tweets that provide new information (possible rumors) or photos, and 17% contain questions requesting for more detailed information. One of the tweets of Table 2 by 'c_concepts' reaches an audience of nearly 10,000 followers within three minutes, due to 10 re-tweets of users that have many followers. Over time, the message was re-tweeted 119 times. Starting from 6:40 PM, users started to mention that scaffolds and trees had collapsed and both the pasture and streets were flooded due to heavy rainfall. It took until 7:01 PM before official news media, e.g. VRT deredactie.be[5], stated that the festival was interrupted and that possibly a tent had collapsed. We notice that the same

[4] source: bit.ly/uq1MiX, published with permission of @JWdijk

[5] http://www.deredactie.be/cm/vrtnieuws/drama%2Bop%2BPukkelpop/110818_Pukkelpop_donderdag

information was available approximately 40 minutes earlier, based on the damage reports from festivalgoers. Furthermore, 1,071 (54%) of the tweets about damage contained hyperlinks to other social media and news media websites. Tweets that referred to news media (e.g. Nu.nl) clarify what properties were damaged, and tweets that point to photo sharing websites (e.g. Twitter Photo service) show some of these damaged properties. Figure 7 displays the first picture of the collapsed tent, published 17 minutes after the incident started.

Casualty reporting and rumors about deaths

Twitcident identifies casualty-related tweets by filtering tweets on keywords: 'casualty', 'injury', 'dead', 'died', 'death', 'kill', 'decease' and conjugations of these terms. Figure 6 shows a stable rate of about 30 casualty-related tweets per minute after the start of the incident. Although at 6:52 PM rumors about deaths started to arise, the tweet frequency remained at a stable rate. We analyzed the tweets mentioning casualties, and more specifically those that contained the keyword 'death'. At 7:12 PM a tweet published by 'rozestadfm' stated: "*BREAKING NEWS: Serious injuries and deaths at Pukkelpop in Hasselt (B) during a heavy storm #storm #pukkelpop #events #belgium #hasselt"* (italics added by the authors). This user did not publish any tweets in relation to Pukkelpop previously. the message of 'rozestadfm' resulted in 60 re-tweets of which 30% questioned the validity of the statement. Although Twitter users requested for official source verification, 'rozestadfm' did not provide it. Until 7:15 PM (the first hour) 521 tweets reported on casualties, of which 60% were retweets containing new information (possible rumors) or photos, and 8% contain questions requesting for more detailed information. It is noteworthy that many twitterers expressed doubts in the tweets about deaths. We encountered doubts in 17% of tweets about deaths. Typical keywords that twitterers used to express their doubts were 'rumor, 'speculate', 'confirm', 'official news', 'source' and 'irresponsible'. Moreover, 118 tweets phrased their doubts in the form of a question, thereby requesting official source verification.

Suddenly, at 7:37 PM the number of tweets about casualties increased rapidly, peaking at 256 tweets per minute at 7:50 PM. Analyzing the rapid increase showed that, from 7:37 PM, journalists and news media editors confirmed there were multiple deaths. From that moment on the number of messages with the term 'death' increased from 33 to 237 tweets per minute at 7:50 PM. This short period of 13 minutes witnessed 1342 tweets about casualties. In total, 699 (52%) of these tweets were retweets spreading the confirmations of deaths by official news media. Many other tweets expressed shock, agitation, astonishment and hope.

In total, 3,676 (27%) of the tweets about casualties published between 6:15 PM and 12 AM contained hyperlinks to other social media and news media websites. Many of these links referred to news articles that confirm the number of deaths and casualties. Among the most referred domains were the news media (Nu.nl, 704 tweets; Nos.nl, 281 tweets; Standaard.be, 266 tweets). Notice that the peaks about damage and casualties coincide. Nearly 40% of the tweets that reported on casualties also reported on damage, of which some examples are listed in Table 2.

Citizen initiatives to stimulate disaster relief

During the Pukkelpop incident, one user took the initiative to stimulate residents from a nearby town to offer aid. This user introduced the hashtag #hasselthelpt with the purpose to connect residents from Hasselt with visitors in need of aid. Table 3 lists a selection of the first tweets published with this hashtag.

User	Tweet	Time
PatriceF	Are you at Pukkelpop and in need of aid? Check @Deborahhasselt @iworx @patricef #pp11 #pukkelpop #hasselthelpt (RT is appreciated)	20:19 PM
PatriceF	Do you want to help? Use #hasselthelpt to support festivalgoers at #p11	20:27 PM
jhml	#hasselthelpt RT @theonehitwonder: If someone needs a place to sleep, let me know. We are from Hasselt #pp11	20:27 PM
brqkke	#hasselthelpt I have a place to sleep for the night.	20:29 PM

Table 3: Tweets with hashtag #hasselthelpt

The initiating user 'PatriceF' was mentioned or re-tweeted 424 times. In total 9,315 tweets contained the hashtag #hasselthelpt, of which 74% were re-tweets. Among the things offered by nearby residents were free places to sleep, food, beverages, transportation, showers, clothing, Internet access, etc. In

addition, nearby residents publically shared their phone numbers on Twitter, and announced that anyone in need of help could call. We found 30 such unique phone numbers with the Hasselt calling code. Furthermore, for some users offering aid it seemed their first time on Twitter, as they neither had any followers nor published any tweets previously.

We manually conducted an interpretative analysis on the responses to this initiative. Although the overall sentiment regarding the impact of the incident was negative, the sentiment regarding this initiative seemed positive. To validate our hypothesis we classified tweets into either positive or negative classes. In total 14% of the responses was positive, taking into account terms like 'respect', 'great', 'fantastic', 'nice', 'homage', 'love', 'heartwarming', 'fortunately', 'impressed', 'solidarity'. We did not find any negative examples regarding this initiative. The #hasselthelpt initiative stimulated other towns as well to offer aid, e.g. hashtag #genthelpt resulted in 1,075 tweets and #brusselhelpt in 335 tweets.

DISCUSSION

This paper aimed to investigate the possibilities of real-time and automated analysis of Twitter messages during crises. Automated analysis was performed through application of the information extraction tool Twitcident, which is a working prototype that so far has not been applied for realtime information extraction purposes. The system is continuously being developed and validated on incidents. So far the system was tested on 79 (mostly small) incidents, including industrial fires, road accidents and power failures. The Pukkelpop storm was the first time for Twitcident to analyze a natural hazard that resulted in both damage and casualties (injuries and deaths). Therefore, results need to be interpreted with circumspection. Here we discuss the four major findings.

First, the analysis focused particularly on abnormalities in the pattern of tweets and on specific topics that could be of interest to operational crisis management. Previous studies of Twitter during natural hazards have shown a gradual increase in tweet intensity with hazard proximity. That is, during hurricanes Ike and Gustav in 2008 the number of tweets gradually increased and peaked when they made landfall (Hughes and Palen 2009). A similar observation was made during the Red River flood in 2009 (Starbird and Palen 2010; Starbird, Palen, Hughes and Vieweg 2010). However, automatically generated graphical displays showed that such a gradual increase in tweet activity was almost absent prior to the Pukkelpop storm, except for a small peak half an hour before impact. Analyzing these tweets one by one indicated that few people interpreted the dark clouds as a threat to their safety. This finding suggests that the festivalgoers were largely taken by surprise.

Second, from the moment the storm hit the festival, the number of tweets increased exponentially spreading over Belgium, the Netherlands and eventually globally. Applying the predefined 'damage' and 'casualties' filters in combination with the 'tweet type' filter showed that retweets accounted for a large portion of the maximum tweet frequency on both topics. Noteworthy, some of the damage-related tweets from festivalgoers received many retweets, while casualty-related tweets from individual twitters were initially regarded as speculative. Many of the damage related tweets contained links to uploaded pictures and video's, leaving no doubt about the credibility of the information about damage. In contrast, photos or videos did not clearly support tweets from individual twitterers stating there were 'mass casualties'. These 'rumors' received few retweets because fellow twitterers publically questioned the validity of the information. Only when the rumors about deaths were confirmed by official news media, the number of tweets increased dramatically, many of which were retweets. This suggests that social norms on Twitter prevent the propagation of unverified information about delicate topics.

Third, this and other studies have shown that solidarity often arises in times of crises and plays an important role in coping with disasters (e.g., Starbird and Palen, 2011; Terpstra, 2011). Within two hours after impact of the storm a nearby citizen started the #hasselthelpt initiative. This initiative to help the festivalgoers was followed by others twitterers who offered their help, such as places to stay, hot showers, warm meals, etc. These findings suggest that social media facilitate community resilience that originates from nearby people who sympathize with the victims.

Fourth, social media also provide clear opportunities for two-way crisis communication between authorities, media and citizens. For instance, on Twitter crisis managers can interact with citizens and media directly by confirming or refuting rumors and by taking emotional responses such as anger, sadness, fear and hope into account in their crisis communications. In this regard it is important to note that we found no tweets from official authorities during the Pukkelpop incident. As we did not interview the local Belgian crisis officials, we cannot explain why this was the case and whether or not crisis officials did follow Twitter and other social media, but simply did not participate actively.

There are a number of avenues for future research. First, early detection of hazards and rumors are important topics for improving crisis communication. The current study showed that only a small proportion of tweets contained information about the approaching storm and rumors about deaths. These topics may not be easily detected. The question is whether filters can be developed that enable early detection of hazards and rumors. Second, the existing 'damage' and 'casualties' filters and the development of new filters require further validation across hazards. This can be achieved by content analysis of tweets and calculating interrater reliability (Vieweg, Hughes, Starbird and Palen, 2010). Third, it seems that retweets play an important role in how twitterers infer source credibility of a tweet. People often base their trust on the extent to which they believe the information source has expertise and can be regarded as trustworthy (Lindell and Perry, 2004; Siegrist and Cvetkovich, 2000; Terpstra and Gutteling, 2008). For example, during the Red River flood (local) media were retweeted relative frequently (Starbird and Palen, 2010). Likely, local media are perceived as trustworthy and experts in validating news as facts before publishing them. However, individual twitterers may have little source credibility. Developing indicators for real-time (changes in) source credibility of Twitter accounts during crises would be a valuable for the performance of crisis communication (Palen, Vieweg and Anderson, 2010).

Despite the limitations of this study, the results provide a number of practical implications for crisis management. First, in real-time situations visual features like graphical displays of tweets over time and maps of tweet locations provide a good starting point for further analyses. These overviews help to identify abnormalities in the twitterverse that may be worth analyzing. For instance, by plotting the tweets on a map crisis managers are able to pinpoint potential 'hot spots'; i.e., locations where people are concerned. In the initial phase a high concentration of tweets likely reflects the incident location, while later spreading provides an indication of the 'news value' or impact of the news on people at other locations. Second, analyses showed that filtering tweets on 'damage' would have provided crisis managers with pictorial evidence of the situation on the ground. Because Twitter is a highly interactive and fast medium, Twitter provides a unique source of original and actual crisis information. Third, especially tweets that receive many retweets attract attention and are an indication that twitterers trust the information provided in the original tweet. Peaks in the tweet intensity often contain many retweets on a 'hot topic', such as news about damage and casualties. These retweets may have important implications for operational crisis management and for crisis communication.. Last but not least, the incorporation of social media in crisis management is not only about designing smart technological solutions. Despite the pace of social media adoption among citizens, official authorities can view new technologies in particular ways, which rationalize a slower acceptance than that of other types of stakeholders. A recent survey in the Netherlands showed that crisis officials hold remarkable positive attitudes towards using Twitter in times of crises (Terpstra, de Vries, Paradies and Hartman, 2011). However, crisis managers also perceived a number of barriers, such as lack of experience, knowledge of the potential of social media and monitoring, and lack of policy that currently hamper full-grown incorporation of social media in crisis management. Both technical and organizational solutions are needed so that professional use of social media as a crisis communication channel is supported by the responsible public administrations and becomes part of their organizational culture.

ACKNOWLEDGMENT

The research was carried out in the framework of the FloodControl2015 program (www.floodcontrol2015). None of the conclusions expressed here necessarily reflect views other than those of the authors.

REFERENCES

1. Hughes, A. L. and L. Palen (2009). Twitter Adoption and Use in Mass Convergence and Emergency Events. *Proceedings of the 6th International ISCRAM Conference*, Gothenburg, Sweden, May 2009.
2. Kwak, H., C. Lee, H. Park and S. Moon (2010). What is Twitter, a social network or a news media? *Proceedings of the 19th international conference on World wide web (WWW '10)*. Raleigh, NC, USA, April 26 - 30, 2010, ACM, New York, NY, USA: 591-600.
3. Lindell, M. K. and R. W. Perry (2004). *Communicating Environmental Risk in Multiethnic Communities.* Thousand Oaks, California, Sage Publications, Inc.
4. Palen, L., S. Vieweg and K. M. Anderson (2010). Supporting 'everyday analysts' in time- and safety- critical situations. *The Information Society 27*(1), 52-62.

5. Siegrist, M. and G. T. Cvetkovich (2000). Perception of hazards: The role of social trust and knowledge. *Risk Analysis 20*(5), 713-719.
6. Starbird, K. and L. Palen (2010). Pass It On?: Retweeting in Mass Emergencies. *Proceedings of the 7th International Information Systems for Crisis Response and Management Conference (ISCRAM)*, Seattle, WA, USA, May 2010.
7. Starbird, K. and L. Palen (2011). "Voluntweeters:" Self-Organizing by Digital Volunteers in Times of Crisis. *Proceedings of the ACM 2011 Conference on Computer Human Interaction (CHI 2011)*. Vancouver, BC, Canada, May 7–12, 2011.
8. Starbird, K., L. Palen, A. L. Hughes and S. Vieweg (2010). Chatter on The Red: What hazards threat reveals about the social life of microblogged information. *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work (CSCW)*, Savannah, Georgia, USA, February 6–10, 2010, ACM, New York, NY.
9. Stronkman, R. (2011). *Exploiting Twitter to Fulfil Information Needs during Incidents.* TU Delft. Master thesis.
10. Terpstra, T. (2011). Emotions, trust, and perceived risk: Affective and cognitive routes to flood preparedness behavior. *Risk Analysis 31*(10), 1658-1675.
11. Terpstra, T. and J. M. Gutteling (2008). Households' perceived responsibilities in flood risk management in the Netherlands. *International Journal of Water Resources Development 24*(4), 555-565.
12. Terpstra, T., M. Hartman, A. de Vries and G.L. Paradies (2011). *Twitter in crisis management. (In Dutch: Twitter in de crisisbeheersin).* Research report for FloodControl2015. Available at http://www.hkv.nl/Upload/Bestanden/541325_Social_media_eindrapport.pdf
13. Vieweg, S., A. L. Hughes, K. Starbird and L. Palen (2010). Microblogging during two natural hazards events: What Twitter may contribute to situational awareness. *Chi2010: Proceedings of the 28th Annual Chi Conference on Human Factors in Computing Systems*, New York, Assoc Computing Machinery.