#geiger : Radiation Monitoring Twitter Bots for Nuclear Post-Accident Situations

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ABSTRACT

In the last decade, people have increasingly relied on social media platforms such as Twitter to share information on the response to a natural or a man-made disaster. This paper focuses on the aftermath of the Fukushima Daiichi nuclear disaster. Since the disaster, victims and volunteers have been sharing relevant information about radiation measurements by means of social media. The aim of this research is to explore the diffusion of information produced and shared by Twitter bots, to understand the degree of popularity of these sources and to check if these bots deliver original radiation measurements.

Keywords

Twitter, bots, nuclear post-accident, radiations, long-term period.

INTRODUCTION

Social media are an important support of human communication. They allow people to easily publish, share and comment information online, also when they face natural or man-made disasters. In particular, since Hurricane Katrina (2005), people have increasingly relied on social media to efficiently exchange and manage critical information during the disaster. Other disasters show that social media could be also useful in the post-accident phase, when victims must make the decision whether to leave or stay, to quit or rebuild their territory.

During this period, the availability, the completeness and the reliability of information broadcasted by social media could be key factors of the decision process. In order to highlight the relevance of these factors, we have conducted an exploratory study on the information delivered through Twitter by a set of bots since the Fukushima Daiichi nuclear accident occurred. Since this disaster, the Japanese have increased the usage of social media in order to get more information than previously received by governmental sources regarding radiation leaks towards food, water, children and so on.

RELATED WORKS

Social media are web services allowing users to create public or private profiles, maintain lists of connections with other users and navigate through those lists (boyd & Ellison, 2008). On popular services like Twitter, automated programs called bots produce a large amount of data (Chu, Gianvecchio, Wang, & Jajodia, 2010). In the past few years, people have increasingly used social media to deal with different crisis situations such as natural disasters (hurricanes, earthquakes, floodings) and man-made events (shootings, bombings, protests). Indeed they share links and spreading information rather than exchange personal messages (Hughes & Palen, 2009). For instance, after the Virginia Tech shootings (2007), students and relatives heavily relied on social media, especially Facebook and Wikipedia, to identify the victims (Palen, Vieweg, Liu, & Hughes, 2009).

Social media also play an important role in the aftermath of the most recent industrial disasters, such as the Fukuskima Daiichi nuclear disaster (Plantin, 2011). A nuclear accident consists conventionally of two main phases: the emergency phase, when radioactive substances leak into the environment, and the post-accidental phase, when the consequences of the accident must be managed. The post-accidental phase is a two-stage process: in the transition stage, the contamination of the environment has not been assessed yet, and, in the long-term stage, populations living in the contaminated areas face a chronic exposure to small doses of radiations. The long-term period may start a few weeks or months after the accident, and it may last years or decades (CODIRPA, 2012). The nuclear risk is man-made and usually associated with cancers, thus leading to high levels of fear in population (Ropeik, 2008). Unlike many another crisis situations (e.g. earthquake, bombing), the nuclear risk cannot be perceived by human senses (Slovic, 1996). In nuclear post-accident situations (NPA), people need relevant information to deal with the invisible danger of radiations[1]. Since the Three Miles Island accident (1979), the media coverage of nuclear crisis has greatly improved, reporting radiation measurements in a more complete manner, by using multimedia technologies to explain this complex situation (Friedman, 2011).

[1] http://ethos-fukushima.blogspot.fr/p/icrp-dialogue.htm

These problems also occurred in March 2011, after the Fukushima Daiichi nuclear disaster, when the population faced an important lack of information regarding the radiological situation (Aldrich, 2012). The citizens quickly stopped trusting the reassuring communication of both the Japanese Government and the plant operator (Li, Vishwanath, & Rao, 2014). Measuring radiations is the only way to reveal the radiological situation and thus to take protective actions.

Therefore, Japanese people have been working together to create radiation measurements maps by scrapping the rare official data available and aggregating readings from radiameters managed by citizens (Plantin, 2011). So far, the researches about the use of social media after a nuclear disaster only focus on the emergency phase (Li et al., 2014), whereas the long-term period has not been studied yet. Through social media, scientists and experts all over the world commented official communication and shared alternative information sources with victims (Friedman, 2011).

This behaviour has two main effects. Firstly, from a pragmatic side, citizens and emergency authorities are able to deal with crisis situation on a parallel and distributed manner (Palen et al., 2010). Secondly, from the scientific side, social media, like Twitter, make human communication persistent (Palen et al., 2009). Indeed, through Application Programing Interfaces (APIs), social media platforms can be used to capture data about users, their relationships and the messages they share. Analysis can then be performed on message content, through topics extraction or sentiments and emotions analysis, but also on metadata such as hashtags and sharing activities (Bruns & Liang, 2012; Rogers, 2009).

RESEARCH QUESTIONS

In this study we focus on the Twitter radiation monitoring bots (Figure 1, Figure 2). Since the Fukushima Daiichi Nuclear Post-Accident (NPA) period, these devices have been diffusing a set of essential information about radiations and the risk for the victims' health.

More precisely, we want to understand if the Twitter bots (Q1) are popular sources of information, (Q2) are reliable sources of information and (Q3) publish original radiation measurements.

(Q1) First, we try to assess whether the Twitter radiation monitoring bots are popular information sources during the NPA period. We posit that the Fukushima Daiichi nuclear disaster triggered a rise in the number of Twitter bots and increased their popularity, whose levels are still high three years after the disaster.

We define the popularity of a Twitter account as a vector including the number of followers (i.e. other users who subscribed to the service and read new tweets sent by the account), listed (i.e. other users who saved the account in a shared list), retweets (i.e. re-diffusion of a tweet by other users) and favorites (i.e. storage of a tweet sent by other accounts).

Figure 1. The radiameter used by a bot[2]

Figure 2. A tweet produced by a bot[3]

(Q2) We aim to know if Twitter bots are reliable information sources in the NPA situation. We hypothesize that this information is as complete and accurate as official measurements. Measurement completeness is defined as the presence of the amount, the unit, the rate, the time, the duration, the location, the type of radioactive material and the type of exposure (Friedman, 2011; Rubin, 1979).

Given the elements usually present in a tweet, we will only consider a few dimensions: the type of location specified in the profile (i.e. geocoordinates, region, city), the name of the device, the unit of measurement and the precision.

[2] https://twitter.com/rad_tweet

[3] https://twitter.com/musashino_rad/status/535795011132997633

(Q3) We focus on the sources of the measurements shared by bots and we wonder whether Twitter bots publish original or existing measurements. We posit that most bots publish original data from radiameters operated by the bots creators.

METHODOLOGY

To answer these questions, first we identified a set of active radiation bots (phase 1) and then we collected radiation measurements they had published (phase 2).

Phase 1: identifying radiation measuring bots.

To identify currently active radiation measuring bots, we used the Twitter Search API[4] to retrieve the 500 last tweets matching each of the following keywords related to radiation measurement units: 'cpm', 'gy/h', 'µgy', 'ngy', 'usv', 'µsv', 'sv/h'. Using both regular expressions and manual examination of accounts with high numbers of tweets, we identified 48 bots accounts tweeting radiation measurements on an automated way.

Using the Twitter REST API[5] we gathered several data about the bot profiles. We also collected the 1000 last tweets of each account to calculate the retweetting and favoring frequencies.

Phase 2: collecting radiation measurements.

We collected tweets in real time through Twitter's Streaming API, using a "follow" request[6] based on the list of previously selected user accounts. Data collection was interrupted a few times because of crashes and network issues. We collected 56120 tweets during September 2014.

[4] https://dev.twitter.com/docs/using-search

[5] https://dev.twitter.com/rest/public

[6] https://dev.twitter.com/streaming /overview/request-parameters#follow

DATA ANALYSIS AND RESULTS

We will detail the data analysis according to our research questions.

Q1. Popularity of the bots

Most of the bots are Japanese, their language was set to "ja" (87.5%), the time-zone set to Tokyo (41.7%), and their tweets contain Japanese letters (75%). Accounts were mostly created in 2011 (39.6%, with 14.6% in March), 2012 (29.2%) and 2013 (25%).

The analysis of the number of followers, listed, retweets and favorites shows a long tail distribution, with a lot of dimly connected users and a few highly popular ones (Table 1).

	Retweets	Favorites	Followers	Listed
0	60.4%	64.6%	0%	20.8%
1-9	14.6%	18.8%	27.1%	50%
10-99	18.8%	14.6%	39.6%	20.8%
100-999	4.2%	2.1%	22.9%	8.3%
1000+	2.1%	0%	10.4%	0%
mean	35.0	8.3	382.7	32.5
standard deviation	147.6	31.1	1022.5	86.7

Table 1. Accounts popularity

The creation date of the Twitter accounts reveals a peak in March 2011 (Table 2). Bots created in 2011 are also the most popular, especially the ones created right before (January 2011) and right after (March 2011) the Fukushima-Daiichi disaster. Then both accounts creation and popularity (i.e. numbers of retweets, favorites, followers and listed) decreased over the years.

Creation	Number of accounts	Retweets	Favorites	Followers	Listed
overall	48	35.0 (147.6)	8.3 (31.1)	382.7 (1022.5)	32.5 (86.7)
2010	1	0 (0)	0 (0)	117 (0)	5 (0)
2011	19	83.1 (225.7)	18.0 (47.2)	912.0 (1471.7)	77.3 (124.9)
2012	14	4.4 (15.2)	1.9 (6.2)	55.4 (119.5)	5.1 (6.9)
2013	12	3.4 (8.9)	2.4 (7.2)	11.9 (15.1)	0.9 (1.9)
2014	2	0 (0)	0 (0)	3 (1)	0.5 (0.5)
jan 2011	2	582.5 (442.5)	118.5 (93.5)	3288 (1604.0)	176.5 (139.5)
mar 2011	7	50.7 (36.0)	12.9 (15.4)	1337.1 (1571.7)	147.3 (149.1)

Table 2. Accounts popularity over the time (mean and standard deviation)

Q2. Reliability of the measurements

All the bots indicate the unit of the measurement, mostly Sieverts (Sv)[7] per hour (58.3%) or Grays (Gy)[8] per hour (12.5%). Several bots (20.8%) provide

[7] Unit of equivalent dose (http://icosymnt.cvut.cz/kifb/en/concepts/_sievert.html)

[8] Unit of absorbed dose (http://icosymnt.cvut.cz/kifb/en/concepts/_gray.html)

measurements in two units, such as both Sievert per hour and Count Per Minutes (CPM)[9].

One account publishes measurements in Roentgen, an obsolete exposure measurement unit. Only a small part (22.9%) of the bots (the ones using the #Radidas hashtag, see Q3 below) provide a numerical assessment of the measurement precision (such as "0.04±0.01µSv/h").

The exact location of each measuring bot is not always specified. A third (33.3%) of the bots provides geographical coordinates, whereas 31.3% just delivers the city name and 14.6% the district name. 10.4% of the accounts does not provide any geographical details. To assess the reliability of the measurements reported by the bots, we compared them with the official measurements. For the bots, we extracted the values of the radiation measurements published in the tweets. For the official measurements, we collected the measurements published on the Japanese nuclear regulation authority's website (NSR)[10].

We compared 10 selected accounts, expressing measurements in micro-Sieverts per hour and providing a sufficiently precise location, with an NSR measurement station nearby. For each account, we plotted both extracted and official values with their timestamps during a week. Some bots reveal very scattered values (Figure 3), while others show more regular trends (Figure 4). We also collected data from an account tweeting measurements from a city health institute (Figure 5). The similarity with the data recorded by the NSR, except for a small temporal offset, may suggest that the same sensor is used by both agencies. It is difficult to assess the measurement quality : while bots and official measurements have roughly the same order of magnitude, more precise changes can hardly be noticed.

Q3. Radiation measurements sources

An important part of the bots (43.8%) does not provide information about the measurements provenance, and 16.7% of the bots mention an official authority as the source of the measurements they share. The other ones, which indicate the name of the radiameter (25%) or more vague information such as a description or a picture of the device, can be considered as providing original measurements.

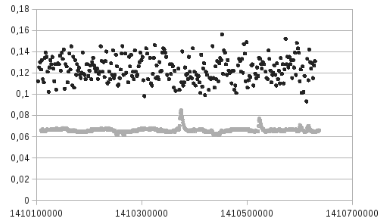

Figure 3. Scattered readings from a bot

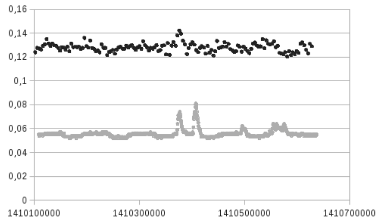

Figure 4. A more regular bot

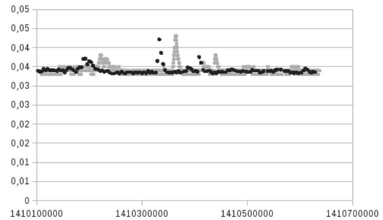

Figure 5. A bot tweeting official measurements

The #Radidas hashtag is used by 13 user accounts managed with the Radidas[11] software. It allows people to share the measurements of a radiameter plugged into a computer, and to visualize measurements published by other users (Figure 7). The accounts produce tweets following the same syntax (Figure 6): firstly, a

[9] Unit of radioactivity count rate

[10] http://radioactivity.nsr.go.jp/

[11] http://radioactive-sweets.seesaa.net/article/224918955.html

measurement expressed in micro-Sievert per hour, every 30 minutes, and secondly, the data concerning the geocoordinates, expressed in a non-standard way. The #Radidas_Alert hashtag seems to be used when the amount of radiation measurements exceed a specific value, which is around 0.05µSv/h. These accounts were mostly created in 2012 (69%).

Figure 6. A tweet from a #Radidas account

Figure 7. A screenshot of Radidas[12]

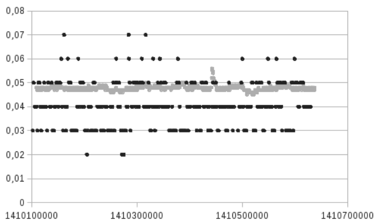

Figure 8. A#Radidas bot

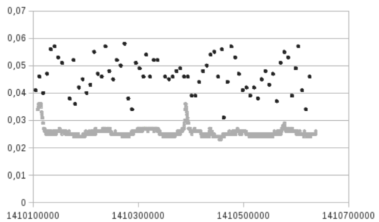

Figure 9. A #Mark2bot bot

Four accounts use the hashtag #Mark2bot, referring to the Mark2 radiameter[13]. This device enables the publication of the measurements on Twitter in an automated way. These measurements are expressed in both micro Sieverts per hour and Counts per Minute. The measurement frequency of the different accounts goes from every 20 minutes up to every 2 hours.

#Radidas accounts publish the measurements with the rough precision of 0.01 µSv/h, whereas the NSR data are highly precise and regular (Figure 8). The only #mark2bot account we could analyse is quite erratic (Figure 9).

DISCUSSIONS AND CONCLUSIONS

Since most bot accounts are Japanese, we can assume that they have been created and used in response to the Fukushima Daiichi Nuclear disaster. We observed that bots creation was more important during the emergency than in the post-accidental phase, and resulted in the highest popularity values. This outcome is consistent with the high concern of citizens and the lack of official radiation measurements (Plantin, 2011). Even three years after the accident, new bots are still being created, followed, added to lists, and their tweets are being retweeted and marked as favorite. Nevertheless, during the post-accidental phase, the popularity of the bots and the frequency of their creation decreased. This may be explained by two main factors: first, the Japanese nuclear regulation authority gradually restored the publication of official measurements and, second, Twitter users not directly affected by the disaster lost interest.

Measurements shared by bots are mostly incomplete and researchers lack relevant details about the devices, as well their location and their precision. This may hinder the opportunity of making valid comparison and verification of measurements. In fact, different devices measure different kinds of radiations. Moreover, there are different measurement setups, for instance on the ground or one meter above, indoors or outdoors, which have relevant effects on the overall measurements. Bots precision may be sufficient to assess a rough level of contamination or to detect the important variations in the radiological situation during the emergency phase. But the lower levels and more subtle changes that need to be monitored in the long-term period are beyond the precision of most bots. Several bots did not deliver details about the original source of the measurement they shared. Our results show that bots seems nevertheless to be more used to broadcast original radiation measurements, than to share existing

12 http://pow2p.web.fc2.com/pgnet/sample/
13 http://www.wakamatsu-net.com/mark2/mark2.htm

official data. This activity is supported by at least two different measurement-sharing tools contributing to the completeness of the measurements.

This exploratory study has several limitations. First, the cues of popularity do not take shared activities outside Twitter (blogs, other social media) into account, nor the number of different users involved in retweeting and favoring activities. The accuracy of measurements is difficult to assess, as official sensors are not always very close to the non-official ones, and both the low precision and high versatility of non-official sensors complicate the comparison. Additionally, the accuracy of the official measurements is not investigated here. Finally, because we just analysed a few number of accounts, the external validity of this study is not significant.

Nevertheless, we can identify a few improvements that could increase the usefulness of radiation monitoring bots for dealing with life in a PAN situation. Bots should rely on more precise sensors, operated in places with less interference. Sharing tools should be used more widely to guide users in providing measurements that are more complete, and thus easier to verify and compare. They could rely on a standard format for radiation measurements sharing on Twitter, listing the information required and describing a recommended syntax. The use of bots to share different kinds of measurements (in food, in water) could also be considered. To support this activity even years after the disaster, local radiation monitoring bots should be promoted amongst citizens, through the dissemination of the technical knowledge, the creation of interactive maps aggregating measurements, and the adoption of quality labels.

Future work may include a long-term study that could show the dynamics of account creations and deletions. A more comprehensive work could extend this study by taking into account radiation sharing on other digital media. Another research direction we are going to explore is the link between the measurement delivered by bots and how citizens build their own resilience process (Cutter, Ahearn, Amadei, Crawford, Eide, Galloway & Zoback, 2013).

ACKNOWLEDGMENTS

This study was produced as part of the SCOPANUM research project, supported by grants from the CSFRS and a doctoral grant from Pays de Montbéliard Agglomération (France).

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