Social Media for the Common Good: the case of EARS

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ABSTRACT

Natural disasters such as earthquakes, tornadoes and floods, are just some of the devastating events that may have catastrophic consequences on wide geographical areas. A quick and targeted response to emergencies greatly contributes in mitigating the losses. In recent years we have witnessed to many situations in which crowds of volunteer citizens have helped emergency responders via the use of widespread social media. Here we argue that technology can help in supporting the population, as well as the decision makers, by introducing tools that enhance the collective awareness level, providing quick yet accurate insights into the unfolding emergency. In this short paper we introduce the EARS system, a social media-based system that supports decision makers during earthquake emergencies in Italy. We discuss the implications and the responsibility related to the usage of such systems by the decision makers. Also, we discuss on how publicly opening systems like EARS to the population might change the problem approach and we introduce relevant opportunities and issues that this solution would imply.

Categories and Subject Descriptors

H.2.8 [**Database Management**]: Database Applications—*Data mining*; K.4.1 [**Computers and Society**]: Public Policy Issues—*Human safety*

Keywords

Social sensing, social media mining, collective intelligence, emergency management, crisis informatics

1. INTRODUCTION

Natural disasters such as earthquakes, tornadoes, floods, etc., are phenomena that affect many parts of the world, some of which are densely populated. Such areas require a constant monitoring to prevent or limit high scale disasters and to act promptly for a first response when disasters strike. In particular, the timely detection of emergency events, the identification of affected areas and the damage assessment activities are priorities in order to provide a better support to the local population [9]. These kinds of events usually unchain people involvement in participation and reporting [12]. In fact in recent years, it has been observed a significant increment of social media (SM) activity in the aftermath of mass convergence and emergency events [1, 3]. To this regard, microblogs such as Twitter, Weibo or Instagram are privileged channels of information diffusion because of their nature and simplicity [8]. During emergencies people usually report their experience on these media, which are consequently overwhelmed by information concerning the unfolding scenario. Messages shared on these media are also often complemented by comments, images or videos [10].

This spontaneous production of content-rich and actionable information can be extremely precious towards the rapid understanding of the emergency scenario, as recently demonstrated by a number of scientific works [2, 4, 6, 7, 11]. These works propose systems that exploit the collective intelligence of the crowds by analyzing the spontaneous emergency reports shared on social media in order to detect outbreaking emergencies and improve situational awareness. Such systems have been originally designed to support decision makers and are not publicly accessible. Specifically, the system described in [11] was among the first works to show the informative power of social sensors[1]. Authors designed and tested a system for the detection of earthquakes and tornadoes in Japan, with promising results. Works discussed in [4, 7] go further in this direction by demonstrating that social media reports can be further exploited to obtain a better characterization of the emergency event thus increasing the overall situational awareness. Finally, works in [2, 6] propose to perform the task of damage assessment by applying data mining and natural language processing techniques to social media emergency reports. Results are discussed in the fields of earthquakes and floods emergencies.

Although recent works in the fields of social media emergency management, crisis informatics and crisis mapping showed compelling results, many issues still remain unsolved. Indeed, the downside of the employment of social media messages during emergencies is that such pieces of information are often fragmented, lack a defined structure and means to assess information trustworthiness and credibility. For these reasons, most civil protection agencies still heavily rely on traditional technologies (e.g. seismographic networks, on-

[1]The notion of social sensor is further explained in the beginning of Section 2

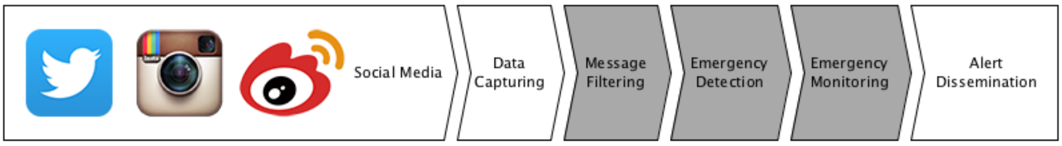

Figure 1: Architectural overview of the EARS system.

the-ground surveys, aerial or satellite images, etc.) in the most intense phases of emergencies. What happened during recent major disasters, such as the Tōhoku earthquake and tsunami (Japan 2011), the Emilia earthquake (Italy 2012), the Himalayan earthquake (Nepal 2015), thus highlighted a divide between the promising results and technologies proposed by Academia and the traditional technologies still employed by the majority of emergency responders. Therefore, a fundamental question arises: how can we help reduce the gap between Academia and first responders?

Here, we discuss the opportunities and the drawbacks of opening novel emergency management systems, such as the ones briefly surveyed before, to the public. We start by describing the EARS system [2] for emergency management. EARS (Earthquake Alert and Report System) is a real-time Twitter-based earthquake emergency management system designed and developed at the Institute for Informatics and Telematics (IIT) of the Italian National Research Council (CNR). The system is deployed for the analysts of the Italian National Institute of Geophysics and Volcanology (INGV), the authority responsible for monitoring seismic events in Italy, since 2013. The lessons learned during our 2 years long experience with EARS can help understand the potential and the risks related to the widespread adoption of such systems. Next, we introduce and discuss the most critical issues to consider in order to publicly open emergency management systems.

Roadmap. The remainder of this paper is organized as follows: Section 2 describes the potential offered by the EARS system, Section 3 discusses the issues related to opening emergency management systems to the public and Section 4 draws the conclusions and describes directions for future work.

2. THE EARS SYSTEM

Sensors are primary sources of information in electronic devices. Since the advent of Web 2.0 and social applications, which are intrinsically people-centric, the crowds have also become sources of huge information streams. The idea behind the EARS system is to keep the crowds as the core of information sources. EARS does not make use of physical sensors, which need to be acquired, tuned and pervasively deployed in potentially risky areas. Instead, it exploits the ubiquitous diffusion of social media allowing users to act as *social sensors*. By exploiting emergency reports shared on social media, EARS aims at leveraging the collective intelligence of on-the-ground social sensors for the detection and the damage assessment of earthquakes in Italy. In the Euro-Mediterranean region Italy is one of the countries with the highest seismic hazard together with Greece and Turkey. In Italy, the relationship between the damage caused by earthquakes and the energy released is much higher than in other countries with high seismicity, such as California or Japan. This is mainly due to the high population density and the considerable fragility of Italian artistic and monumental heritage[2]. As suggested in [11], the highly seismic nature of Italy makes it one of the best countries where to carry out a study on the detection of earthquakes based on Twitter data.

The system is organized like a pipeline of components in which data flows from the *Data Acquisition* component to the *Alert Dissemination* component, passing through an analysis and refining process in which useful knowledge is extracted from raw social media data, see Figure 1. The architectural components responsible for the data analysis and refining operations represent the core of EARS and appear as greyed-out in Figure 1.

The data entry point into the system is represented by the Twitter Streaming API[3], which gives access to a real-time stream of messages (henceforth *tweets*) optionally filtered by keywords. Currently EARS performs the data acquisition process only from Twitter. However, the modular architecture of our system is easily extensible with interfaces to other social media such as Weibo and Instagram. Data generated by social sensors is known for being noisy and bursty, with significant peaks in activity registered in the aftermath of mass convergence or emergency situations. A *Data Filtering* process is necessary to discard unrelated messages and filter out the meaningless babble typical of Twitter streams. After discarding noisy tweets from the stream, EARS applies a burst detection algorithm to the remaining (relevant) tweets. EARS triggers the detection of an earthquake when it identifies an exceptionally high frequency (i.e. a burst) of tweets carrying earthquake-related keywords. Once an earthquake has been detected, it is possible to further analyze the data stream to extract useful information on the unfolding situation. In fact, spontaneous earthquake reports convey a multitude of information describing the widespread scenario: like journalists, people report damage to buildings, infrastructures, injured and missing people, etc. The exploitation of automatic data-mining techniques for the analysis of emergency related message streams makes it possible to rapidly process the information deluge which is typical of emergency situations.

EARS provides a self descriptive and easy-to-use web interface in which users have the opportunity to browse the collected timeline of tweets and inspect their content. As briefly shown in Figure 2, the system offers several views organizing the different pieces of information extracted from the raw tweets. Among the different views, the system features a geographic view, a temporal view showing the volume of relevant messages over time and a chronologically ordered content view where every relevant tweet is accessible. Most relevant tweets are also expanded beside the

[2] http://www.protezionecivile.gov.it/jcms/en/homepage.wp
[3] https://dev.twitter.com/streaming/overview

Figure 2: Excerpt of the EARS web interface.

geographic map and the system periodically computes term clouds showing the current topics of discussion. Figure 2 shows an excerpt of the EARS web interface related to the earthquake that struck Emilia regional district in May 2012 which led to 26 deaths and widespread damage[4]. We are open to presenting a demo of the EARS system as well as disclosing both technical details and further details on its features.

3. OUR VISION

The EARS system was designed to be of support for decision makers, keeping in mind that final users would have been members of a civil protection agency or experts in managing emergencies. While developing and fine-tuning the system, we debated whether a more transparent handling of the extracted information could also be of direct benefit for the population at-large, if publicly disclosed. However, a series of concerns may arise which are related to the possible misinterpretation of the information made available by the system and to possible malicious behaviors. We believe this considerations ask for a deep discussion on the benefits and the drawbacks of opening these systems to the public. Next we survey the main pros and cons of such matter.

Monitoring authorities. Publicly opening emergency management systems would allow the population at-large to better understand the kind and the volume of information available to decision makers. As a consequence, this would stimulate civil protection agencies to better exploit information extracted from social media thus improving the response action. This would also ensure crowd generated reports to be timely taken into account. In fact, an efficient bidirectional communication between population and institutions is fundamental to improve emergency response. This communication and cooperation can be enhanced by exploiting social media in order to allow citizens to forward public requests for help and to notify dangers and critical situations. In particular social media are becoming monitoring tools that encourage collective intelligence and this leads institutions to improve service quality, being aware that the effectiveness of their actions is verifiable.

Citizen empowerment. An open social media-based emergency management system would increase self consciousness among digital volunteers by making them aware that the information they share can directly help emergency responders. This would cause population empowerment, since it would push people to participate in discussion and to being proactive in documenting the unfolding scenario via tweets, photos and videos. It could also possibly lead to a *virtuous circle* fostering the participation of the crowds, thus providing more or better information for decision makers to act. Twitter enabling power is a flexible driver for promptly heading first aid intervention and straight to the right direction, using just a tweet or a photo to help save human lives.

False alarms. On the other hand, opening these kinds of systems to the public at-large poses some serious questions about their reliability. False detections might induce panic and fear in populations, and create false alarms. Frequent false detections will inevitably lead people to ignore the system making it completely useless and unreliable. False detections are a problem that every statistical system has to cope with. Moreover social media-based systems are usually tested against correct detections, while the problem of false detections is often overlooked. False detections might also be caused by malicious users, which lead to the next point.

Attack resilience. Indeed, performance drops may also be caused by malicious users willing to purposely disrupt the service. Robustness to attacks in critical systems like the emergency management ones, is mandatory and must become a primary guideline in system design. In EARS we experimented with fake detection algorithms in order to reduce security concerns and mitigate the problem of fictitious (i.e. fake) messages [5]. The Data Filtering component introduced in Section 2 surely helps in discriminating single tweets, but it may still be tricked if bursts of bogus tweets are produced purposely.

Emergency management. One of the key points of discussion concerns who should really manage and organize emergency response and communications. A centralized approach has the drawback of a lack of fine-grained presence on struck areas. Indeed it is unfeasible for civil protection agencies to continuously and accurately monitor the territory. Moreover, emergency responders are usually reluctant to the adoption of systems that differ from those traditionally used due to authoritative and responsibility issues. This position potentially hinders the amount of information available to decision makers and makes them not completely aware of the situation when reacting to a crisis. On the other hand, relying on the crowds allows tasks parallelization, but the lack of a central authority may deteriorate decision quality. Furthermore, citizens often lack technical skills and thus efforts might be inhibited by a lack of competences.

Future directions. Finally, it is worth noting that an opportunistic approach applied in the field of citizen sensing,

[4] http://en.wikipedia.org/wiki/2012_Northern_Italy_earthquakes

like the one used by our system, captures a wide variety of information, rich of heterogeneity and spontaneity. In previous works only a small amount of tools were designed using this approach, in favor of a participatory approach. Indeed, the opportunistic approach is in some sense a weakness point as much as a strengthen point of the system. It introduces a high level of noise in the content and requires the systems to handle unstructured text. Anyway, it also dramatically increases the volume of messages captured. EARS collects and stores a significant amount of textual information as well as a minor, yet not negligible, part of multimedia content. Such content, reporting information about collapsed buildings, damaged streets and off-line services, is essential for the scenario comprehension. Also, messages carrying multimedia content usually spread very rapidly on social media, even faster than text-only tweets. Therefore the possibility to detect photo and video subjects and to automatically cluster them is appealing and would be handful for those who are trying to estimate the severity of an emergency. However, this still represents an open area to investigate. Moreover, tweets volumes, multimedia material and writing styles change significantly among emergencies typologies.

4. CONCLUSIONS AND FUTURE WORK

We envision that tools like EARS will be widely applied in the future and that they will be tuned to deal with many kinds of emergencies. We are also confident that these systems will be helpful in areas that are difficult to survey directly or that are not well covered by the seismographic networks, thus requiring alternative channels of investigation. Given the mild requirements to operate with social media (a smartphone and a data communication network), system precision will be affected just by the number of social sensors in a given area. This also requires that social media will still be providing open services and that information will be available to anyone easily. Rate limit policies and privacy issues may, on the other hand, slower or even stop the development of these kinds of systems.

We are currently looking forward to deepen our knowledge on how to mine social media to infer knowledge for the common good and for the citizens. We believe it will be possible to automatically detect anomalies in social behaviors in order to identify malaise in people, symptoms of facts or events that could impact a single person, a little community or populations, thus providing countermeasures to control shattering situations. Social media platforms enable citizens to be proactive in social good participation and monitoring, incrementing everyone responsibility to take part to public discussions for common good and to better react to wide scale crises. From this point, the possibility to expand such techniques towards massive application of social media on intelligence tasks for automatically studying human dynamics, seems rather straightforward.

In conclusion, we are interested in possible publications beyond the conference, through which our work and vision could be described thoroughly, both from a scientific and an applicative perspective.

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