

# CrowdMonitor: Monitoring Physical and Digital Activities of Citizens During Emergencies

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**Abstract.** In recent times, emergencies such as the 2013 flood in mid Europe have clearly shown that besides the professional emergency services and authorities, citizens get a more and more active role in crisis response work. They organize themselves and coordinate private relief activities. Those activities can be found in (physical) groups of affected local citizens, but also within (digital) social media groups. To detect and use this civil potential by professional emergency services, approaches are needed that support the instructing of citizens and coordinating of their actions to avoid needless duplications or conflicts. In this paper we present a concept, based on a mobile crowd sensing approach, which was designed as well as implemented as the system prototype CrowdMonitor and facilitates the monitoring of physical and digital activities of and the assignment of specific tasks to citizens.

**Keywords:** Crowdsourcing · Emergency management · Mobile crowd sensing · Social media

## 1 Introduction

Events such as the big flood in mid Europe 2013 or the typhoon Haiyan in Philippines 2013 clearly show that ordinary citizens already take a more and more active role in responding to emergencies. Citizens already organize themselves independently within relief communities often via social media for coordinating private response activities<sup>1</sup>. Currently, symbiotic approaches already exist for combining the civil activities with those of the professional emergency services. Citizens can help for one thing physically, e.g. by filling sandbags<sup>2</sup>, for another thing they can help online, e.g. by providing crisis-related information<sup>3</sup>. Although the emergency services have already recognized the relevance of civil physical and digital activities – besides legal issues – the problem still remains, how on-site as well as online activities can be managed in very time-critical and uncertain situations and thus be integrated usefully into the current professional work practice.

In the recent years, open innovation concepts – emerging from Web 2.0 – have been geared to citizen engagement. *Crowdsourcing* is a “*type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals via a flexible open call, the voluntary undertaking of a task*”<sup>4</sup>. Within crisis management, crowdsourcing can be applied within different

areas. One of them is the field of situation assessment, where a crowd can be used for the provision of on-site information<sup>5,6</sup> and the online community acts as a group of reporters<sup>7</sup>. Community members already create, provide, share, evaluate and discuss photos, videos, posts, news, etc. in social media groups. But how professional emergency services can use and make sense out of this mass of citizen-generated content with regard to their physical on-site activities in order to better respond to the emergency remains a big issue.

A subset of crowdsourcing is the concept of participatory sensing<sup>8,9</sup>, in which the public is requested to gather, analyze and share data and information with the integrated sensor capabilities of mobile devices<sup>10,11</sup>. Such sensors can be the camera, GPS or microphone for providing and transmitting e.g. locations or noises<sup>8</sup>. For crisis management, social media services such as Facebook or Twitter are of great interest<sup>5</sup>, because on the one hand such services contain relevant information about an emergency<sup>12</sup> and on the other hand affected citizens already can be found within them. This is demonstrated by the fact that citizens communicate via social media and share information directly from the incident's location<sup>6</sup>. The concept of *mobile crowd sensing*<sup>13</sup> tries to combine the participatory sensing concept with a "collective" sensing view by supplementing environmental or sensor data collected via mobile devices on-site with citizen-generated content within social media<sup>14</sup>. This creates a great amount of information, which supplements sensor data with opinions and experiences of citizens<sup>15</sup>.

Within this paper, we analyze the related work and specific approaches to crowdsourcing and mobile crowd sensing in emergencies. In a qualitative empirical study of emergency services, we explored the impact of citizen-generated content of social media as well as on- and off-site citizen involvement. Based on our pre-studies we derived an approach, which allows the combination of both on-site civil as well as digital activities. We used the empirical findings to implement the web-based application "CrowdMonitor" which is based on the mobile crowd sensing concept and is intended to support the situation assessment and collaboration between emergency services and citizens.

## 2 Crowdsourcing Systems for Emergencies

There are a lot of existing approaches that try to make use of crowdsourcing during emergencies. Such systems focus on supporting the actions of emergency services and those of citizens, especially in very time-critical situations. In the following section we will present different types of crowdsourcing systems.

CrisisTracker is a platform for exploring Twitter within a specific type of disaster. It pre-filters tweets by a keyword and location with the aim of creating a 'social awareness'. In addition, tweets can be visualized on a map or a timeline. Although CrisisTracker can provide important information, it does not use other social media sources or include civil interactions or sensing capabilities<sup>16</sup>. Ushahidi is a platform, which tries to support professional organizations with options for requesting citizens or digital assistants to gather, structure or share information<sup>17</sup>. This information mainly contains reports about the intensity of a disaster like medical needs<sup>17</sup>. In addition, those reports originate from different sources, like social media<sup>18</sup>, E-Mail<sup>3</sup> or SMS<sup>19</sup>.

Within Ushahidi, reports are visualized on a map to improve the situation assessment<sup>19</sup> and they are frequently updated<sup>17</sup>. Ushahidi was used during different emergencies such as the tsunami in Japan 2011 for the allocation of food<sup>3</sup>. Although it embeds information from citizens as well as different sources, information from social media is not used. With Mobile4D, emergency services request affected citizens to submit reports about their local situation by using a dedicated mobile application. Emergency services use this application to directly communicate with the public and verify submitted information. In addition Mobile4D supports the warning of citizens, depending on submitted reports. Mobile4D was used within smaller incidents in 2013 Luang Prabang in Laos, where reports about floods and the avian flu were collected. Affected people can be contacted directly<sup>20</sup>. By providing citizen-interaction and participatory sensing approaches, the potential of digital volunteers still remains unused.

Compared to the systems previously described, CROSS uses social media to initiate the using of a mobile application of citizens by a public call. With the help of this application, citizens can collect information from the incident's place and transmit it with location data. The location allows the emergency services to coordinate and monitor participating citizens<sup>5</sup>. Although using social media for a first interaction, CROSS does not embed it as an additional source of information. With CrowdHelp, citizens can submit information about their medical conditions, which is then visualized and clustered by its urgency on a map. The clustering allows emergency services to allocate units on-site more effectively<sup>18</sup>. But an integration of social media information within CrowdHelp is not apparent.

The system DIADEM represents another way of gathering and validating civil information. Here a pre-selected expert group of citizens are requested by emergency services to use a mobile application for identifying strange smells with the help of surveys during chemical disasters<sup>21</sup>. The collected responses are shared between experts and visualized on a map, so that emergency services can derive possible locations of an affected chemical factory<sup>22</sup>. Although providing interaction and participatory sensing functionality, the use of social media is not part of DIADEM.

Microtasking-applications like MicroMappers (<http://micromappers.com/>) enable performing small tasks by citizens with just a few mouse clicks. Emergency services request digital volunteers to fulfil tasks by a crowdsourcing-platform<sup>23</sup>. Such applications were used e.g. during the 2013 typhoon in the Philippines to categorize photos<sup>7</sup>. On the one hand those approaches use the potential of digital volunteers, but on the other hand they do not integrate physical activities on site.

The approaches presented above are mainly used to request citizens for information gathering or its evaluation. Especially the potential of local physical activities often remains unused. Moreover the systems neither use the potential of social media, where crowds of citizens submit crisis-relevant information, nor a combination of those with the activities on-site. Within the approaches social media is occasionally used for initiating participation or rarely as additional information sources. Addressing this gap, an approach that allows both digital and physical involvement of citizens during emergencies is still an open research question. In the next step, we examine the potential of citizen-generated information for situation assessment and integrating local involvement into the current work practices of emergency services.

### 3 Empirical Study

Our objective is to examine the potential of citizen-generated content from social media in situation assessment as well as of a physical involvement into current work practices of emergency services. The research question of this paper is how physical as well as digital activities of citizens can be combined and made manageable to emergency services during emergencies. We first must understand the current potentials of an integration of citizens in professional emergency response work. We therefore conducted and analyzed 42 interviews (Table 1) from 2010-2014 with different organizations involved in emergencies (members of police, fire department and regulatory authority) in Germany as well as in the European Union with a view to establishing, inter alia, the potential of citizen-initiated activities as well as citizen-generated content from social media in emergency management. The interviews (I1-24; IM-15; IS1-4) were audio recorded and later transcribed or documented (C1-11) for subsequent data analysis.

**Table 1.** Interviews (2010-2014)

Name	Title and Focus	Year	Quantity	Place
I1-24	Work Practices and IT Support	2010 - 2011	22	GER
IM1-5	Mobile Collaboration Practices	2012	5	GER
C1-11	Social Media in Emergencies	2014	11	EU
IS1-4	Citizen Involvement in Crisis	2014	4	GER
Sum:			42	

#### 3.1 Integration of Citizens into Emergency Practices

During the everyday work practices, citizens are not involved by emergency services, *“because someone [a citizen] cannot work for fire services without any qualification”* (IS03). But during large-scale or long-term emergencies the collaboration of citizens is appreciated, because activities like *“filling sandbags does not require any special training”* (IS03). In order to integrate the public, it is *“extremely important that we instruct the citizens”* (IS04), because only professional emergency services have an appropriated knowledge about the overall situation: *“What is the use of having 150 people and 50 bags or maybe nothing to do at all? I must also get an overview on the entire area of operations and the situation itself”* (IS01). Emergency services must therefore *“allow them [citizens] to act under our command, to try to convince them through conversations and to make them adapt our operational strategy”* (IS01), because otherwise citizens can hamper the official actions (IS03) or can take damage in hazardous areas, e.g. if a breach in a dam occurs (IS04). So, coordination and instructions in accordance with the organizational structure and the overall emergency management strategy is essential (IS01). In addition to those physical activities, special local knowledge and abilities (e.g. foresters, chimney sweepers) or language skills might be needed in a situation (IS01): *“There are many special things for which you need basic knowledge or foreknowledge. But there are also things for which you can make use of the knowledge and skills of citizens because it is their daily bread”* (I11).

Beside physical activities, citizens can provide and collect important information directly from the disaster's location or validate existing information to achieve situational awareness, especially in inaccessible areas and large-scale disasters such as flooding. But acquiring information from citizens only makes sense until the professional emergency services arrive (IS04). However, such citizen-generated content can differ from the actual situation on-site (IS04), because citizens "*are not very capable of assessment*" (IS03) and therefore often consciously or unconsciously mislead task forces. A validation and review on crisis-relevant information is therefore required. This can be achieved either by a number of on-site-reports or by virtual activities, like monitoring social media (IS02), e.g. giving an overview on what is going on and where people meet (IS01) or supporting the communication via social media.

### 3.2 Integration of Off-Site Citizen Activities

As already mentioned – apart from the physical activities on the ground – emergency services already have recognized the potential of social media and citizen-generated content. Especially the communication with citizens during emergencies was highlighted, which normally does not take place during everyday incidents due to time constraints (IS03) or a lack of additional value. With the help of social media data, emergency services can "*control activities and volunteers better*" (IS02). Moreover such information contains relevant information of an emergency, like "*location information, [...] which can achieve a better overview of the situation*" (IS02). But this has to be filtered (L10) to avoid incorrect and overwhelming information (L10). Problems that can occur during the communication with the public via social media were described as "*problems of understanding*" (IS04), such as different meanings or different use of specific terminologies that citizens do not understand. Furthermore information provided on-site could on the one hand "*attract nosy bystanders*" (IS03), but on the other hand "*prevent that many people will go into hazardous areas*" (IS04).

## 4 Implementation of the Monitoring System: CrowdMonitor

As our empirical study has shown, emergency services already recognized that they need support in handling citizen-generated content of social media and instructing on the ground physical civil activities. However, the current approaches<sup>5,7,16–23</sup> do not facilitate a combined assessment and management of social media and citizen-initiated activities. To proof the findings from the empirical study we argue that a support could be achieved by monitoring social media and physical civil activities. We therefore developed the system *CrowdMonitor*.

CrowdMonitor consists of two parts: (1) a web platform, described within this paper and (2) a mobile crisis application. The first is an administrative tool (Figure 1) for actors of professional emergency services with the aim of supporting situation assessment practices. The central part of CrowdMonitor is an Open Street Map, which displays all information on different layers (1). As the literature already has shown a layer-based map is an important part for situation assessment activities during

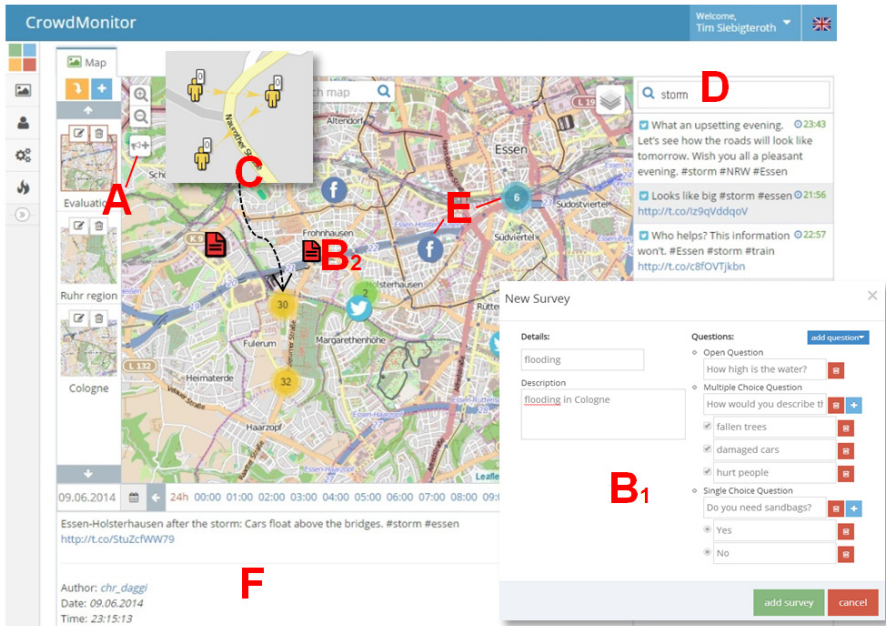


Fig. 1. CrowdMonitor

emergencies<sup>24</sup>. Besides showing different layers like hydrants or the weather, emergency services can request citizens to fulfil special kinds of tasks (A) such as information gathering or physical activities. The emergency services must therefore define a title, a description and the specific questions (B<sub>1</sub>). If a citizen enters a pre-specified location area, he gets a push notification on the mobile application to participate and help in an emergency situation by answering the survey or following official instructions. All responses are displayed on the map by time of transmission and its location (B<sub>2</sub>). In addition, CrowdMonitor collects sensor data from participants. Thus, emergency services can see e.g. movements on the platform's map (C). By assessing the locations of citizens on-site, emergency services gets a better situation overview and have the option for directly communicate with the individuals.

Beyond this, the map offers possibilities to search social media (e.g. Twitter, Facebook, Google+) by a keyword and time (D). The results of this search are automatically filtered by an algorithm that focuses on the location and content<sup>25</sup> and will be displayed on the map (E). Depending on the zoom-level, all information is clustered to provide a better situation overview. Furthermore it is possible to directly answer social media messages. All information, either social media messages or on-site reports are presented in detail within the 'detail area' (F).

Compared to the previously described approaches, CrowdMonitor embeds citizen-generated content from different sources, including various social media services as well as the important civil on-site reports. In addition, it provides different functionality of participatory and mobile crowd sensing functionality to request and instruct citizens along crisis-related activities.

## 5 Conclusion and Outlook

The work of professional emergency services has been confronted with (at least) two separate issues: The first and newly emergent issue is the appropriated handling of citizen-generated content from social media and the second a management of physical citizen-initiated on-site activities (newly coordinated through social media). Our paper contributes a mobile crowd sensing approach that focuses on both types of citizen involvement during emergencies by combining the citizens' digital as well as physical activities could support the work of professionals.

Based on our empirical work, which outlines the current intersection between citizens and professional emergency services during emergencies, we developed the web application CrowdMonitor. It facilitates the concept of mobile crowd sensing as part of crowdsourcing and provides functionality for gathering on-site movements and requesting data from the ground as well as digital social media information and therefore covers both real and virtual activities. With the help of our approach, emergency services can request information from local citizens or collect it from social media, especially in non-reachable areas, and therefore can get a first overview of a situation.

As a next step, we are looking forward to evaluate our system with several actors from the emergency services to derive first implications for its practical usage and improvements.

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