Using crowdsource information for managing climate events through the use of modern mobile technology

Philipp Hertweck[1], Tobias Hellmund[1], Désirée Hilbring[1], Hylke van der Schaaf[1], Jürgen Moßgraber[1]
[1] Fraunhofer IOSB, Fraunhoferstr.1, 76131 Karlsruhe, Germany

{philipp.hertweck; tobias.hellmund; desiree.hilbring; juergen.mossgraber; hylke.vanderschaaf}@iosb.fraunhofer.de

KEY POINTS

- *We propose a mobile application facilitating an ontology to support all participants of a climate-related crises.*
- *Semantic classification is achieved by involving the user and without requiring semantic analysis tools.*
- *Participants in the field can share and exchange information with the control centre.*
- *Using multimodal input and potent analysis modules enhance situational awareness.*
- *Additional crowdsourcing based on ontological backend offers machine-interpretable data.*

1 INTRODUCTION

The number and extend of climate related events, like floods, forest fires and heat waves is increasing [SEN15] The effective management of such a disaster is called emergency management. According to [NEH16], emergency management is a cycle consisting of four phases: Preparedness, Respond, Recover and Mitigate. Acting in these phases of a crisis is highly driven by effective information collection and dissemination [KUN06]. A decision support system (DSS) retrieves, analyses and visualizes relevant information to support a user solving complex tasks. The following part firstly presents the challenges for gathering information and secondly the challenges for communication between end users and the control centre during a natural disaster. We propose an ontology supported mobile application to enhance the capabilities of the control centre in charge while enabling the public to report machine-understandable data to the DSS, to overcome the following challenges.

A key challenge during every disaster is gathering reliable up-to-date information to improve situation awareness about the scope, extend and impact of an event. This is complicated by information overflow and the accompanying task to find the required information [NET11]. Possible information sources are static in-situ sensors placed within the affected area [POS10]. Sensors (e.g. water level sensors, video cameras, etc.) provide reliable data for specific locations and physical phenomena. Since deploying and maintaining such sensors is expensive and their availability is limited, other sources need to be considered as well. Recent work [PAL16] focused on collecting and analysing social media data (e.g. Twitter messages). While collecting social media data is comparatively easy, the information content is for computers hard to determine. Additionally, the analysis can be complex due the problem of ambiguities in text messages. Retrieving the location of the reported event is similarly complicated when no location names are present in the text or no coordinates are provided. Still, incidents, which occur during a climate event, are limited to a specific area. Effective mitigation requires the specific geographic location of the impact. With the help of the mobile application, we introduce another source of information: the citizens themselves that are affected by a natural disaster. The application enables the user to directly share their information with the authorities. Mobile devices include a variety of sensors like camera, microphone or GPS-antennas and allow people to send various types of data (such as pictures, videos, audio and text) simplifies assessing the current situation. In contrast to social media, the mobile application offers not only the possibility to deliver unstructured information (pictures, videos …), but also structured information: by choosing categories, the reported information is linked to the ontology in the back-end. Analysis components can promptly use the information without requiring any formatting. Furthermore, submitted reports will not only contain structured data but mostly important specific geographic coordinates. The mobile app gives the possibility to define the position of the incident by clicking on a map. By exploiting the existing communication infrastructure in both ways (civilians/first responders to control centre and vice versa) and the usage of an ontology, we open up a new source of information during a crisis

incident.

Several authors identified challenges in communication and communication technologies for first responder teams in action [MOß15]. Reddy et al. [RED08] identified (amongst others) the following two challenges for communication in teams during an emergency: firstly, teams working on the same incident can have heterogeneous information. Secondly, synergy effects are not used. Teams close to another are not coordinated at once, but from different centres. As a third point, Dilmaghani [DIL10] identifies incompatibility of technical hardware as a problem: first responders using incompatible communication tools cannot communicate effectively. We address these challenges with the ontology supported mobile application. We improve the first and third drawbacks as follows: different teams from different organizations can use the mobile application to exchange information. Since we use platform independent web technology, our mobile application supports various smartphone platforms. This allows users to apply their existing equipment and to have contact to the same control centre. All first responders can use one standardized communication channel, which – dependant on the applied role – delivers all necessary information. Regarding the second challenge, we see the following advantages of our mobile app: since users connect to a common source of information, they have access to the same knowledge base. Reports coming from first responders are stored in the knowledge base, which makes this information explicitly available for all upcoming requests. The ontology can give information about nearby teams or similar coherencies to suggest close teams or nearby incidents. Additionally, the ontology uses a standardized vocabulary. Therefore, every message sent out uses a specific wording, known to all participants.

To address all these challenges in involving citizens as well as first responders during a climate event, we designed and developed a mobile application covering the three aspects information retrieval, task management and alerting in an integrated and uniform way.

2 RELATED WORK

The wide availability of smart phones and the omnipresent connection to the internet offers a large variety to inform the public. Many mobile applications for disasters like NINA[1] or KATWARN[2] make use of the possibility to reach out to people filtered on their location or preferences about regions they want to be informed about ([KAR014], [REU17]). However, reviewing existing applications and literature showed that there is currently no mobile application available covering the whole cycle of managing a climate event for both civilians and first responders. Moreover, the communication of existing applications is one-directional: since information is only intended to be sent from the control-centre to the user, civilians or first responders cannot sent in reports.

Crowdsourcing is no new practice for providing information and researched by several authors ([LIU16], [XU016], [PAL16]). However, the combination of a mobile application with an ontological back-end for crowdsourcing with the goal to provide machine understandable data is rather less considered.

3 INTEGRATION INTO A DECISION SUPPORT SYSTEM

The plain usage of an isolated mobile application is not sufficient, especially when addressing different aspects during climate event managing. The full benefits come in effect by integrating the mobile application as module into a decision support system. An architecture for such a DSS is proposed by Moßgraber [MOß16]. In the design of the mobile application at hand, an ontological backend is used to share the information with a DSS. The solution at hand provides a technological back-end whose interface bases on the previously mentioned ontology. This interface channelizes data sent to or coming from the mobile application. Through this approach, standardized information is exchanged and subsequent modules only receive processable data. This facilitates the integration into a DSS.

The ontology consists of three parts, each focusing on one specific task: reporting, task management and alerting. The interface for reporting commits two types of information: the first part contains concepts like

[1] https://www.bbk.bund.de/DE/NINA/Warn-App_NINA.html
[2] https://www.katwarn.de/

description, location, timestamp and attached media. The second part contains the user's specifications about the report he or she wants to send in, for example what category this report is, what type of incident shall be reported (fire, flood, heat) and what the quantification of the observation is. By using this approach, we allow users to send two kinds of information. On the one hand, the report can contain different formats (picture, video, audio, text). This offers an easy way to capture the current situation. Still, further analysis and clustering of the sent media is necessary to prevent an information overflow to decision makers. On the other hand, the sent reports can be annotated with category, type and quantification information (e.g. category "Flood", type "Water level report", quantification "5m") allowing the further usage without the drawback of uncertainty due to analysis components. However, since smartphones can provide accurate information about the geographic location, the application is also able to provide specific coordinates of where the report comes from and where the incident is.

To ease the integration of first responder task management, the proposed ontology contains concepts to model roles and task assignments. The role concept defines which type of user uses the app. Hence, the mobile app can display information, which is relevant for a civilian or a first responder. If the role is set to "civilian", there is no further differentiation and only civilian-relevant information will be displayed. In contrast, for first responders, there is a further differentiation regarding the level of authority. Information for a team leader might not be of interest for a team member etc. Additionally, distinguishing between organisations is possible: information relevant for an organization in the field of medicine is not relevant for an organization providing technical support etc. Through efficient role modelling the communication channel of uninvolved organizations will not be flooded.

The third part, which needs to be considered in integrating the mobile application into a DSS are public alerts. Extensibility is a main goal of this implementation. Therefore, the Common Alerting Protocol CAP is used to receive public alerts [OAS10]. CAP is a format for exchanging general hazard-related emergency messages and public warnings. It guarantees consistency of a warning message that is simultaneously spread over different warnings systems. The CAP elements have equivalents in our proposed ontology facilitating the integration into other DSSs, which support the CAP standard. During a crisis, some information might be communicated to the public. This can be an informative message with low priority (e.g. "Do not park cars in areas close to the river") or important instructions like evacuation orders. Common channels to distribute this information are sirens, radio, TV or social media. A drawback of all these is that recipients cannot be specified based on fine-grained locations. This can be overcome by using the integrated localization functionality of mobile devices to regulate the distribution of messages.

4 EVALUATION

Reviewing existing applications and literature showed that there is currently no mobile application available covering the whole cycle of managing a climate event for both civilians and first responders. We propose an ontology supported mobile application that helps gathering information during the pre-emergency phase, coordinating the information retrieval during a disaster as well as reaching the public with warnings and additional information. First responders can be coordinated through one common channel mitigating well-known challenges during emergency communication. During the design phase, we orientated ourselves on the CAP standard rewarding the proposed system with reusability and flexibility considering the integration into different DSSs.

The design and development of this mobile application is part of the EU-founded project beAWARE[3] (Enhancing decision support and management services in extreme weather climate events). In this project, domain experts were involved from the beginning. This ensured real world requirements based on professional expertise as well as continuous feedback on the implementation of the mobile application. The result is a highly end-user oriented system. In the context of this project, further evaluations will take place in combination with the complete DSS of beAWARE. This includes three large pilots regarding different climate events (flood, forest fire and heat wave). During this process, the participants will use the mobile application for sending reports about the ongoing situation, receiving task and public alerts. We expect further insights in the ability

[3] http://beaware-project.eu

of our approach in combination with a DSS.

5 CONCLUSION

Information and communication during a natural disaster are critical elements. These concerns affect civilians, as well as the first responders in the field. With the ontology-supported mobile application, we propose a possibility to satisfy the need for information and coordination of these two parties. The presented solutions can prevent communication errors and simplify the exchange of information. By enabling citizens to use modern technologies to collect machine processable data about the ongoing situation, situational awareness is enhanced. The ontology makes information available to whom it concerns and opens up a new way of gathering structured information from mobile applications.

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