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Please answer the following.

- **Title of Paper**: Geographical Information System Supporting Data Gathering and Fast Decision Making in Emergencies Situations
- **Track**. Geographic Information Science and Technology (GIS&T) for Crisis Response and Management
- **Type of paper**. Work in progress.
- **Contribution of the paper**. Create a platform which allows real-time registration from different field agents during their evaluations enabling data upload combining mobile devices (phones and tablets) and telecommunication network (or Wi-Fi) technologies. This platform also allows teams to build customizable forms for different information classes (i.e. landslide assessment, rescued person, blocked road) and still possibility to attach images, videos, other files related to each inspection. All incoming data is stored into a web database available for a real-time coordinators evaluation wherever they are (sometimes over a thousand of miles away from disaster area).

GIS Supporting Data Gathering and Fast Decision Making in Emergencies Situations

Tiago Badre Marino
Programa de Pós Graduação em Informática
Departamento de Ciência da Computação
Universidade Federal do Rio de Janeiro, Brasil
tiagomarino@ufrj.br

Bruno Santos do Nascimento
Programa de Pós Graduação em Informática
Departamento de Ciência da Computação
Universidade Federal do Rio de Janeiro, Brasil
bruno.nascimento@ufrj.br

Marcos R. S. Borges
Programa de Pós Graduação em Informática
Departamento de Ciência da Computação
Universidade Federal do Rio de Janeiro, Brasil
mborges@nce.ufrj.br

ABSTRACT

This proposal rises from the Center for Disasters Scientific Support experience over eleven years supporting over a hundred disasters in Latin America. It also presents a case study applied to landslides assessments in Teresópolis (Brazil) city, when all field-generated knowledge was still registered in paper and later, at the base station, uploaded to database and finally available for managers evaluation and decision. The proposed methodology creates a platform (still under development) which allows online registration from different field agents during their evaluations enabling data upload combining mobile devices and telecommunication network (or Wi-Fi) technologies. Teams can also customize forms for different information classes (i.e. landslide assessment, rescued person, blocked road) and still retain the possibility to attach images, videos, other files related to each inspection. Incoming data are stored into a web database available for a real-time coordinators evaluation wherever they are (sometimes over a thousand of miles away from disaster area).

Keywords

Geographical Information System, GIS, mobile devices, mobile networks, emergency management, field assessments, data sharing.

INTRODUCTION

Information is the most valuable resource during emergencies or disasters. It is the basis for coordination and decision making during the emergency response. It is an essential aspect of an organization's ability for gaining (or losing) visibility and credibility and has a powerful impact on how national and international resources are mobilized. Above all, information is necessary for providing rapid and effective assistance to those affected by a disaster. It is also essential for after-actions analysis, evaluation, and lessons learned.

An emergency response activity usually involves several teams from different organizations working cooperatively for the purpose of saving lives or properties. These teams have to make many decisions under time pressure to accomplish their goals. Most decisions require contextual knowledge coming from the emergency settings, including those which report the activities of other emergency teams.

Diniz et al. (2005) introduced a conceptual map (Figure 1) that organizes three types of knowledge that the command team, designated to manage an emergency, uses for decision making and for directing field team operations. These decisions are based on combinations of three kinds of knowledge: the previous (Personal and Formal) knowledge and the current contextual knowledge. The latter represents information generated during the emergency evolution process. Situation assessment performed by field agents, including information about victims and damages, orders issued by the command and their effects are examples of current contextual knowledge. When this information is combined with previous knowledge it builds what is called "Combined Knowledge" in the diagram of Figure 1, which helps the command decision-making. This knowledge is very dynamic. It changes all the time and therefore it has to be constantly updated. Most updates come from field agents, but it can also be enriched by voluntary workers, directly involved in the emergency or not.

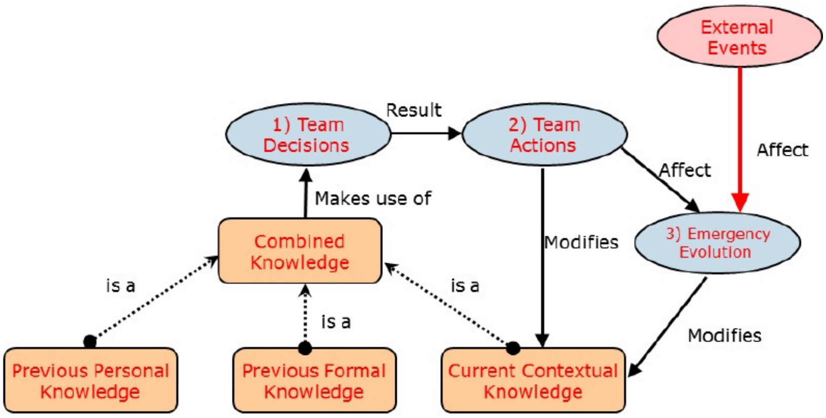

Figure 1. Conceptual map of knowledge support during an emergency response phase (Diniz et al., 2005)

From a typical example of evolution from a Previous Personal Knowledge as case study of Teresópolis-RJ (Brazil) (2011). This work proposes creating a platform (still under development) which allows online registration from different field agents during their evaluations enabling data upload combining mobile devices and telecommunication network (or Wi-Fi) technologies. For this, our proposal also was based on work of (Lima, 2011) about Relative Rapid Landslides Analysis methodology, and also on recommendations identified by (Marrella et al., 2011) which has investigated the use of mobile devices for supporting emergency operators, through the provision of collaborative features, geo-collaboration and mobile internetworking.

Although exists other initiatives to address this problem (such as ESRI ArcGIS™ for Mobile - http://www.esri.com/software/arcgis/about/mobile-gis-for-you.html), this methodology adopt open source solutions, free of charge (unlike commercial applications), fully customized to the need for disaster service, being built and improved by specific demands from people who faces different disasters situations over years of experience. The platform for data gathering from mobile devices presented in the methodology is still under development. However, Manager Data Visualization (Figure 3.C) is already working but also still need modifications for mobile devices data reception in real-time.

MOTIVATION FROM CASE STUDY

The case study presents a real situation experienced during routine activities of slipped areas assessments where the collected data must be recorded as well as multimedia for later organized into a Geographical Information System (GIS) - VICON - Vigilance and Control – http://www.viconsaga.com.br. From the difficulties found during this process, the group has identified the opportunity to enhance the process through adoption of information technology during data gathering activities.

The group of the Center for Scientific Support in Disasters – CENACID (http://www.cenacid.ufpr.br), of the Federal University of Paraná – UFPR, has been supporting the response in almost all the most significant disasters related with landslides in Brazil since the year 2000 and has developed a new approach to face the challenge of fast evaluation of risk in these events. This new approach is proposed as a tool to rapid and systematic evaluation of groups of landslides, which we call "landslides systems". This methodology is called "Relative Rapid Landslides Analysis" (Lima, 2011) and is based on five different risk indicators if the potential mass movement happens: a) phase of the dangerous process; b) possible volume of the expected mass movement; c) velocity and distance to be reached; d) probable impact; e) factors of aggravation. Each one is estimated from one to five based on experience, judgment and the observation of the similar landslides in the system. The sum of these values results in the index of relative landslide risk of the area. This relative evaluation allows authorities to prioritize immediate response to the most dangerous landslides systems in each situation and facilitates to develop emergency actions including actions to prevent the continuity of the movements, to monitor the evolution of the landslides, to select systems to perform detailed studies or even to evacuate the people.

However, all gathered data originated from assessments along a field journey are still registered in handwritten forms as well as site images and videos, stored in digital cameras. When agents arrive at the base station, they still must join, validate, upload all collected data (forms, images, videos) after a tiring workday. Several times, during one journey, dozens of locations are visited and evaluated generating a large amount of data, which often make the data upload process more difficult, at the end of the day. When agents work on the field many pictures and videos are generated and many papers are used as drafts. Much of the produced material can be discarded due to duplicate or bad quality photos, or even by lack of relevance. All this bulk data contributes to increase complexity in the upload task. Often, after a grueling workday, the agent looks at the pictures taken by himself, that same day and cannot identify from which location that was taken. The site incursions get agents too busy that is almost impossible to take notes about each photo in order not to get lost later.

Over many experienced missions and repeatedly facing this kind of problem, we realized the opportunity of speeding up this process through the use of mobile devices. The following section will present each phase of the proposed methodology, showing the sequence of events and procedures since the field inspection, all screening data until it is available to the coordinator, so that, even remotely, it would be possible analyze and take decisions in real time.

(a) (b)

Figure 2. Landslides assessment by CENACID members in Teresópolis - Brazil (2011) and Data Gathering Platform (under development) (b)

METHODOLOGY

The proposed methodology combines Geographic Information Systems (GIS), telecommunications networks and mobile devices aiming to enhance the process from data acquisition by field teams, organization and presentation for remote coordinators. Figure 3 shows an illustrative diagram presenting the architecture components and processes involved. Each step of the process (A, B, C, D) is detailed in the following sections.

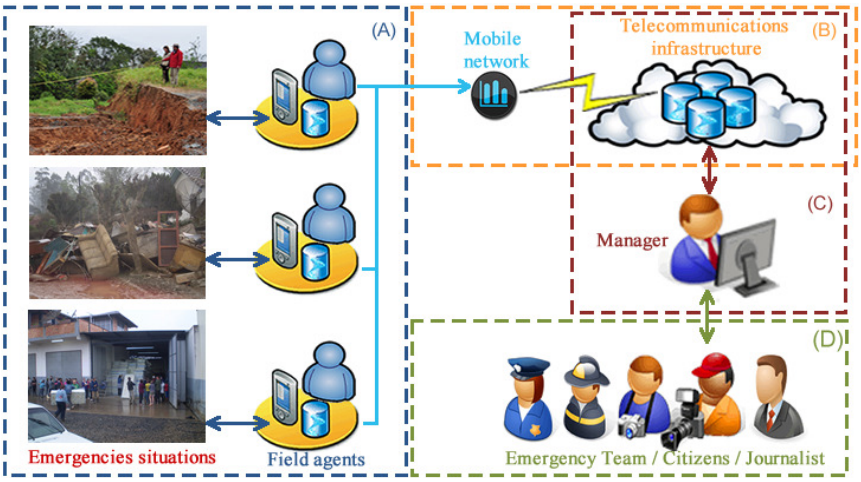

Figure 3. Components and processes from methodology architecture

A. Field Data Collecting Platform

During the disaster response several field teams work on different fronts (technical, medical, rescue, basic infrastructure reconstruction), applying their previous personal knowledge (geologists, engineers, etc.) combined with the “Current Contextual Knowledge” (acquired from site surveys), producing technical reports resulting from the combination of knowledge which results in the “Combined knowledge” (Diniz et al., 2005). The data acquisition phase is usually composed of a written report as well as multimedia content such as photos and videos portraying the local scene.

A major problem facing a large number of surveys in a short period of time is related to the organization of all generated data. The mobile device solution rises at this stage as an organizer for all that generated information. The platform has a data input module designed for smartphones and tablets, checking the location coordinates from it GPS sensor, and also uses integrated digital camera to acquire images and videos. It should be remembered that all surveys are completed based on standard forms, predefined by each working group, fully customizable, in order to standardize each kind of inspection and increase data analysis capacity by remote coordinators. All data is stored in the device database. If there telecommunications network is available at the time, agents can upload data to the server database, hosted on the Internet and then available online to remote coordinators, wherever they are.

B. Field Data Transmission

Today, concerns about the mobile network availability and coverage, especially in disaster situations has decreased as Internet and telecommunications infrastructure have been treated as primordial for the population. Corroborated by some mission experiences, it appears that increasingly this service has been reestablished thereupon occurrence of catastrophic events. This is the basis for intercommunication between the affected people and also the professionals involved in the disaster response. During a rapid response mission for the earthquake occurred in January 2010 in Port au Prince, Haiti, which resulted in the deaths of more than 200,000 people, a few hours after the incident communications services were re-established by the national telephony company, reinforced by United Nations Disaster Assessment and Coordination (UNDAC) telecommunication support cluster.

Thus, because it is a platform-dependent telecommunications service, this is no longer seen as a critical factor for the mobile data collecting platform operation. Moreover, even if it occurs, the device is completely capable of storing all data in an internal database, ready for upload as soon as connection is available again. Even in the worst case, when telecommunication is not available, data can be transferred through cable from the mobile device to a desktop.

C. Manager Data Visualization

Emergency management processes are highly time-critical and response activities must be defined and performed quickly and efficiently. The figure "Manager" in this case is a composition from highly experienced professionals, commanders and public administrators, working in emergency management offices.

Coordinators usually operate and take decisions remotely managing all kinds of information available. Databases organize all this information coming from multiple sources in real time and can be spatially visualized and analyzed using Geographic Information Systems (GIS). As the agents submit new information in real time, new points (or areas) of information emerge in the Management System in real-time. Each piece of information is grouped by type (evaluation of sliding, search and rescue,...) and standardized through predefined forms, providing filtered queries performed from search criteria.

For example, from assessments that adopt the methodology Relative Rapid Landslides Analysis (Lima, 2011), presented the case study, if Coordinator wish to retrieve the most critical areas for landslides, can perform a filtered search for "all evaluations that had total sum between 20 and 25 points" (Figure 4). Recalling Lima, 2011, scale ranges from between 0 (lowest risk) to 25 (highest risk). The result retrieves only the most critical areas, according to the proposed evaluation criteria. Thus, the coordinator transforms the collected data into useful information for decision making, prioritizing interventions in places. Figure 4 depicts the Geographic Information Systems with field information available on the coordination segment. Reports and maps can be generated for spatial analysis proceedings by any other analysis tools.

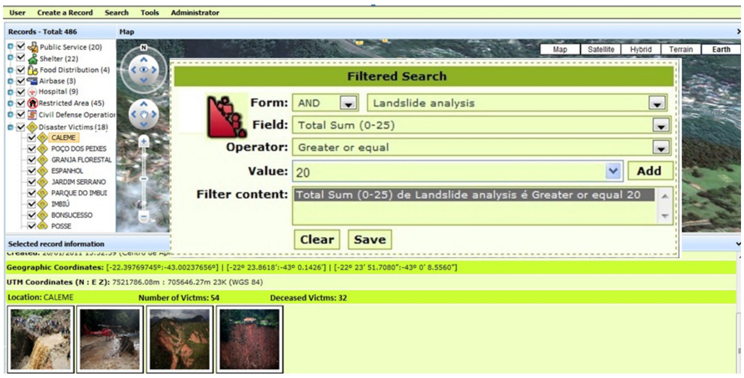

Figure 4. Information relating to disaster classified and available in real time on a Geographic Information System for coordination segment

D. Manager Decisions

Citizens and "Emergency Teams" consume information, logically organized and certified, from the manager. After compilation of all data, the manager command can evaluate the situation and prioritize immediately response to the most dangerous cases in each situation and facilitates to develop emergency actions. They direct the Emergency Teams, Citizens and Journalist to support them with useful information in order to reduce the response emergence time, leading to a more effective work.

CONCLUSIONS AND FURTHER WORK

This work-in-progress proposes creating a mobile platform (still under development) which allows online registration from different field agents during their evaluations. The idea is that agents can also customize forms for different information classes (i.e. landslide assessment, rescued person, blocked road) and still retain the possibility to attach images, videos, other files related to each inspection. Incoming data are stored into a web database available for a real-time coordinators evaluation wherever they are (sometimes over a thousand of miles away from disaster area).

According to (Marrella et al., 2011), the use of mobile devices and applications in these scenarios is very valuable as they can improve collaboration, coordination, and communication among team members. Most of the tasks are highly critical and time demanding, e.g., saving minutes could result in saving people's life.

Although the platform depends on telecommunications network availability, considering the importance of such infrastructure for a community increasingly, this is not a critical point for the proper functioning of the methodology even under catastrophic situations. Nevertheless, even in the absence of network infrastructure, the platform implements a mitigation plan for these extreme cases, storing the collected data in a database within the device itself.

Considering increment of social networks popularity like Twitter and Facebook, the next efforts are intended to integrate the system manager, a new information layer that is collaborative information coming from ordinary people, classified, according to (Diniz et al., 2005), as "Current Contextual Knowledge". The Twitter, for instance, is used by many people as a direct channel of information. Some government agencies (e.g. traffic department) are using this channel for promoting almost in real time the latest events happening in the city. However, the challenge today, in all kinds of social networks, is how to separate the true from fake information.

By the way, due to the growth of interoperability afforded by the Linked Open Data (LOD), official government departments should enrich the "Previous Formal Knowledge" base for decision making**.** In case of government information, coming directly from its own public channels, for example, websites, main concerns are not about validating the data veracity. In this case, the challenge is the creation of a common protocol to be applied to all government sectors. A solution to this problem would allow changing information without generating inconsistencies. The growth of e-government programs is rapidly growing the volume of data available for citizens, although, data and access heterogeneity creates difficulty for their integration, as detailed in (Kelly et al., 2011).

Finally, efforts can be made in order to allow distributed sensors data upload remotely transmitted in real time, for any phenomenon of interest monitoring, for example, the evolution of an erosive process through distance sensors, level of rivers, rainfall, all these can be collected through sensors, today increasingly cheap and easy to be implemented, generating time series and enriching the knowledge base for decision making.

This paper presented a set of suggestions for future research activities (e.g., sensors data, social network collaborative information) and lessons learned to be taken into account when designing mobile applications for first responders supporting their collaboration.

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