Enriching Disaster Control Management based on Human-Centered Design

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ABSTRACT

Hurricanes or earthquakes reveal the increasing importance of the research in disaster control management, which is essential to coordinate the amount of rescue activities. The German Federal Agency for Technical Relief is responsible for tasks like coordination, high capacity pumping and infrastructure. To support them in their management process and to improve the efficiency and the effectiveness in their workflow, we built an interactive table and established a human-centered design process to understand the context of use and to create a system out of the users' perspective. In this paper we present further scenarios as a result of the second iteration in performing human-centered design methods together with experts in the domain. We show that methods like ethnography studies, task analyses or workshops are suitable and essential in this context and arise in helpful tools that support the experts with additional information in case of decisions.

Keywords

Human-centered design, user needs, disaster control management, THW, mobile devices.

INTRODUCTION

New available technologies are often the trigger for the development of new and innovative products. At the same time, the focus on identifying reasonable scenarios from the early stage is lost. However, talking at first to the users about their needs will increase their efficiency, effectiveness and satisfaction while using new technologies. Especially in the field of disaster control management (DCM) this is significant in order to support the helpers in their time critical and stressful tasks with useful tools.

In the research area of DCM some studies are available (Kobayashi, Kakizaki, Narita, Hirano and Kase, 2007; de Vries, 2009), which address collaboration and coordination by using innovative information technology. However, only little effort has been spent taking real-life workflows from disaster control organizations (e.g., fire departments, police, medical services) into account for the design of new systems. Traditional materials like pens, paper sheets, paper-based maps and plastic labels are well proven – even children are able to interact with these materials during the kindergarten – and failsafe in the fact that they do not need any power supply. Therefore, the use of new technologies is often rare in this area. Nevertheless, the idea of using interactive displays for disaster control training seems to be very promising (Kobayashi et al., 2007).
De Vries (2009) introduces some ideas on how multitouch can be an effective assistance for decision making in case of a disaster. It has been investigated in which emergency services departments interactive displays could be used and which workflows could or could not be mapped. According to this study, also less IT-experienced people could use interactive tables without much learning effort. The test persons have even managed to collaborate on such devices. However, there is much more potential in the system design that could have been addressed by integrating the users into the design process right from the beginning.

An established methodology in the software development is human-centered design. In the process, the focus lies on the users of a future system. The aim is to create solutions that match the users' needs, their requirements as well as to support their tasks and goals. The advantages for the users are extensive and lasting and include improved productivity, quality of work and user satisfaction (Jokela, 2001). One of the central quality attributes for interactive systems is their usability (Bevan, 1999). The main standardization organizations (IEEE and ISO) have addressed this parameter for a long time (Granollers, Lorès and Perdrix, 2002). Especially for tasks that are highly time-critical, e.g., DCM, interfaces are required that are controllable and easy to understand.

Being interested in doing research on innovative technologies, we built our own interactive table – called the 'useTable'. This interactive table consists of a 55-inch display that offers a full HD (high definition) resolution using a projector and two mirrors mounted beneath the table surface.

As we have already shown (Nebe, Klompmaker, Jung and Fischer, 2011), innovative technologies like interactive tables and the included natural interaction techniques (multitouch, tangibles objects, digital pens) can enrich the coordination and management tasks in a crisis.

Hence, after describing our human-centered design process and the used methods, we will shortly reflect the overall workflow and improvements of our cooperation partner the German Federal Agency for Technical Relief (THW, German: Technisches Hilfswerk). Resulting on the next step of iteration, we will then present further achievements in DCM including mobile devices.

METHODS

In order to create usable solutions we established a human-centered design process compliant with ISO 9241-210 (see Figure 1) and involved our users from the THW right from the start. Human-centered design provides different methods applicable at different stages of the development of interactive systems. Due to contextual and behavioral analysis (in terms of interviews, site-visits, etc.), for example, the users requirements, needs and habits can be gathered. In addition it is important to know the user's environment and to perform user-tests in order to prove that the solution fits the user's needs.

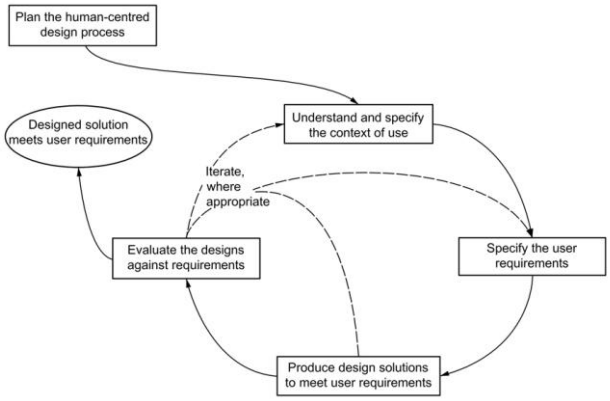

Figure 1. Human-centered design for interactive systems (ISO 9241-210)

Understand and Specify the Context of Use

A key goal was to ensure that the scenario exploited the technology in a meaningful way. To this end, we started the process with an initial workshop with some domain experts of the THW in order to get first ideas. We received important insights about the workflow, rules and regulations the THW staff has to follow. After the decision that it is a meaningful field for exploration, we formulated user requirements and created some sketches that we thought would fit the needs and habits of the THW staff. With this input we established a further meeting in order to evaluate the ideas with the users and to receive more detailed information. After that, we conducted an ethnographic study of the behavior and abilities of the emergency workers in a real-life full day practice. We observed the involved people and analyzed their workflows in detail. Having video cameras and microphones installed in the operation command and communication center, the interaction and communication had been recorded.

Specify the User Requirements

Back in the laboratory, we reviewed our observations and recordings and drew up detailed workflows of every involved person having a specific role. Based on this context of use description and the identified users' needs, we formulated user requirements and developed models for all supported core tasks.

Produce Design Solutions

All our information, requirements and workflows were than transferred into a first software prototype. Thereby, we also investigated in advanced interaction techniques and enriched the multitouch functionality of our

useTable with tangible and pen-based interaction (Nebe et al., 2011) as well as with depth cameras for using arbitrary surfaces and arbitrary objects (Klompmaker, Nebe and Fast, 2012).

Evaluate the Design Against Requirements

Together with our project partner, we did a first evaluation where the representatives from the THW had a closer look on the software and gave recommendations for the next software version and for some minor hardware modifications.

Currently, we still iterate the human-centered design lifecycle and gather further information, ideas and improve the whole scenario. We also had many presentations and discussions with representatives of other DCM organizations, e.g., police, firemen, medical services, which were interested in the scenarios and gave us additional input for inter-organizational DCM. Recently, we had our third on-site practice observation at the THW and focused on software support for further tools for planning and decision support. The next section focuses on the formerly built software and the scenarios we are currently adding as an outcome of the observation, workshops and comments with and from the users. .

SCENARIOS

Corresponding to our on-site observations and a context analysis, the useTable and the THW application were designed to support situation planning. The THW division in our project cooperation mainly operates in the field of situation managing, water supply and the handling of flooding. People, vehicles, pumps and materials have to be allocated. Preparing also infrastructures for communication and supply, the tasks of coordination and communication are the most important ones. Analyzing the user requirements, it was possible to translate parts of the existing workflow into software. In the current approach an emergency situation is represented on paper-based maps on a so-called ‘situation wall’ or ‘situation table’. This approach allows the emergency personnel to perform many tasks, for example to identify and mark flooded and inaccessible areas and damaged infrastructure, to draw up so-called ‘damage accounts’ (descriptions and allocations of damages and units), associated with particular points, or areas on the map, and to send emergency intervention units to the locations concerned. These units provide an overview of the situation with their reports and are the only ‘eye’ of the operation command and communication center.

To ensure that the technology meet the user requirements based on the context of use analysis, these and other work practices were implemented on the useTable exploiting the technological possibilities it has to offer, e.g., multitouch, tangible interaction or pen-based interaction. Hence, it is possible to create and manipulate damage accounts with finger and pen input to place the accounts on a digital map and to enrich them with further information (e.g., information on emergency intervention units and contact details; see Figure 2). To improve efficiency, the system can handle different kinds of maps while keeping the data geo-referenced for the whole mission. Giving an example, replacing a road map by a topographical map can sometimes be helpful in order to predict the propagation of a flooding. In addition, the expert of the THW has the task to calculate the amount of pumps and holes to transport water based on many parameters (e.g., pressure, altitude). In our observation they used a pen, a calculator and topographical maps, which takes some time. Using pen-based interaction, the expert is enabled to simply draw the way of holes on the digital table and the software calculates the position and amount of pumps. For further detailed information of the previous state of the scenario, see (Nebe et al., 2011).

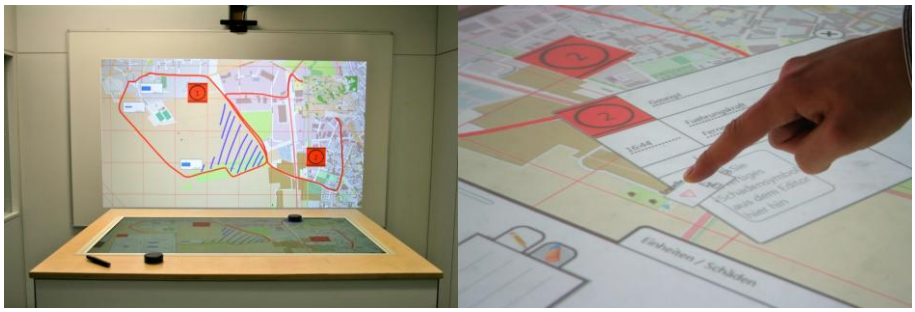

Figure 2. Setup of the useTable (left); Enriching damage accounts with further information, e.g., using drag&drop (right)

Situation Overview Using Mobile Devices

As mentioned previously, the THW staff in the operation command and communication center work in total 'blindness'. That means the only information they get about the current situation is based on their own radio communication and the communication with possible other DCM organizations.

Many people own a smartphone with a digital camera and a global positioning system (GPS) inside. Having that comments from the users in mind, we drawn up the scenario that every member of the THW units in the field is able to use a smartphone to take a picture of the situation and to send it via mobile radio communication to the operation command center. There, it can be displayed geo-referenced on the interactive table and will provide a better and more realistic overview for the staff working on the planning process. In addition, the units in the field can also add damages to a damage account with their smartphones. Using smartphones or car PCs (small computers for installation in cars) the other way around, it is also possible to send information from the operation command center to the units in the field. For example, the units can receive orders for new activities or routing information in case that the current route is blocked due to a destroyed bridge after an earthquake. Impassable routes that are not registered yet, can be reported to the operation command center. Hence, the information will enrich the further planning and the operation command center can inform other units.
Using these possibilities, which are already available, like the own human resources with their mobile devices, can enrich the process of data gathering to create an overview of the current situation.

Flying Cameras and Overview of Injured People

Further on, the users state that real bird's-eye view pictures and also positions of injured people would be valuable. Therefore, we cooperate with the funded research project 'SOGRO Sofortrettung bei Großunfällen' (en.: 'rapid help during mass casualty incidents') (Niemeyer and Stern, 2009)..
The SOGRO project focus an optimized first care provided to casualties and to collect and aggregate comprehensive information on the emergency site. There are two interesting points for our work with the THW. First, injured people during a mass casualty incident (MCI) will be classified in terms of the severity of their injuries they have sustained, forming a first idea of the treatment they will need. In the SOGRO project this so-called triage had been improved using hand-held computers and radio-frequency identification **(**RFID) tagged wristbands. The hand-held computer is used to record a patient with its health status, eventually treatments and the location he was found. This information is saved on the wristband and is simultaneously transmitted to the emergency control room to organize the transportation to the hospital. According to our scenario, the THW may be responsible to ensure passable access roads in case of an earthquake or a tsunami and to organize the operation of their salvage teams with their sniffer-dogs. The data about the injured people and their position will improve the efficiency in the planning process. Therefore, we established a connection between the SOGRO project and the THW software application to get the positions and injury states of found people and to visualize them on the interactive table (see Figure 3).
Second, another part of the SOGRO project deals with flying drones to capture images of the emergency site, which will be merged into a map and will be analyzed with image recognition algorithms, e.g., to find injured people. As we mentioned previously, such an up-to-date bird's-eye view displayed on the interactive table will increase the efficiency of the planning workflow because the THW staff does not have to wait on and evaluate radio communication messages.

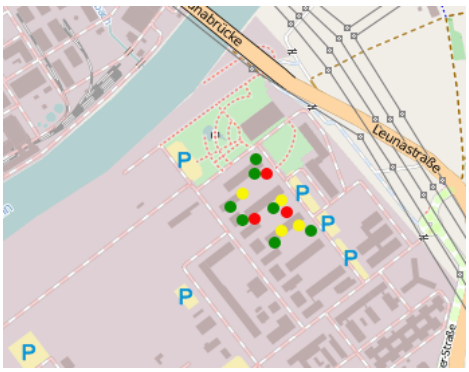

Figure 3. Visualized positions and states of injured people

CONCLUSION

All these developed scenarios are an outcome of our human-centered design process. Together with the users – the staff of the THW – and their needs, we finally were able to formulate further user requirements and to realize them in design solutions. The users are the experts in their domain. Hence, listening carefully to their ideas and needs will enrich every software or product and will create further innovations..

We have shown in this paper that human-centered design is a powerful methodology to define meaningful scenarios for the field of disaster control management. Technology is often the trigger for the development of new systems and thereby it is essential to understand the context of use, the system is built for, in order to ensure its consistency in the market and the satisfaction of the end-users.
Performing ethnography studies, task analyses and workshops with the staff of the THW enabled us to understand and improve their workflow, which results in a better efficiency and effectiveness.

According to ISO 9241-210, the next step will be to evaluate these solutions with the domain experts of the THW and to integrate their feedback in the next iteration of the development process. Until now, our project partners provided positive feedback and used the results to learn more about and rethink their own process. Additionally, new possibilities to support the process of decision-making had been identified, (e.g., the tool for water pumps calculation) which especially arose from ideas of the domain experts. According to their expertise, such a tool decreases the time of performing the calculation from 20 minutes to 20 seconds. In addition, calculations are more precise and the remaining amount of pumps and hoses can be used on further critical places. Nevertheless, the whole system and the new scenarios have not been evaluated in an on-site practice so far and the measured impact of applying human-centered design is based on estimations of the users.

Further steps will include the evaluation during an on-site practice and the ongoing investigation in the field of natural user interfaces and tangible interaction.

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