Designing for the User: Tailoring a Simulation Software Interface to the Needs of Crisis Managers

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ABSTRACT

This paper presents the development and evaluation for a graphical user interface (GUI) of a simulation tool in crisis management, which follows a User-Centered Design (UCD) approach. UCD places the focus of the development on the needs, abilities and the background of end users, by passing iteratively through four development phases: (1) the analysis of the end users' personal background and work context; (2) the specification of requirements; (3) the design of the system; and (4) the final evaluation of the design with end users. This approach is particularly suited for crisis management systems, since their efficient usage has profound impacts on the execution of crisis response actions, and in turn on the well-being of citizens. Our work gives valuable insights into the characteristics and the working environment of crisis management practitioners. Furthermore, it sheds light on the design issues which should be taken into account when developing GUIs in crisis management.

Keywords

Warning, Simulation, Crisis Management, User-Centered Design

INTRODUCTION

The design of software applications for crisis response and management is a challenging task. Crisis management software systems support important work processes and decisions, which have a huge impact on the handling of a crisis situation and, as a direct consequence, on the population. In order to be able to best respond to crisis situations, it is crucial to include citizens' characteristics and behaviors into decision making processes, and at the same time to provide a tool that matches the needs and working practices of decision makers.

Within the project Alert4All, we are developing a simulation tool for supporting regional decision making in crisis warning and alerting up to the European level, with a special focus on its graphical user interface (GUI). The GUI presents and visualizes results of an agent-based simulation (Engelbach, Kluckner & Kurowski, 2011). The underlying model takes several characteristics of citizens into account, such as their cultural background or their experience with a specific incident, as well as warning and alerting channels and incident specific parameters. The final goal of the simulation tool is to help decision makers to estimate and analyze the dissemination of warning messages when using a mixture of warning and alerting channels.

However, such a tool can only develop its full potential if end users (in our case the staff of crisis warning, response and planning organizations) can efficiently use it. One approach for developing software that supports its potential end users efficiently is User-Centered Design (UCD), which strongly integrates the needs, abilities and the background of users into the software development process (DIN, 2010). This approach has been applied in the development and design of computer systems and applications in a variety of fields, from applications for health care (e.g., Johnson, Johnson & Zhang, 2005) to the design of information systems in crisis management. For example, Lindgaard et al. created a public health crisis management system with the

UCD methodology (Lindgaard et al., 2010). However, applying UCD to design, specify and implement a crisis management simulation has rarely been done before. Sautter et al. describe their plan to leverage UCD for designing an integrated crisis management simulation (Sautter, Engelbach & Frings, 2012), but have not yet published results. Complementary to their approach, we want to promote a shift from a technical oriented to a more user-centered software development process for crisis management systems.

Our main guiding question was how a simulation tool for supporting crisis management can be designed so that it provides all the needed functionality, yet has an interface that is easy to understand and can be used efficiently by the respective end users. The presented work gives answers to this question and presents valuable insights into the characteristics, needs and the working environment of users working in crisis management.

METHODS

For the development of the tool, we adopted the UCD approach by passing iteratively through four development phases: context analysis, requirements specification, design and evaluation (DIN, 2010). In the following section, we briefly explain these phases and how we applied them.

In order to get an overall picture of the potential end users (planning responsibles such as emergency and crisis managers, system operators in support to incident commanders, and staff from command and control centers) and their working environment, we conducted a **context analysis** that helps to specify design and usability requirements the tool should meet (Thomas & Bevan, 1996). In qualitative interviews and workshops with staff from crisis management (5 males, ages 30 to 60, 2 administrative and 3 operative staff) and relief agencies in Europe, we gathered information about the end users' characteristics, their organizational, technical and physical working environment, as well as their tasks (Beu, 2003). In the **requirements specification** phase, use cases and overall requirements for the tool were derived from the results of the context analysis. Each issue from the context analysis was transformed into a specific qualitative requirement. These were prioritized according to the specific context of use and to the limits for design and implementation. On the basis of the mandatory requirements, we **designed** a prototype of the GUI in form of paper mock-ups, including the GUI's dialogue structure, its main functionalities as well as a preliminary visualization of the simulation results. This low-fidelity prototype allowed a quick response to design modifications that emerged during the early design phase (Dumas & Redish, 1999).

In a last step, the GUI's usability was **evaluated** through usability tests (Dumas & Redish, 1999) and pluralistic walkthroughs (Bias, 1994). In total, 15 end users took part in the evaluation, of which five of them participated in the usability tests and ten in the pluralistic walkthroughs. Participants of the usability tests were professionals working in areas related to crisis management in the German public sector (civil protection, fire brigade, population warning; 2 females and 3 males, ages 25 to 55, 2 administrative and 3 operative staff). Participants of the pluralistic walkthrough were experts in crisis management from all over Europe (UK, NO, SE, DE, and ES; 3 females and 7 males, ages 30 to 60, 5 administrative and 5 operative staff). Moreover, one tool developer and two usability experts participated in the pluralistic walkthroughs.

For the evaluation of the tool, a fictive scenario was created to represent a common crisis situation. It integrated tasks for the users to carry out with the help of the tool. The participants' main goal was to use the tool to find out which warning and alerting channel mixes would be the best for alerting the population efficiently in case of a flood catastrophe. While participants in the usability tests performed the tasks individually one by one with paper-based prototypes of the GUI, participants in the pluralistic walkthroughs solved the tasks in two groups with a first interactive version of the tool (see Figure 2 in the results section for a screenshot).
During the realization of the tasks, participants were asked to comment on all the actions that they tried to perform with the tool by thinking aloud (Dumas & Redish, 1999). It was then observed whether any usability problems occurred, i.e., weak points within the design that prevent the intuitive and easy use of the tool. All evaluation sessions were audio-recorded and concluded with a post-test interview. The comments expressed during the tests and the data from post-test interviews were qualitatively analyzed, and were grouped into five GUI specific problem areas (see Figure 3). Five usability experts then rated the severity of each usability problem, using the scale proposed by Nielsen (1993), which uses a range from 0 to 4 (0 = not a usability problem at all; 4 = usability catastrophe). For determining the degree of severity of each usability problem, the arithmetic averages of the usability experts' ratings were calculated.

RESULTS

This section shortly summarizes the results of the four development phases.

The workshops conducted during the **context analysis** revealed information about the characteristics of the end user group, two different working environments (depending on the situation) and their tasks:

- <u>Specific characteristics of the end user group</u>: there are big differences regarding age, gender, experiences in the field and computer affinity: All users are educated to a level higher than secondary school, are older than 22 years, and have different cultural backgrounds and languages due to the tool's target region Europe. They are also experienced with computer-supported applications for crisis management, and can handle many computer screens at once. Users have a low-to-medium technological affinity and hardly adapt to new technologies quickly.
- <u>The "normal" working environment:</u> desktop computers with a keyboard and mouse interface, running the Microsoft Windows operating system are the most commonly used. Crisis situation rooms are equipped with projectors and monitor-walls.
- <u>The "crisis" working environment:</u> desk spaces are limited and the time-critical work gets almost constantly interrupted by other influences. Moreover, crisis management authorities work in teams with colleagues from completely different fields.
- Four relevant <u>tasks</u> were found, which form the basis for the use cases explained below.

During the **requirements specification** phase, we could derive four <u>use cases</u> (UC) from the tasks: "Planning and preparation of alerting plans" (UC1) and "Selection of an efficient warning channel mix in a time critical warning situation" (UC2) were derived as major uses cases. The use cases "Making investment decisions" (UC3) and "Preparation and conduction of exercises" (UC4) were identified as two minor (similar) use cases.

Subsequently, <u>requirements</u> were derived from the use cases and the context analysis. The mandatory requirements encompass issues on interaction design, functionality and usability, and formed the basis for the design and subsequent evaluation of the tool. *Requirements for the overall graphical and interaction design* apply to the technical environment, consisting of normal desktop computers with keyboard and mouse interfaces. Therefore, it is mandatory that the GUI supports the interaction with these input devices. For the adjustment of the given parameters, it is mandatory that the GUI provides input masks and sliders. As for *functional requirements* for the simulation, it is mandatory that the GUI offers its users the possibility to choose a specific geographic area, and to add new channels for this area. Moreover, the GUI has to give the users the possibility to save, select, load and compare simulation runs. In order to provide a tool that can be used intuitively with minimal training efforts, *usability requirements* reveal that the GUI should consider design patterns from Microsoft's operating system. Especially in time critical warning situations it is crucial that the tool is easy to use and that parameters can be changed with a "few clicks" to get new simulation results. For this reason, the GUI needs to support an intuitive task flow and to limit the interaction steps that are necessary to accomplish use case specific tasks.

On the basis of these mandatory requirements, first interaction- and graphical **design** prototypes for the tool were developed. The GUI consists of six thematic tabs that integrate the different parameters about the geographic area, the population, the channels used and the simulation results. Figure 1 shows a first mock-up used during the usability tests, while Figure 2 visualizes a screenshot of the first working prototype of the tool, which was used during the pluralistic walkthroughs.

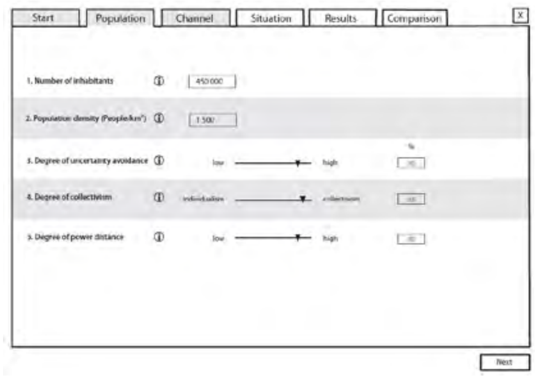

Figure 1 : GUI-mock-up "Population"-tab

Figure 2: Screenshot Interactive Tool "Results"-tab

The **evaluation phase** revealed that participants liked the general idea behind the tool and felt that the consideration of the efficiency of a mix of different warning channels was a true added value for them. Concerning the user interface, the tool's overall appearance and functionalities were regarded as appealing and usable.

However, using the tool in an acute crisis situation was generally not regarded as appropriate due to time constraints in the situation. Participants stated that in a crisis situation they would rather use every warning channel available in order to reach as many people as possible. Another point of discussion was the quality and reliability of the data used within the tool. All participants had serious reservations in terms of the data's reliability as most of the parameters that were used cannot be measured in objective terms, and are based on subjective estimations on the part of the users.

Type of problem	No.
Major usability problem	19
Minor usability problem	28
Cosmetic usability problem	24
Total	71

Major usability problems	No.
Wording problem	11
Functionality problem	3
Alignment problem	3
Navigation problem	2

Figure 3: Types and number of usability problems found, focusing on major usability problems

Regarding the **usability problems** of the GUI, in total 71 were found. From these problems 19 were considered to be major usability problems with average ratings ranging from 3.2 to 2.5 (see Figure 3). As in the first iterative design phase only major usability problems were considered to be important to be fixed, in the following the results concerning the major usability problems are presented more in detail.

The most severe problem identified was that participants did not understand the **wording** of the parameters (in total 11 problems). In particular, parameters which specified a population's cultural background (Figure 1) and which were derived from Hofstede's cultural dimension theory ("Degree of uncertainty avoidance", "Degree of collectivism" and "Degree of power distance") (Hofstede, Hofstede & Minkov, 2010) were either not understood or misinterpreted, even with additional explanations provided within the tool. In general, the moderators had to explain the concept behind the terms.

Participants also ran into usability problems regarding the tool's **functionality** (in total 3 problems). Participants were looking for some sort of directory structure for saving the simulation runs. A pre-selection of already saved simulation runs by geographic area was also mentioned to be missing. Also, the users expected to get predefined channels with additional information on the usage of specific channels depending on the time of day. During post-test interviews, users mentioned that they would like to have additional functionalities such as an export function, a geographic map representing the selected region, and reference values for the parameters.

Finally, we found a total of five usability problems concerning the **alignment of interface elements** (3 problems) and the **navigation** within the tool (2 problems). For example, participants had problems in finding various buttons within the tool - for instance, the button which starts the simulation process. Another problem was that users did not know how to navigate between different channels within the "Channel"-tab.

DISCUSSION

The UCD development approach presented in this paper shows how crisis management specific simulation software can be designed to match the users' needs and requirements. Applying the UCD approach to the design of the GUI of the simulation tool helped us immensely in getting to know the user group of the tool, their tasks and their working environment. From this base, we could elicit appropriate and useful requirements for the design of the simulation tool.

The UCD approach also helped us to expose weak points of the current version of the tool and its user interface, enabling us to optimize it. The evaluation of the GUI's usability turned out to be crucial for validating the results of the preceding development phases. For example, we found that "Selection of an efficient warning channel mix in a time critical warning situation" (UC2) was not as relevant for users as we assumed during the requirements phase. It turned out that the tool would be especially useful for planning and preparing alerting plans (UC1) and for making investment decisions (UC3).

We received many hints and comments about the elements of the GUI that still need to be optimized to guarantee smooth workflows. For instance, evaluation results showed that the wording of the parameters and the information buttons need to be renamed and further explained, be it online or in an additional user manual. This is especially true for the parameters derived from Hofstede's cultural dimensions theory which require further knowledge on the underlying theoretical concepts. Also, the parameters that are based thereon could use default values for specific countries (Hofstede, n.d.). Such a service would also fulfill the wish of the end users to retrieve reference values to support them in estimating parameters. Furthermore, we learned that important buttons, such as the button to start a simulation, should be visible at all times within the tool in order to avoid delays in the operational procedure of the end user group.

As for the overall tool we also received valuable insights about missing functionalities, such as a directory for saving the simulation runs, filter options for selecting saved simulation runs or an export function for the simulation results. These functions would help the users to organize, manage and communicate the data produced by the tool and to relocate simulation runs quickly in case of a crisis situation.

As this was the first iteration of the UCD-cycle for this tool, we foresee a number of possible improvements that can be made. To this end, we are currently starting the second iteration, using the software prototype to go further into the details, enabling us to improve the software to fit the user's needs as closely as possible.

CONCLUSION

In the work that led to this paper, we found that a shift from a technical-driven to a more user-driven development strategy can yield successful results in designing software systems for crisis management. We have shown that the UCD approach is especially suited for these types of applications, as their efficient usage might have profound impact on the work of crisis management staff. The evaluation of our GUI has shown that it is important to use non-ambiguous terms, have reliable data available, keep important buttons visible constantly and integrate functionalities to organize the data produced. For the next iteration, we plan to adjust the simulation tool's GUI to the findings from the evaluation phase. We want to assure that during all stages of the development process the users' background, needs and abilities are taken into account. We are confident that by following this approach, the tool will be used and appreciated by the users and help in their daily work.

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