1 Introduction

Various processes in safety-critical environments are uncertain, unstable and time-critical. As a consequence, in these environments, e.g. in crisis scenarios, the support of people by the means of interactive systems is challenging: Even smaller blind spots in the human computer interaction (HCI) might cause the unusability of the overall system.
Therefore, the effective, efficient und joyful use of the interactive system is essential for the success of the overall system. However, usability testing in crisis situations is highly complex: The usability tests have to be smoothly integrated in the crisis scenario. In crisis scenarios realism leads to an overproportional need for resources. This publication describes a prototypical safety-critical environment and discusses the usability challenges in safety-critical environments.

2 Mass casualty incidents

One of the greatest problems in safety-critical environments is the lack of scalability. With increasing incident sizes, effectivity and efficiency of the management processes decrease. For instance, in a smaller day-to-day emergency in Germany a patient is usually medicated and transported to hospital by a team of two paramedics. In life threatening emergencies the paramedics are additionally supported by an emergency doctor. However, if several patients are involved, this approach quickly leads to resource problems: Especially in rural areas the number of available paramedics and emergency doctors might be not sufficient to treat all injured patients at once. Therefore, within the so-called triage the emergency medical chief (EMC) inspects the injuries of all patients and defines priorities for further medication [1].
In MCIs (mass casualty incidents), even the triage itself leads to resource problems. The EMC cannot triage all patients contemporarily due to the great number of injured. Consequently, the first relief units at the scene instantly start with triage in order to identify the severely injured patients as quickly as possible [2]. The optimal resource allocation, however, can only be guaranteed when an overview on the incident is available to the EMC. This overview on all patients requires in turn that all relief workers finish their triage processes as quickly as possible and relay their results to the EMC [3].
In order to further analyze the consequences of resource restrictions and management overhead we outlined a prototypical mass casualty incident process within our interdisciplinary team (see figure 1) [4]. This process outlines the different components and functionalities which will be needed, e.g. patient information, scene information, team collaboration, infrastructure information, knowledge, technical support and management support. As a consequence, this prototypical MCI process was the foundation for shaping and discussing the various interactive systems for MCIs and the implications on safety-critical HCI in general, as proposed by Jakobs [5].

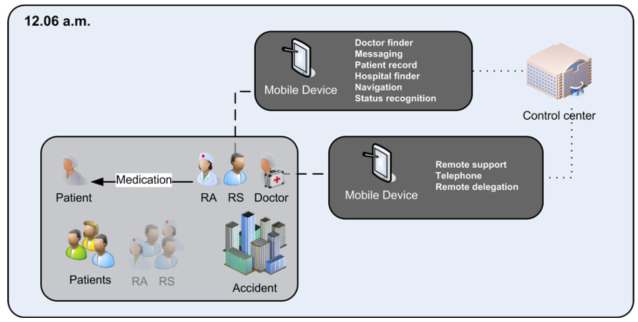

Figure 1: Small excerpt from our prototypical mass casualty incident process [4].

3 Interactive systems for safety-critical environments

In the first step, we designed, implemented and evaluated various interactive systems to solve two challenges in MCIs. Firstly, we used mobile technologies to collect information in safety-critical environments. Because information collection must not decrease the paramedics' performance, this was mainly an HCI issue. Secondly, we used simulations to train relief workers in order to increase their performance. This issue touched many different HCI topics as well. Besides these two fields of application interactive systems can be additionally used to support the social collaboration processes itself. Social collaboration in a safety-critical environment can be considered as human computer human interaction (HCHI).
We made contributions to all three areas of application, which we will now discuss in further detail.

2.1 Mobile computing in safety-critical environments

Due to the increasing use of algorithms in safety-critical environments the implementation of these algorithms on mobile devices stands to reason. In the first step, a mobile user-interface to assist paramedics in disaster operations based on the mSTaRT triage algorithm [6] has been designed and developed [7]. Since mobile, computer-based triage systems for paramedics must not delay the care taking procedures, the solution has been evaluated in a disaster control exercise.

The lack of predictability and certainty in the overall situation requires that the user-interface can adapt to changing and unforeseen situations. The concepts for adaptive mobile user-interfaces differentiate between static, patient related and environmental information. By taking the user's current duties and responsibilities as well as the concrete situation into account, the amount of information presented in the interface has to be adapted dynamically [8].

Figure 2: RFID Enhanced Patient Tags (REPTs) [9].

Whereas mobile interfaces lead to various benefits, paper is a powerful tool for supporting safety-critical task and is consequently still used widely. Therefore, the digital information has to be smoothly integrated in the existing paper-based workflows. The relief workers' documentation task has been improved by developing RFID Enhanced Patient Tags (REPTs, [9]) (see figure 2): On the paper part paramedics can easily scribble down medical results, while the electronic part enables paramedics to log their patient contacts [10].

2.2 Simulating safety-critical environments

In safety-critical environments various processes, e.g. the mSTaRT triage algorithm mentioned above, have to be applied. In order to enhance disaster preparedness continuous training of all relief workers is indispensable. Due to the fact that large disaster control exercises are laborious and expensive, additional training on a small scale makes sense. Therefore a virtual reality patient simulation (VRPS) (see figure 3) has been developed [11]. The approach includes gesture based interactions with the virtual patients in order to simulate the triage process as realistically as possible. During intensive evaluations 160 triage processes have been performed with the system and compared to the results from previous disaster control exercises [12].

However, in the field of safety-critical human computer interaction, there is a second field of application for environment simulations: Usability testing is expensive in these fields due to the resource requirements that go hand in hand with taking the context of use into account [13]. Crisis related applications, for instance, typically require the reenactment of the crisis scenario itself. To lessen the resource requirements crisis scenarios can be reconstructed as virtual reality simulations [14].

Figure 3: Virtual reality patient simulation (VRPS) [12].

2.3 Social media in safety-critical environments

The third class of applications, that include safety-critical human computer interaction, are social media solutions. Social media can support crisis communication and has been used in various incidents during the last ten years [15].

Public authorities and organizations that perform security tasks depend on a regularly estimation of the general feeling of (in)security. Our concepts improve existing estimations by taking information provided in social media additionally into account. The early warning system helps authorities to react earlier and more effectively on insecurity and fear [16]. In studies we could extract information on the feeling of (in)security even from Tweets (with only 140 characters) [17].

On the basis of this work we could develop a first model which describes the correlation between subjective and objective security. This model can be used as a foundation for the crisis-related communication of authorities and organizations. Furthermore, the model is a solid basis for discussions

during the overall crisis management process [18]. In a second step we extended the model to fit to terrorist attacks and rampages as well [19].
Specific research on activity streams [20] and more general research on corporate social software [21] led to the conceptual design of a new system for government safety, security and emergency communications, which we call social emergency software (see figure 4) [22].

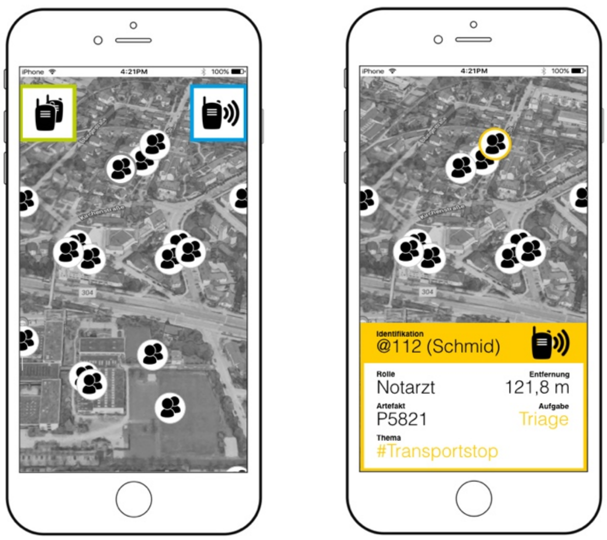

Figure 4: Social Emergency Software [22].

4 Conclusion and further work

In the next step all research results have to be brought together in order to be able to build interactive systems for safety-critical environments.
All people in these environments have to be supported by mobile interactive systems. Due to various disaster control exercises, the knowledge on the (un)usability of mobile handhelds in safety-critical situations can be used as a foundation. Disaster and crisis situations occur in low frequency; the experiences from training people to follow specific processes can be used to implement "training on the crisis" concepts. Last but not least people can only solve a crisis jointly. Due to our insights on communication structures a new communication concept can be integrated in the future interactive system as well.
Furthermore, usability tests will still play an important role to facilitate the iterative development of this interactive system. However, with our integrated approach for usability testing in safety-critical environments [23] we will be able to increase the frequency of usability tests without increasing the overall effort. Thus, our iteration cycles will be shorter and our overall process of analysis, design, implementation and evaluation of safety-critical applications will be a lot faster.

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