Disaster Management and 3D User Interfaces

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Disaster Management has become an issue of growing importance. Planning for and managing large scale emergencies is complex. The number of both victims and relief workers is large and the time pressure is extreme. Emergency response and triage systems with 2D user interfaces are currently under development and evaluation. Disasters present a number of spatially related problems and an overwhelming quantity of information. 3D user interfaces are well suited for intuitively solving basic emergency response tasks. Such tasks include commanding rescue agents and prioritizing the disaster victims according to the severity of their medical condition. Further, 3D UIs hold significant potential for improving the coordination of rescuers as well as their awareness of relief workers from other organisations.

1 Motivation and Overview

The importance of adequate emergency management is acknowledged by most countries in the world. Disasters have always happened and they will continue to. What changes though, is global awareness of these disasters as well as the number of people affected. The terror attacks in New York, Spain and London as well as the Katrina hurricane, to name a few, are some recent examples of large scale emergencies. The cause of such emergencies could be natural disasters like flooding, earthquakes, volcanoes etc. Man-made disasters like terrorist attacks, industrial disasters, radiation contamination, etc. have increased dramatically in recent times. Computer systems could facilitate all phases of Disaster Management. This work presents some of the current developments in that field. The aim is not to describe the functionality of every Disaster Management system available, but to investigate the way Human-Computer Interaction takes place in such systems. Especially the application and potential benefits of 3D User Interfaces are considered.

A brief general introduction to Disaster Management is provided in Chapter 2.
Chapter 3 summarizes the main functional and non-functional requirements for Real-Time Disaster Management Systems.
Real-life applications as well as prototypes of Disaster Management Systems exhibiting 2D User Interfaces are listed and shortly described in chapter 4.
Chapter 5 discusses the possible benefits of 3D User Interfaces in Disaster Management Systems. Relevant current research is presented.
Chapter 6 summarizes the work and provides an outlook into the future of Disaster Management and especially the use of 3D User Interfaces.

Figure 1: A simulated mass casualites accident at the Allianz Arena in Munich as part of the preparations for the FIFA World Cup 2006

2 Introduction to Disaster Management

The chapter provides some basic Disaster Management knowledge. Important characteristics of large scale emergencies and the challenges in their management are discussed.

Behaviour in disasters follows a characteristic cycle. The Disaster Cycle conceptualizes three phases - Before, During and After phase [1].

2.1 Planning, Preparation and Mitigation

The Before phase is the time before a disaster strikes. During this period plans are worked out and preparations are taking place to meet the challenges of a disaster situation. Recent events have shown that disaster preparedness, even in developed countries, is partially lacking and unrealistic. Disaster management to a great extent is a resources allocation problem. During a disaster the available resource have to be committed to the relief effort. Rehearsal and evaluation of resources allocation and management scenarios therefore is paramount. In large scale emergencies the Operation Command Centres coordinate and manage the response. The availability and capabilities of such centres is one of the main criterions for the adequacy of preparedness for a disaster. Training of relief unites of different organizations - fire-fighters, paramedic, police, etc. is also taking place in the before phase. Plans for action in different emergencies are being prepared and rehearsed in every organization. Preparation includes stockpiling of food, waters, supplies etc. as well. Mitigation efforts, during the Before phase, aim at lessening the effects of hazards in the long term. Example of such mitigation efforts would be improved housing construction or reforestation of watersheds.

2.2 Response

Response takes place in the During phase until the danger situation is over. The time period immediately after the disaster has struck is a critical. The first 60 minutes after a person has experienced a life-threatening trauma are referred to by paramedics as the "Golden Hour". Certain parallels are observed in disaster response. The initial hours and days are the time where most lives and property can be saved. These first actions set the pattern for further developments. Information gathering is a main task during the relief efforts. Data about

Figure 2: The Disaster Cylce divided into three phases.

area of the disaster number of victims, position of emergency units etc. have to be constantly gathered in the Emergency Command Centres. The Emergency Command Centres evaluate the data, monitor the accident development and perform relief resources allocation and command. Efficient Communication between all stake holders in the relief effort is a decisive factor. First on-scene respondents perform prioritizing the disaster victims according to the severity of their medical condition.

2.3 Rehabilitation and Reconstruction

During the After period rehabilitation and reconstruction phase people and communities put their lives, livelihoods, and homes back together.

2.4 Management Challenges

The main challenge in Disaster Response Management is the large number of victims and the also large but typically much smaller number of Relief Units. This scarce resources allocation task is complicated further by the fact that respondents come form separate Public Service Organizations (Police, Fire-fighters, Paramedics, etc.). Time critical decisions have to be made in a quickly changing situation. Simultaneously vast amount of information is accumulating rapidly and has to be managed and evaluated. On scene some of the main challenges faced include communication and coordination with other relief units as well as acquiring situational awareness. Another issue of extreme importance is the already mentioned prioritization of victims, the triage, which will be discussed in detail later.

3 Requirements for Real-Time Disaster Management Systems

Some general functional and non-functional requirements for Real-Time Disaster Management Systems are elicitated in this chapter.

3.1 Functional Requirements

Only dependability is considered here, because of its primary importance in Emergency management. Dependability is the extent to which a system performs the task it is supposed to. Specific criterions are used to determine how dependably a system works such as confidentiality, data integrity and availability. Disaster management systems work with patients data, relief units data as well as general situation data. Data of such nature should be kept safe and unavailable to unauthorized access. Specific confidentiality criterions have to be determined and fulfilled for every system. High availability in life critical applications such as Disaster Management Systems is a must. Service levels have to be 99.5% with 5 minutes maximum downtime.

3.2 Non-Functional Requirements

Facilitating a time critical task, Disaster Management Systems should conform to various time limits. Such limits for example are: medical checks time limit, transportation time limit and many more depending on the system's objectives. An appropriate Disaster Management Systems have to be well integrated into the overall rescue effort and not slow down or distract from the main task. This means that the system has to be intuitive and requiring little or no extra attention. These requirements could potentially be better satisfied by 3D User Interfaces as will be discussed in Chapter 5.

4 2D User Interfaces in Disaster Management Systems

Various systems for Disaster Management tasks are deployed around the world at different operational levels. Some of these systems and especially the 2D User Interface they make use of, are reviewed in this chapter. Two main groups of systems are presented - Resources Planning and Management Systems and System for Mobile Real-Time Triage.

4.1 Resources Planning and Management Systems

With the increasing attention paid by governments to the problems of disaster management, a number of IT projects have been initiated. The aim of these projects is to create global, distributed systems that could be used in the preparation phase as well as in the response phase of a disaster.

4.1.1 MulitTeam

Multi-Team [11], [10] is an advanced network for communication, coordination and logistics during disaster conditions. It connects multiple organizations involved in Disaster Management efforts, such as municipalities, Emergency Command Centres, Fire-Fighting departments, Paramedics, etc. Multi-Team has modules for extensive planning and resources allocation. All relevant data from an emergency scene is entered through mobile computers.

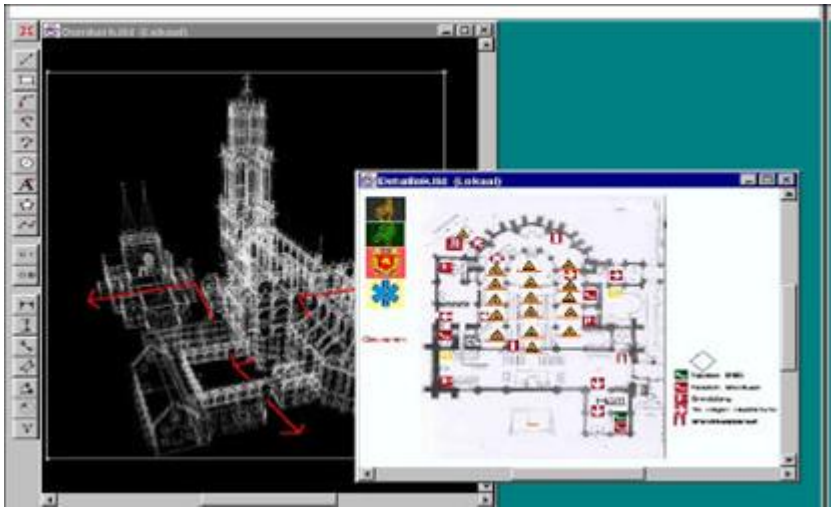

Figure 3: A 3-Dimensional model of a building loaded into the MultiTeam system.

Efficient gathering, exchange and distribution of information are main priorities. This system's interfaces are predominantly two-dimensional. There however is a module [10] that allows loading of a 3D model of a building or some other structure. Such a models are used for task such as planning or marking relevant scene information in the course of the rescue efforts. These actions could be optimized and made more intuitive usage 3D User Interfaces concept.

4.1.2 DeNIS

DeNIS [12] is a German Disaster Management System that serves as a disasters-related communication platform on the Internet. Relevant data is provided for two types of target audience. First one is interested citizens and specialists. The second type of target audience includes executives with decision-making authority in case of a large scale emergency. DeNIS is integrated with a Geographical Information System and supports the work of Emergency Control Centres. There are tree main modules - status management, communications management and resources management. DeNIS makes use of 2D maps and runs in a web browser.

4.1.3 MilSOFT

MilSOFT [9] is an Emergency Management Information System supporting Disatser Management efforts throughout the whole Disaster Cycle. It supports Geographical Information Systems and uses 2D User Interfaces.

4.2 Realtime Triage

Triage is defined as prioritizing the victims in a large scale emergency according to the severity of their medical condition. Triage is performed by the first on-scene respondents. Its quality and swiftness make the difference between life and death. A number of Real-Time Mobile

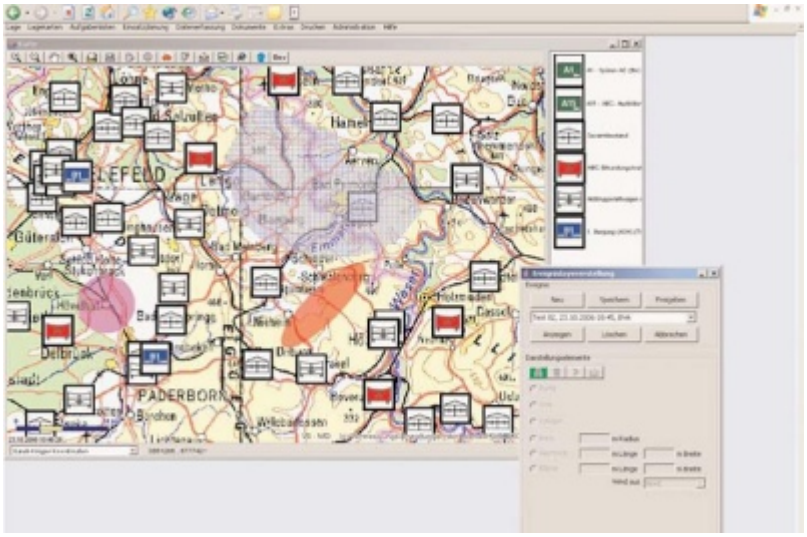

Figure 4: Showing damage status in deNIS II plus.

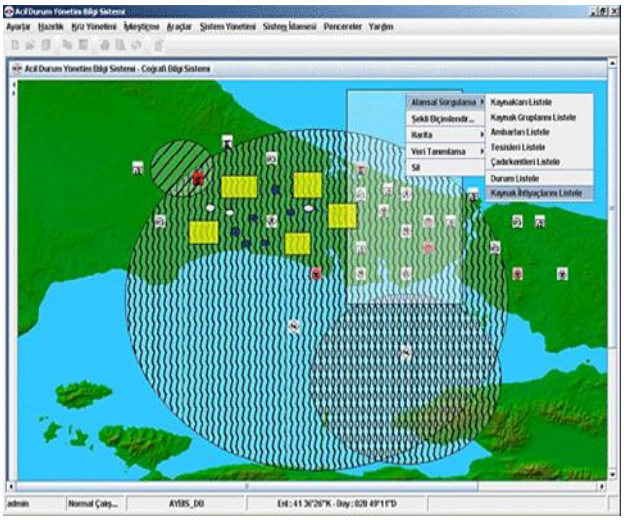

Figure 5: Emergency planning at the Bosporus using MilSOFT.

Triage applications are under development and evaluation. These applications should improve the capabilities of emergency teams to classify the victims quickly, mark their status and make decision how the treatment should continue. Data from the mobile triage devices could be gathered and used for situation assessment. Four real-time mobile triage systems and the interfaces they use are presented below.

4.2.1 US Army ARTEMIS

This system is being developed for the US Army [3]. Soldiers are equipped with mobile devices and biomedical sensors that monitor and report vital signs. The 2D User Interface these devices provide could be tailored specifically to the preference of the user. Various types of data such as current position, ammunition status, injury type and injury location are gathered along with the vital signs. This additional data is entered by the soldier. He enters that data for himself or for a buddy that has been injured. The information from all devices is gathered and different triage strategies are analysed.

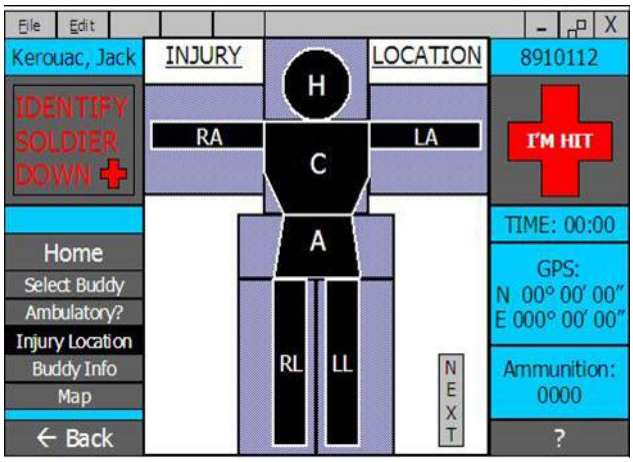

Figure 6: Soldiers input data through a touchscreen interface in the ARTEMIS system.

4.2.2 Pediatric Emergency Department

A simple 2D User Interface based on check boxes is used in a mobile triage system developed at the University of Ottawa [7]. This mobile application is designed to be employed at a pediatric emergency department. It uses a rule-based decision model and recommends how to proceed further after a child has been initially examined.

4.2.3 mSTaRT System

mSTaRT is a triage system that has already been tested as a prototype by professional emergency units in Germany [2]. It is intended as an aid to first respondents in a mass causalities emergency. The user goes step by step through the mSTaRT triage algorithm [4] to classify victims on the scene. The client application, which is deployed on a mobile PDA device carried by the pramedic, uses a button based 2D User Interface. All data is gathered in a central server. There it is available for different queries.

Figure 7: Pediatric Emergency Department triage.

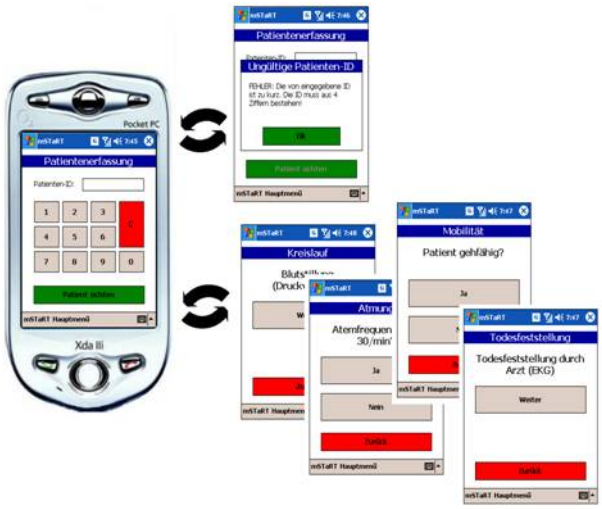

Figure 8: The mSTaRT algorithm performed by first respondents on a PDA.

4.2.4 M-AID

First aid algorithm that is to be performed by a layperson on the scene of an emergency before medics have arrived is visualized in M-AID [14]. This is a standard mobile phone application and takes the user through the first aid procedure by showing instructional pictures and text.

Figure 9: Step-by-Step first aid instructions provided by M-AID.

5 Application Areas for 3D User Interfaces

Applications of 3D User Interfaces [13] in the different phases of Disaster Management are discussed in this chapter. Current research about this topic is presented first. The potential of 3D User Interfaces to improve some main Disaster Management tasks is then elaborated upon.

5.1 Planning

Virtual and Augmented Reality systems are well suitable for training purposes. They provide controlled environments where many action scenarios could be simulated. The technology enables interaction with three-dimensional data, such as buildings 3D models, in new ways and improves overall situational awareness. Th

Having plans for action and having trained to perform that action is an indispensable component of preparedness. In [8] a fire-fighting simulator has been developed. Intended usage is testing of safety procedures and modelling of fire and emergency resources behaviours inside tunnels. The scenarios developed using such as system ascertain fire safety and are also to be used while training rescue personell.

Another possible use of 3D User Interfaces during the Before phase of a disaster is proposed in [6]. Response and Evacuation planning there is performed by multiple users interacting with a 3D Geographical Information System Interface. The users perform their task simultaneously using hand gestures.

Figure 10: Development and analysis of fire fighting scenarios with the help of Virtual Reality.

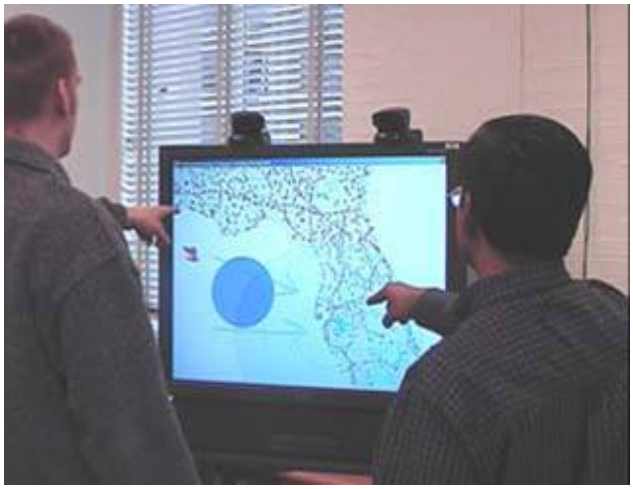

Figure 11: Multiple users planning with a GIS system.

5.2 Command

Emergency Command Centres have a hard task involving a constant flow of information under enormous time pressure. [5] proposes a Multi modal 3D Human Computer Interaction system that aims to facilitate commanders' decision making and control. Fire development is visualised on a large screen display in front of the commander. Interacting naturally - with the hands - the commander points at the place where new fire has broken out and then points at an emergency vehicle. The vehicle is order to respond to this new fire by a speech command. Such simultaneous use of gestures and speech improves the effectiveness with which orders are issued.

Figure 12: Commanding emegency vechiles using a multimodal 3D User Interface.

5.3 Future Potential

3D User Interfaces hold significant potential for future use in Disaster Management. They allow interaction with data as in the real world. This interaction has a lower abstraction level and is more intuitive, thus allowing the user to concentrate on the given task only. The aspect of multimodality makes 3D User Interfaces even more effective. Some of these advantages have been explored in the systems presented above. Spatial Orientation/Wayfinding, as very important in Disaster Management, is a further potential area of application. Knowledge of

a rescue unit's location and viewing direction is paramount when navigating through areas struck by a massive disaster. Additionally having spatial knowledge, such as location of victims, location of other rescue teams or information about current and developing hazards, creates a level of situational awareness that could greatly improve the effectiveness of the rescue effort. To have all this information in three dimensions would be of enormous benefit. 3D User Interfaces would present such data appropriately and let the user manipulate it efficiently.

6 Summary and Outlook

Disaster Management is a massive and continuous effort. In its different phases, the power of IT technologies is just beginning to be utilized. Most deployed Disaster Management systems as well as research prototypes are interfaced in 2D. With further improvements of such enabling technologies as Head Mounted Displays, Sensors Networks, CPU Power etc., 3D User Interfaces are likely to gain importance and attention because of the intuitiveness and effectiveness of interaction they stand for.

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