Multi-Touch Interaction for Disaster Management

Volker Paelke, Karsten Nebe, Florian Klompmaker, Helge Jung

Abstract—Multi-touch interaction has become popular in recent years and impressive advances in technology have been demonstrated, with the presentation of digital maps as a common presentation scenario. However, most existing systems are really technology demonstrators and have not been designed with user requirements in mind. This paper will report on ongoing activities in a user centred approach to the use of large multi-touch displays to support disaster managment applications. Building on the detailed analysis of user requirements in real-world tasks, the focus is on the design of presentation and interaction styles that exploit the potential of large scale multi-touch displays to reduce cognitive workload while monitoring the impacts on usability and ergonomics, including a study of the potential physiological dangers involved in long-term use.

Index Terms—Multi-touch, multi-user interaction, large scale displays, usability, ergonomics, visualization, disaster management.

MOTIVATION

A critical factor in the management of disaster is the access to current and reliable data. The supply of spatial data has been improved tremendously by new sensors and data acquisition platforms (e.g. satellites, UAVs, mobile sensor networks). However, in many cases these are not well integrated into current crisis management systems and often the capabilities to analyze and use data lag behind sensor capabilities. Therefore, it is essential to develop techniques that allow the effective organization, use and management of heterogeneous data from a wide variety of data sources.

Standard user interfaces are not well suited to provide this information to crisis managers. Especially in dynamic situations conventional cartographic displays and mouse based interaction techniques fail to address the need to review a situation rapidly and act on it as a team. The development of large scale multi-touch tables provides a promising base technology to improve the central tasks: to provide an adequate overview of the situation and to share relevant information with other stakeholders in a collaborative setting.

However, design expertise on the use of such techniques in interfaces for real-world applications is still very sparse. Complementing existing work that has largely focused on the development of base-technologies and individual visualization and interaction techniques we are conducting an ongoing project that investigates the use of multi-touch technology with a user and application centric focus in the domain of disaster management.

1 APPLICATION

Our application is a disaster management application that is studied in close collaboration with the German Federal Agency for Technical Relief (Technisches Hilfswerk/THW).

1.1 User centred approach

A user centered approach is essential to develop new user interfaces that realize the benefits of technologies like large scale multi-touch displays in real-world applications. Large scale multi-touch tables have high potential to improve situation awareness and collaboration in time-critical multi-user applications. To establish requirements recurring interviews and workshops were conducted with disaster managers and technicians from THW and training exercises observed. These revealed a number of areas for potential improvements that could be addressed through multi-touch tables. In an iterative process these were refined into application scenarios from which concrete requirements were then identified.

1.2 Scenarios

A typical scenario is the management of an incident by a THW team. Tools used include (paper-based) maps and special sheets (so called 'damage accounts') that contain summaries of local incidents and assigned units (Figure 1 a,b). Sheets are referenced to map locations by using little magnetic tiles. Typical activities are the creation, manipulation and spatial update of damage accounts. While desktop GIS can provide a lot of desirable additional functionality it is difficult to integrate with this established robust workflow that is clearly visible to all stakeholders, can adapted to non-digital data sources, and easily integrates untrained personal (e.g. local support staff).

The key requirements derived from the analyzed scenarios require to create a user-interface that maintains the benefits of the established workflow while providing access to the advanced functionality of a digital system (e.g. access to real-time sensor and location data, spatial analysis functions).

2 MULTI-TOUCH TABLE

The "useTable" is a multi-touch-table constructed at C-LAB to specifically address the requirements of the disaster management use case.

2.1 Table Construction

Figure 2 shows the construction of the useTable. It features a 52'' screen and supports both finger and pen-based input, as well as interaction with objects on it's surface to implement tangible user interface concepts.

2.2 Interaction Techniques

Different interaction techniques have been implemented to interactively manipulate damage accounts on the useTable, e.g. to locate them on the map or to add detail information. The base-line implementation is the direct equivalent of the manual workflow. Building on this base-line experiments allows to establish the benefits and problems introduced by more advanced techniques like automated up-date or layout as well as the usability differences between pure touch input, pen-input and the use of interaction-objects in a tangible user interface implementation (Figure 3 a,b).

2.3 Visualization Techniques

A key advantages of the interactive display is the ability to rapidly switch between different maps and map representations while maintaining the damage accounts. Using a layer concept different maps and additional information (e.g. airborne imagery) can mixed while maintaining the established workflow. Display is not limited to pure map-display but allows to experiment with automated integration of different maps, integration of derived information (e.g. danger zones, uncertainty) as well as task dependent generalization and highlighting strategies (Figure 4).

- *Volker Paelke is with Institut de Geomàtica, E-Mail: volker.paelke@ideg.es*
- *Karsten Nebe, Florian Klompmaker and Helge Jung are with C-LAB, University of Paderborn, E-Mail: {nebe,klompmaker,jung}@c-lab.de*

3 User Studies

Ongoing user studies form a central part of our approach. These cover not only experiments on the usability of different interaction and visualization techniques (used to guide further development), but in close collaboration with psychologists and ergonomics experts we also aim to study the impact on the cognitive workload of users and examine the potential physiological dangers that may be incurred by prolonged use of a large-scale multi-touch display. While the ergonomic requirements of desktop workplaces are well understood the same is not true for new interaction environments like tables. Established ergonomic standards were often ignored in early demonstrators because of technology constraints (e.g. lighting levels). And while interaction techniques like free-hand gestures are intuitive they can also cause a high-level of fatigue. We are therefore working on initial studies on the ergonomic impact of large scale multi-touch displays and hope to be able to report initial results at the workshop.

4 Additional Functionality

The digital implementation also enables the integration of functionality that moves beyond information display and sharing towards analysis and automation.

A promising extension of the system would be it's extension with a mobile sensor network. In the project group FireNet we conducted early experiments with a mobile personal sensor network, in which each rescue worker was equipped with a sensor node (using Sun's SunSpot as the basis and extending it with GPS receiver and additional sensors). Integrating such functionality with the disaster management application will improve situation awareness in the command centre by allowing real-time tracking of rescue personal and equipment position and state. Integration into a real-world system will require technological improvements in the base technology to ensure robust positioning and communication.

Another area in which additional functionality will be added concerns the extension from the current focus on observation (situation awareness) to analysis and prediction. The digital basis enables the use of GIS analysis functions and a future extension towards simulation/prediction could be useful, especially in dynamic natural disaster situations like flooding or fires.

5 Demonstration

We plan to provide a live demonstration of the useTable at GeoViz to provide an opportunity to experience the different interaction modes.

6 Conclusions

To exploit the potential of advanced visualization techniques and user interaction techniques in disaster management and similar applications requires research to evolve from small technology demonstrators to usable real-world systems (requiring adequate tools and stable base-technologies) and to evaluate and validate the different design options (requiring the development of design expertise that employs these emerging technologies effectively). We present an initial step in this direction with a focus on usablity and ergonomic aspects.

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Figure 1 (a): Conventional THW command post

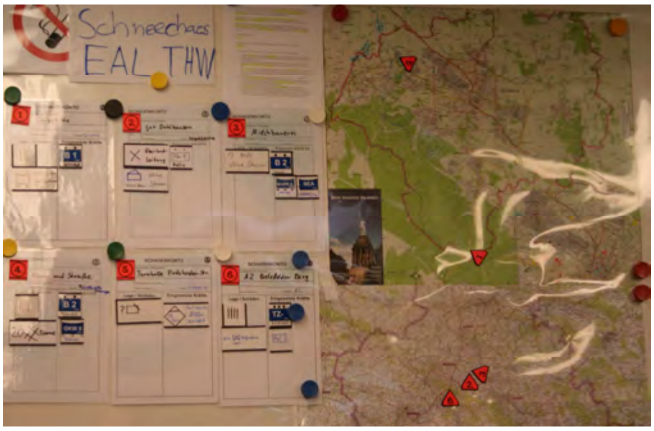

Figure 1 (b): Conventional damage accounts

Figure 2: useTable construction

Figure 3(a): Interaction on the useTable (touch)

Figure 3(b): Interaction on the useTable (tangible)

Figure 3(c): Interaction on the useTable (pen)

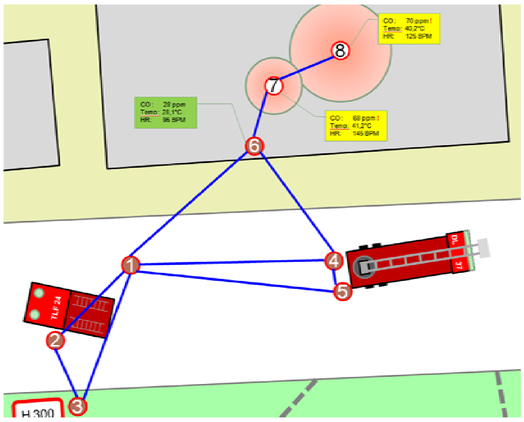

Figure 4: Visualization integrating sensor data and uncertainty