Is it possible to interact with a handheld device while holding it in both hands?

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Abstract: Intuitiveness, attractiveness and efficiency are in general important characteristics of high quality User Interfaces (UI). In the case of a **M**ass **C**asualty **I**ncident (MCI) and other life threatening situations good user interfaces are essential as every second counts in these time-critical situations. Finding the best way to interact with the system is a challenge with many open issues. Therefore, it is essential to test different UI alternatives to determine important usability issues as those mentioned before. This paper focuses on the research question how patients can be selected on a map application which runs on a rugged tablet PC. A rugged tablet PC is in general heavy because of its robustness, which introduces a new special requirement in addition to the existing UI requirements. The implementation and the evaluation of the UI alternatives presented in this paper were performed within the scope of the SpeedUp project[1].

1 Motivation - Usability brings order in the chaos?

A **M**ass **C**asualty **I**ncident (MCI) is an incident which generates more patients than the locally available rescue workers can manage simultaneously. Since there are too many injured people to handle at once, they need to be categorized. There is already an ongoing research which digitizes this triage approach using PDAs [NK07]. Using PDAs equipped with GPS sensors has the advantage to track the position of the patients. The PDAs are supposed to be used by the relief units in the field. The tracking positions are transferred from the distributed PDAs in the field to the tablet PC used for this work. The positions of the patients are visualized in an overview map on the tablet PC in the scope of this work. Currently, the **E**mergency **M**edical **C**hief (EMC) is getting the information about the situation from the rescue units verbally. The number of injured people and their classification are written down by the relief units on paper. So this information can be incomplete, redundant and/or wrong. Obviously, using an IT solution can improve and introduce order

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in the chaotic situation in such incidents. This is why we propose that the EMC should use the tablet PC to acquire the required information about the patients. However, because of the users' tendency to resist or even reject new technologies with inadequate user interfaces or bad usability, all conceivable improvements can be useless. It is therefore essential to develop the user interface close with the user to find out which UI alternative is the most intuitive, efficient and attractive. Special requirements on the user interface suitable for an MCI situation have to be considered and explored. This paper focuses on designing a usable UI to select items (patients or relief units for instance) fulfilling these special UI requirements mentioned in 2.

2   Special Requirements

The requirements in general can be split into hardware and software requirements. The hardware requirements and common software requirements are described in the long version of this paper. Therefore, only the special requirements are described here. To date, the information in an MCI situation is mainly captured on paper. Since this method provides an easy, familiar, intuitive and flexible way to realize the information capture task, the first requirement is to achieve a comparable performance with the tablet PC UI as compared to paper. Another special requirement from the fire department of the Technische Universitaet Muenchen (Feuerwehr TUM) is to use just the thumbs for all interaction tasks while holding the tablet PC with both hands. The fire department staff is using a heavy ruggedized tablet PC during their daily work (xplore iX104). The staff complained about the fact that holding it with one arm during interacting with the free hand causes their arm fatigue. Therefore, to solve this problem, the users should be able to interact with the application while holding the tablet PC with two hands. This leads to the fact that only the user's thumbs are able to reach the screen. As a consequence the application must provide all interaction elements on the left and/or the right edge of the tablet PC screen as shown in figure 1.

Figure 1: Tablet PC xplore iX104 holding in both hands

3   Concepts to select patients

The UI of the map application will be developed gradually to increase the chance of its acceptance by the target group (EMC). The goal of this paper is to find an answer to the

question: **How can patients be selected?** There will be different items like vehicles, special places, relief units or patients in the final application. Since the UI has to be completely controllable from the edge of the screen, items cannot be selected by just touching them. Three different UI concepts which fulfill this main requirement are introduced in this section. All of them will create special UI elements (buttons) at the edge of the tablet PC screen which can be reached with the thumb while holding the tablet PC in both hands. And since the space on the edge is limited, only a subset of all visible patients can be selectable at once. Therefore, how to determine this subset is the main topic of this section. To be able to compare the three selections methods which each other, all three should use the same buttons to finally select one patient among the determined subset. The three investigated selection methods are: Horizontal Line (SE1), Selection Quad (SE2) and Automatic Mapping (SE3). **Horizontal Line:** One approach to select patients which are not reachable with the thumb is to draw a horizontal line from the user's right thumb position to the left hand-side of the screen (see figure 2 (a)). This line disappears when the display is not touched anymore. If the user slides his right thumb up or down the horizontal line will follow it. The speed of the line's movement is one-to-one mapped to the thumb's speed in order to make the movement more intuitive. Each patient intersected by the line will be a member of the subset described before, and is therefore selectable through pressing the corresponding button on the left-hand side edge of the screen. This way every patient which is visible on the current segment of the map can become selectable by moving the horizontal line. **Selection Quad:** The approach here is to render a square on the tablet PC screen as shown in figure 2 (b). Each patient who is inside this square is mapped to a member on the left side of the tablet PC and thus selectable by the left thumb. The user is able to move this square by a graphical joystick. In the contrary to the selection with the horizontal line there is a risk that there are too many patients inside the square, so there has to be a possibility to resize it. For this issue the joystick is extended with a plus and a minus button to control the size of the square. Even though this will increase the complexity of this selection method compared to the horizontal line, it also provides more flexibility to the user. **Automatic Mapping:** Our last approach is to map all of the visible items to both edges of the screen. On the one hand an obvious advantage is that the user can select an item without the step of determining a subset (see figure 2 (c)). This alternative provides a button to toggle the selection on and off which makes it easier and faster compared to the horizontal line (SE1) and the selection quad (SE2). On the other hand this method introduces some undesirable effects. Since each patient can be selectable, every patient needs a correspondent button on the edge which requires more space from the limited interaction space.

(a) Horizontal Line (SE1)
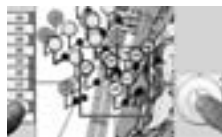
(b) Selection Quad (SE2)

(c) Automatic Mapping (SE3)

Figure 2: Concepts

4 Evaluation

The first part of this section explains the participants used for this evaluation, followed by a subsection describing the procedure to be performed by the users. After that the results are presented and discussed.

Participants According to literature we will learn the most from our first few test users. It is recommended to have between three to five test users, since more users will not necessarily improve the results of the evaluation [Nie94]. Therefore, the system was evaluated by five test users. In this first approach those test users were not from the rescue service. This decision was made because the **initial** usability issues are the same for most of the people during the **first** evaluation of an UI, whether they are from the rescue service or not. Actually, it is more important to choose people with low experience in the field of human computer interaction in this first step. People from different fields were randomly chosen for that reason: Two biologists, a political scientist, a sociologist and a jurist. The results of this evaluation will highly improve the presented UI elements and may lead to filtering out of some elements. The remaining enhanced and optimized UI elements will **then** be evaluated with the rescue service team (EMC) in future work. The remaining enhanced UI elements will then be evaluated with the rescue service team (EMC) in future work. All of the five test users (two females and three males) have low to average experience with computer interaction in general and with touchscreens in particular according to their own estimation. All of them were between 25 and 28 years old. To find out usability issues and to be able to rate the different UI alternatives, the test users have to use and experience the UI elements. Therefore, it makes sense to define the same task in all three alternatives to be performed by the users. The time duration it takes to finish a task, is measured for all users for each alternative. For each of the interface elements the users fill out two questionnaires: SUS (System Usability Scale) [Bro96] and AttrakDiff [HBK03]. After that a short interview is held with each of the test users. In this interview the test users are asked how they feel and think about the different UI techniques. This is important to find out the reasons for the scores of SUS and AttrakDiff and to be able to determine specific difficulties using these UI techniques.

Procedure During the execution of each task the test user is observed to detect some usability issues and clarify potential ambiguities faced by the test users. To avoid the learning effects, the sequence of the different alternatives are randomized. During the interview phase, the test users give their feedback and experience multiple UI alternatives. Finally, the test users are asked to choose and argue about the preferred UI alternative for selecting patients. Concerning the task description, there are 26 patients at the beginning displayed at the center of the map, and the ability to move or zoom the map is disabled. The patients' locations and triage states will be the same for each alternative. The test users are first asked to select every red categorized patient, then every yellow one with each alternative. Every selected patient will disappear immediately in this test scenario from the map. The task is completed when no patient to select is left on the map.
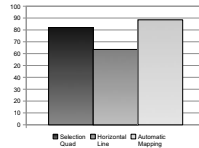
5 Results

In this section the results are presented for each UI selection alternative and discussed. In the first paragraph the results of AttrakDiff are recapitulated, while the next paragraph summarizes the results from SUS. Finally the outcome of the test users' feedback during the interview will be summed up and discussed.
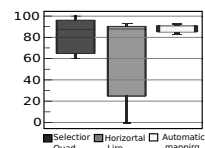
AttrakDiff The results of AttrakDiff are divided into four dimensions (see figure 3 (a)). The first two dimensions describe the hedonic quality of the UI and enclose stimulation and identity. For the stimulation part the selection quad (SE2) shows the best results while the automatic mapping has the highest score in the remaining three dimensions. The differences between UI alternatives are higher for the pragmatic quality (PQ) and the attractiveness (Att). Moreover, the order of the scores for the identity quality, pragmatic quality and the attractiveness respectively are the same. That means, the automatic mapping (SE3) has scored the best results in all three qualities followed by the selection quad and finally the horizontal line. Nevertheless, the results are good for all alternatives since the score is never below four, but there are evident tendencies for the automatic mapping alternative.
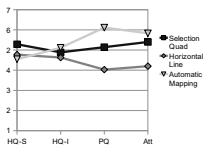
(a) AttrakDiff   (b) SUS - Means   (c) SUS - Boxplot

Figure 3: Results for AttrakDiff and SUS

SUS The results for the system usability scale support the results from AttrakDiff (see figure 3 (b)).Actually, the usability of the automatic mapping alternative obtained as well the highest score of 88.5 among the three alternatives. Figure 5 (c) shows clearly that the results of the automatic mapping alternative are very decisive since all test users rated this alternative in an interval between [82.5 ; 92.5]. Even though, the selection quad alternative obtained the second best score with a mean of 82.0, the test users rating was spread over a bit larger interval of [60.0 ; 100.0] compared to the automatic mapping alternative. The reasons for those scores become clearer after the interview and the feedback of the test users.

Interview The interview shows that the reason for the low score of the horizontal Line (SE1) is that the line was too thin to intersect the patients easily. That is even more disadvantageous for the specific task performed by the test users during the evaluation where they had to select all patients. However, if the specific task is to select one patient among a huge number of patients geographically, the horizontal Line (SE1) might score the best among the three UI alternatives. This has been also confirmed by one of the test users. The selection quad is not immediately understood from all the test users which make this alternative not as intuitive and practical as the automatic mapping. A better visualization of the functionality and the usage of the selection quad could improve its usability and

practicality. Even though the complexity of the selection quad is higher than the automatic mapping, it provides also more flexibility to the user since scrolling and zooming can be integrated in a very compact way with no extra UI element. This benefit could not be seen by the test users during this evaluation because the scrolling and zooming feature of the selection quad was disabled for this evaluation.

6 Conclusion and Future Work

During this evaluation, the automatic mapping was clearly rated as the best selection technique. But this result has to be regarded carefully, since this was an initial evaluation with a predefined task. This task is not representative for all possible real tasks in a real MCI, in our case the result of the evaluation is strongly bounded to this task. Nevertheless the evaluation points out important issues for all three techniques. Investigating those issues and learning from the test users' feedback, improve greatly the proposed UI selection alternatives. Within the SpeedUp project there is ongoing work researching the best UI scrolling and zooming alternatives based on the same requirements presented in section 2. So the next step is to combine the alternatives for these three basic map features (selecting, scrolling and zooming) which was rated with the highest scores and integrate them to a compact system. Additionally, a new UI alternative with all basic map features has to be introduced for the purpose of evaluation. Finally, defining new tasks is also needed to heavily evaluate the UI alternatives; those tasks should make the user employ all provided UI alternatives features.

References

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