

User-Centered Development Of UI Elements for Selecting Items on a Digital Map Designed for Heavy Rugged Tablet PCs in Mass Casualty Incidents

Tayfur Coskun
Institute for Augmented Reality
85742 Garching b. Muenchen
Munich, Germany
coskun@in.tum.de

Amal Benzina
Institute for Augmented Reality
85742 Garching b. Muenchen
Munich, Germany
benzina@in.tum.de

Eva Artinger
Institute for Augmented Reality
85742 Garching b. Muenchen
Munich, Germany
artingee@in.tum.de

Clemens Binder
Institute for Augmented Reality
85742 Garching b. Muenchen
Munich, Germany
binder@in.tum.de

Gudrun Klinker
Institute for Augmented Reality
85742 Garching b. Muenchen
Munich, Germany
klinker@in.tum.de

ABSTRACT

In a Mass Casualty Incident (MCI) time and good management are critical. Currently, the first arriving rescue units perform the triage algorithm on paper instead of a mobile device. By using mobile devices, the patients' triage state and position can be instantly shared through a network. We implemented a map application to visualize this data on a rugged tablet PC that is intended to be used by the Ambulant Incident Officer (AIO). Even though, using a mobile device offers more benefits, it also requires some mental efforts from the user. The goal of the SpeedUp project¹ is to ensure the speed-up of the rescue process. It is crucial to carefully develop, introduce and evaluate the User Interface (UI) iteratively close to the target group and adapt it to an MCI situation. Thus, multiple UI concepts have been developed to compare, rate and optimize them. This paper represents a follow up study and focuses on approaches to select patients on a digital map displayed on a heavy rugged tablet PC. An evaluation is performed to estimate how intuitive, efficient, and ergonomic the UI is without the need of special training for the target group and to increase the acceptance of new devices.

Categories and Subject Descriptors

H.5.2 [User Interfaces]: Ergonomics, Interaction Styles

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General Terms

Design, Human Factors

Keywords

MCI, AIO, Usability, Digital Map, Selection, Virtual Joystick

1. INTRODUCTION

A Mass Casualty Incident (MCI) is an incident which generates more patients than the locally available rescue workers can manage simultaneously. The medical rescue teams have to face a vehement organizational challenge to manage those incidents while they find themselves in a chaotic and stressful situation. The goal of the SpeedUp Project is to extend the current approach with an IT infrastructure to manage an MCI, rather than replacing it. The current procedure is to collect all available data on paper and share it with each other, either by phone or face to face. Thus, spreading out new information is slow and can be error-prone due to different psychological and human factors. It is evident that introducing IT would be the solution. However, the target group, the Ambulant Incident Officer (AIO) in this case, will not adopt a new technology if it does not fulfill the high demanding requirements discussed later. Besides common usability issues for touchscreens and map applications, there are special requirements derived from different factors related to the MCI. Those requirements can be divided into three main categories in terms of: Hardware, Functionality, and Usability. This paper focuses on the usability of a map application (Section 1.1) which runs on a heavy rugged tablet PC. The tablet PC itself is part of an IT infrastructure which is comprised of multiple PDAs, the tablet PC and a multitouch surface. Then, the related work is described in Section 2. The previous work on which this work is built on is presented in Section 3.

1.1 Contribution of This Paper - Bring Order Into the Chaos

This paper focuses on the usability of a digital map application which runs on a heavy rugged tablet PC. Although a lot of work has been done in the area of digital maps, the special situation of an MCI in such a ubiquitous computing environment introduces additional requirements. These additional requirements are not only due to the psychological circumstances that the rescue units face in an MCI, they are also imposed by some hardware requirements which increases the heaviness of the tablet PC. The fire department staff of the Technische Universität München (Feuerwehr TUM) have been using a tablet PC in their daily work – *explore iX104*. Based on their experience, they mentioned that holding the tablet in one hand and interacting with it simultaneously with the other free hand, is exhausting and hence reduces their acceptance of that device. Therefore, we study different concepts to provide a way to interact with a digital map on the tablet PC while holding it in both hands. We investigate the most fundamental interaction features for a digital map – *Selecting of items, Moving the map, and Zooming it*. This paper however, focuses on the selection part.

2. RELATED WORK

A lot of efforts has been done in the recent years to introduce electronic devices into the rescue service work flow. The progress in mobile technology has also led to new possibilities to improve the handling and the organization during an MCI. Nestler et al. [14] for example digitized the mStart [9] algorithm on a PDA equipped with GPS sensors and an RFID-reader in 2007. Additionally, the paper-triage tags which are currently used to mark a patient with its associated triage priority were enhanced with RFID tags. This way, once the triage state is determined it is saved on the triage tags and it is transmitted along with the position to a server. In fact, our work builds up on that approach. There are several other studies which try to digitize the triage algorithm; for example, Gao et al. [7] developed a system in 2006 progressively which were also based on electronic triage tags and wearable vital sign sensors. PDAs were here used to support documentation and communication. And in 2007 Gao et al. published a work [6] where they found out that the real-time collection of data using their Light-Weight Wireless Medical System for Triage drill could approximately triage three times larger as the traditional paper triage. Kileen et al. [10] focused in 2006 on developing a system called WISSARD First Responder (on a PDA) which is part of the Wireless Information System for Medical Response in disasters. There are also ongoing projects looking at the electronic triage like the e-triage project² where a tablet PC for the digital triage instead of a PDA or a smartphone is being used. Another project investigating multiple aspects of an MCI is called SOGNOS³. For example Flentge et al. [5] who are part of the SOGNOS project investigated context-aware user interfaces for collaborative Emergency Management. Also part of the SOGNOS project, is the work done by Kohlhammer et al. [11], they used visual analytics for supporting strategic decisions making in the case of an MCI. Another work which is developing a UI

²www.e-triage.de -last visited 30.06.2011

³www.soknos.de -last visited 30.06.2011

for a multitouch table and which is a parallel work to the SpeedUp project has been performed by Artinger et al. [1] in 2011. In this work new gesture sets were conceptualized, implemented and evaluated for interacting through a digital map application in a multitouch table.

3. PREVIOUS WORK

This work represents a milestone in the process of a map application development. An evaluation was performed previously in 2010 and included all the three interaction features for selecting, zooming, and scrolling tasks on a map ([3], [4]). We were therefore able to improve our concepts based on the quantitative results of the used questionnaires in the evaluation (SUS [2], AttrakDiff2 [8]) and the qualitative feedback we extracted from the interviews. In the process of the formative shaping of our interaction concepts on a map, a further evaluation is designed taking into consideration the following:

- The problems were eliminated and the usability was improved based on the outcomes of the previous evaluation.
- The shortcomings of the evaluation tasks were eliminated to avoid influencing the results.
- The previous evaluation was not performed with the right target group, in our case, the rescue service.
- The results of the previous evaluation presented tendencies but no significant results.
- The focus of this work is just on the selection interaction feature exclusively, to have more time for interviewing each test user.

4. REQUIREMENTS

The most relevant requirements are already described in details in 2010 [3]. However, since these requirements are important they are briefly summarized in this section. The hardware itself is not within the scope of this work. Nevertheless, the hardware requirements in Section 4.1 have the most significant influence on the design of the UI. The UI requirements are then listed in Section 4.2. Finally, the most important requirement derived from the heavy tablet PC are introduced in Section 4.3.

4.1 Hardware Requirements

The hardware requirements can be put into two categories: MCI related and UI related.

MCI - Related Hardware Requirements. First of all, the hardware has to be very performant, to reduce the computational delay and the users' frustration. Second, the hardware need to be equipped with a GPS receiver to track the AIO's position. Also, to synchronize data and to increase the robustness of the connection, the hardware should be equipped with the available network and communication adapters. The battery life should at least lasts for four hours. Additionally, a car docking station for the tablet PC should be available to recharge the battery during the drive. Last but not least, due to the instability of the environment of an MCI, the used hardware might endure situations with fire, water or dust. There are standards which define the degree

of protection for the hardware. To conform with these requirements, the device should apply at least to IP55 defined in DIN EN 60529. That means that the device is fully protected against contact, interior dust deposits and water (out of a nozzle) from all directions. The hardware should also be equipped with an SSD hard disk to avoid disk corruption.

UI - Related Hardware Requirements. The display should not be smaller than 10.4" to provide a better overview with a map application according to our experience. The display has also to be touch sensitive to fulfill our special requirements that will be described in Section 4.3. Ideally, the touchscreen should be with a resistive sensor to allow interacting with the device while wearing gloves. Resistive touchscreens suffer from the fact that a touch has to be accompanied with some force to be detected. This is more relevant for a rugged tablet PC since the touchscreen is cloaked with an extra built-in slipcover. Another hardware requirement is also related to our special requirement: The device bezels have to be as thin as possible to provide more space for the interaction areas on the edges of the screen.

4.2 User Interface Requirements

Our map application runs on a 10.4" touchscreen, and hence the UI should fulfill common touchscreen requirements. To achieve a comparable performance to desktop applications, the UI elements on touchscreens may not be smaller than 22mm [13]. Otherwise, special techniques to improve the performance of the UI elements like soft buttons should be used as described by Lee et al. in 2009 [12]. Another consideration to be taken into account is that the elements which are activated by touch are occluded by the pressing finger.

Shneiderman's 8 golden rules still provide a good base to develop a high quality UI [17]. Hence, our goal is to try to apply all of them. One rule of easy reversal of actions is particularly important in our case to provide a way to undo actions or decisions during an MCI to avoid mistakes and undesirable frustration. Additionally, the UI has to be highly intuitive because a special training for each AIO would cost money and time. The user should also be able to immediately understand and grasp the information presented by the UI and hence perform the basic interaction with the application. Last but not least, the target group, the AIO, will reject a new application if the learning phase is exhaustive.

We additionally consider Norman's 7 design principles [16]. One principle is especially important to allow to interrupt each process during an MCI. This is because the real context during an MCI has the highest priority, the application itself is just complimentary. If an important event occurs, which has to be handled immediately, the AIO should be able to do both: a) Interrupt the current process completely and switch to a new one; b) Suspend the current running process and concentrate on the real environment. For the latter reason, a clear system's state perception by the user [16] is even more relevant in an MCI.

4.3 Special Requirement

The special situation of an MCI does not only emphasize the existing conventional UI requirements, but it also introduces new special requirements. The fire department staff of the Technische Universitaet Muenchen (Feuerwehr TUM) have been using a tablet PC in their daily work (see Fig. 2).

They hold the tablet PC in one hand while interacting with it with the other hand (see Fig. 1 (b)). Although, this way of interacting with the tablet is better than with a notebook (see Fig. 1 (a)), it's still not ergonomically optimal. Based on their experience, the fire department staff expressed the fact that it is exhausting to hold the tablet PC in one hand. They also tried to find a practical hardware solution, for example to carry the tablet PC with a shoulder carrier bag. However, mounting the heavy device to a person was not accepted because it would hinder the person's body movement. For this reason, the goal of this work is to adapt the UI to make it possible to interact with the device while holding it in both hands as shown in Figure 1 (c). Therefore, only the user's thumbs can reach the edges of the screen. Consequently, all UI elements has to be placed on the edges of the screen (see Fig. 2). The size of the bezels of the used tablet PC are not symmetrical, in fact the right bezel is significantly larger than the left one. Consequently, the available space for the interaction areas are also not symmetrical. We flipped the screen 180 degrees to adapt the tablet PC for right handed people. Thus, the original right bezel of the tablet PC with the hardware buttons moved to the left side and the thin bezel moved to the right side. Based on our informal testing we decided to use 19mm for the left interaction area and 44mm for the right one. Finally, even if the the heaviness of rugged tablet devices decreases because of the technology progress, we expect that this thumb interaction concept will still be more comfortable and more ergonomic in the field of ubiquitous computing.

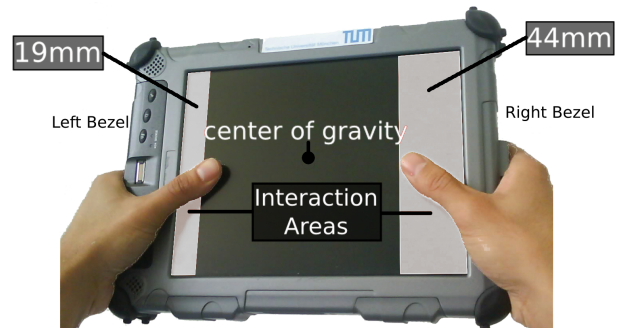


Figure 2: Tablet PC xplore iX104 held in both hands

5. FOLLOW UP CONCEPTS TO SELECT PATIENTS

Three different concepts to select patients on a digital map were developed. All of them generate a sub-list of patients which can be mapped to the interaction areas on the the edges of the screen. In the interaction area, the patients will be selectable simply through soft buttons, which can be reached with the thumbs. The soft buttons are labeled with the corresponding patient's triage id.

Red Bar (SE1.2). One concept is called the Red Bar. That is a horizontal transparent red bar which appears if it is activated by touching its control on the right-hand side of the screen. The user can move the horizontal bar up and down by moving the thumb up and down. The horizontal bar always follows the user's thumb. Each patient that is inside

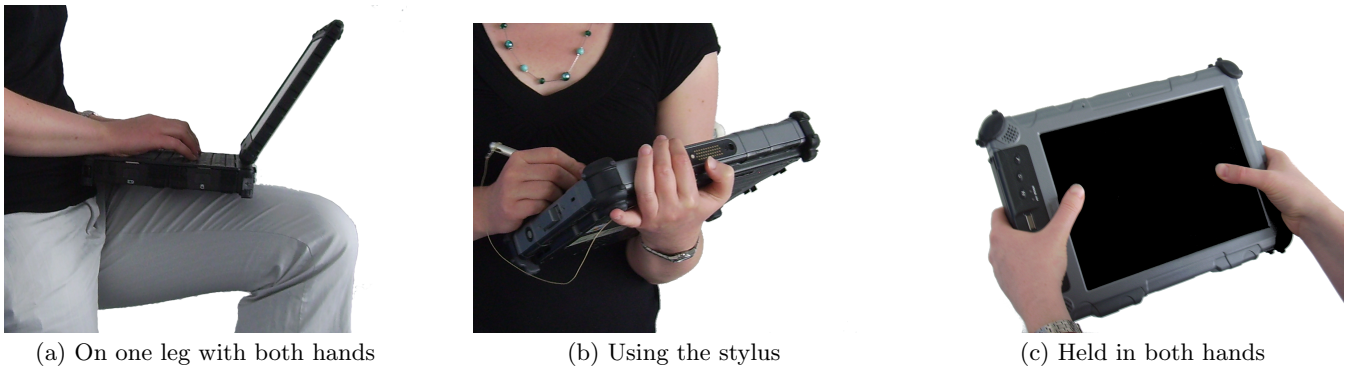


Figure 1: Tablet PC xplore iX104

the horizontal bar is mapped to the sub-list of patients (see Fig. 3). For each patient in that sub-list, a button will be placed on the left hand-side of the screen. We additionally added a feature to resize the horizontal bar. We couldn't use dual-touch gestures because our tablet PC is a single-touch one. Thus we added an arrow-area on the bars' control to resize the bar's height by dragging the arrow-area up or down. In the previous version, the bar was a non-resizable line. But according to the users' feedback in the previous evaluation, it was difficult to select patients due to the thinness of the line.

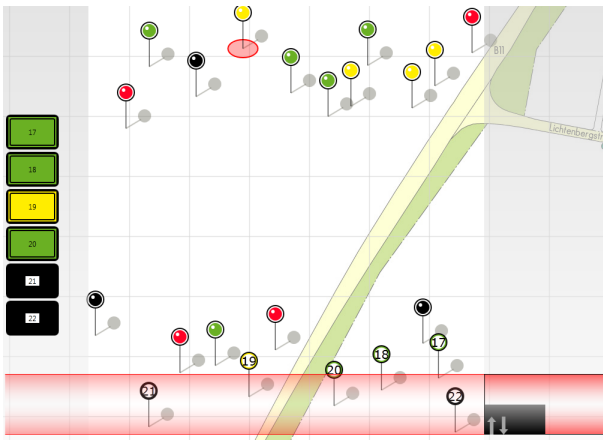


Figure 3: Red Bar

Selection Quad (SE2.2). Another concept is called the Selection Quad. A movable and resizable transparent gray quad is initially centered on the screen. Each patient which is inside the quad becomes a part of the sub-list and is selectable with a soft button placed on the left hand-side of the screen. The quad is moved with a virtual joystick placed on the right hand-side of the screen. Two buttons to increase or decrease the size of the quad are attached to the virtual joystick (see Fig. 4). We also took into consideration the users' feedback, to improve the design of the selection quad. In fact the previous quad had only an orange colored edge that could be interpreted for a color code. The joystick represents a virtual joystick that allow the user to move the

quad in all directions with an adjustable speed and it has been described by Coskun et al. in 2010 [3, 4].

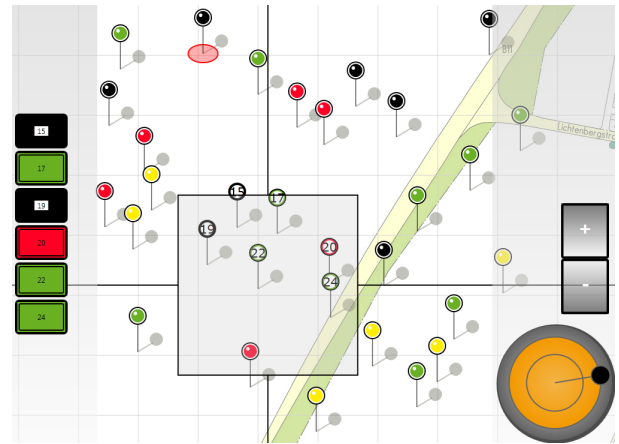


Figure 4: Selection Quad

Automatic Mapping (SE3.2). The last concept is called Automatic Mapping. It works like a split screen. Each patient on the left half-side of the screen is automatically mapped to the left edge and each patient on the right half-side of the screen is mapped to the right edge. In our first evaluation this concept was preferred by the test users. Consequently, it has been kept like the previous version. But we changed the setup of the evaluation to be able to emphasize both: the advantages and the disadvantages. This is described in Section 6.3.

6. EVALUATION

The previous evaluation revealed some weak spots in the concepts and showed some tendencies of the users but no absolute results. The automatic mapping was rated the best selection interface among the tested selection interfaces. However, the analysis and the interviews of the previous evaluation showed a clear influence of the defined task on the results. In fact, the Automatic Mapping was the best fitting selection alternative for the given specific task, and not the best selection alternative in a digital map in general.

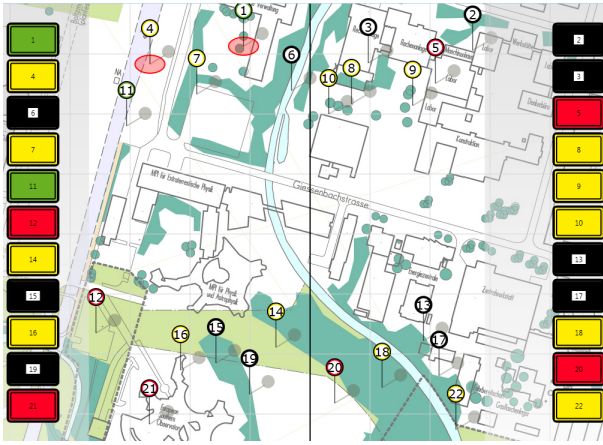


Figure 5: Automatic Mapping

For this reason, we redesigned the tasks to highlight both: the advantages and the disadvantages of each selection alternative. The design of the evaluation is described in Section 6.1. This is followed by presenting the demographical data of the participants in Section 6.2. Finally, the procedure of the evaluation is specified in Section 6.3.

6.1 Evaluation Design

The evaluation is composed of the following three steps:

1. Preevaluation
 - Analyzing and discussing the results of the previous evaluation among a group of user interface experts.
 - Eliminating the shortcomings.
 - Improving the concepts and the evaluation design.
2. First Formal Evaluation
 - Evaluate the concepts with participants who are not members of the rescue service.
 - Optimize the task setup and the concepts according to the first obtained results.
3. Second Formal Evaluation
 - Evaluate the concepts with the **real target group** (AIOs).
 - Optimize the concepts according to the second obtained results.
 - Learn from the feedback of the target group to improve the UI.

6.2 Participants

1. Preevaluation. The informal pre-evaluation has been performed among 5 User Interface experts. The optimized UI elements were discussed as well as the new evaluation tasks. As a result of these discussions, the final task setup was defined and the application was ready for the first formal evaluation.

2. First Formal Evaluation. According to Nielsen, it is recommended to have between three to five participants to evaluate a UI. More users will not necessarily increase the benefits of the evaluation [15]. To make sure that the evaluation procedure is well designed, we first performed the evaluation with 5 students (4 male, 1 female). All of them are between 23 and 25 years old, have experience in using touch screens on smart phones, and are right-handed. The goal was to evaluate the introduced UI elements independently of the rescue service to evaluate the general usability of our edge interaction UI elements. We used a within-subject design where each user of the latter group evaluate all UI elements in a randomized sequence.

3. Second Formal Evaluation. The second formal evaluation was performed by five **Ambulant Incident Officers** (AIO) from the **Arbeiter-Samariter Bund** (ASB) Muenchen, i.e. our target group, they are all males aged between 27 and 46 (36.4 in average) and right-handed. Four of them confirmed having experience with touchscreens. But we were more interested in their experience as an AIO. Consequently, the feedback of the second group is a prerequisite to develop a UI which increases the acceptance of the SpeedUp system. We used a within-subject design for this group.

6.3 Procedure

To find out usability issues and to be able to rate the different UI alternatives, the participants have to experience the UI elements. For this reason, we again defined tasks to be solved by the participants. We designed the tasks to fulfill both: Represent a real task in the target group environment and to accentuate as mentioned earlier the advantages and the disadvantages of each alternative.

The participants' task was to select geographically presented patients on a 2D map application with the introduced UI elements on the rugged tablet PC. This time each selection task was divided into 4 rounds. Each round was especially designed to emphasize the advantages and the disadvantages of each selection alternative. The participants had to solve each round with all the alternatives (within-subject design) in a random order to compensate the learning effects. The features to scroll or zoom the map were disabled to avoid influencing our results for the selection alternatives. The application automatically centered the map to the correct position for each round. The patients' positions were predefined for each round.

The user had to select only a subset of the presented patients for each round. The patient to be selected next was marked with a red ellipse as shown in Figure 6. If more than one patients were marked, the participants could choose their own sequence. Thus, the user had to realize which patient to select using the current selection alternative and to add this patient to the selectable sub-list on the interaction areas of the tablet PC's edges. The selection is then performed through soft buttons.

A message informs the participants whether a marked patient was selected or not. The task was resumed in both cases. In the failure case, the participant could immediately retry to select a marked patient. Otherwise, the ellipse was

removed and the participant could either continue with the next patient or with the next round. From the second round on, the participants had to execute multiple selection sub-tasks during this round. Those sub-tasks have the same positioning of the overall visible patients, but the distribution of the marked patients to be selected is either clustered or loosely distributed.

For each participant (in both formal evaluations), the application automatically logged the time needed to select each patient. The participants were also taped while solving the tasks on the tablet PC. This way, additional analysis could be done afterward. When a participant finished all four rounds with one selection alternative, they were asked to fill out the SUS (System Usability Scale) questionnaire which is a fast usability scale [2]. Finally, a recorded interview has been conducted for each alternative.

The first round. The participants had the opportunity to learn the respective UI element and the task to be solved. Four patients were randomly placed on the map current cutout. The logging of the selection time duration was deactivated for this first round. We clearly informed the participants that the focus was not on speed of execution, but rather on understanding the selection alternatives. Once this is explicitly confirmed by the participants, the second round could be started. The participant could continue only if no misunderstanding remained.

The second round. For the second round, a cluster of patients was placed on the upper left edge of the current screen's cutout like shown in Figure 6 to depict a realistic positioning of injured people in a real MCI. The main reason behind this setup is to verify the assumption that the positioning of the patients influences the performance of the selection alternative. In the Automatic Mapping case for example, most of the visible patients will be placed on the left edge of the screen, since those patients are actually on the left half of the screen. This leads to a large number of soft buttons and hence the search task of the corresponding selectable patient button gets complicated and its size gets impractically small. As a result, the selection speed will suffer from this additional complication (*Assumption 1*). This is not necessarily the case for the red bar and the selection quad, because of the user's possibility in resizing these elements. The evaluation will allow to verify our assumption.

The third round. For the third round the patients were spread out on the upper and lower edge of the screen like shown in Figure 7. The distribution of the patients on the left and the right half was similar in terms of the patients' density. According to our experience from the previous evaluation and given this patients' distribution, we expect, that the automatic mapping will be the most efficient alternative in this round (*Assumption 2*). An overall of 22 patients were placed in round 3. Then, if the participant increases significantly the size of the selection quad or the red bar, a large number of the mapped buttons on the left side of the screen will be visible which again will introduce some additional complications. Based on our experience from the previous evaluation, we know that an automatic resizing of the selection quad limiting the selectable sub-list to a specific number, i.e. the patients' number within the quad or



Figure 6: The patients' distribution for round 2 showing the active Automatic Mapping (splitscreen)

red bar, confuses the users. Thus, in the current evaluation, manual resizing was enabled instead of the automatic one. We expect, that the resize feature of the red bar and the selection quad will not be used frequently (*Assumption 3*).

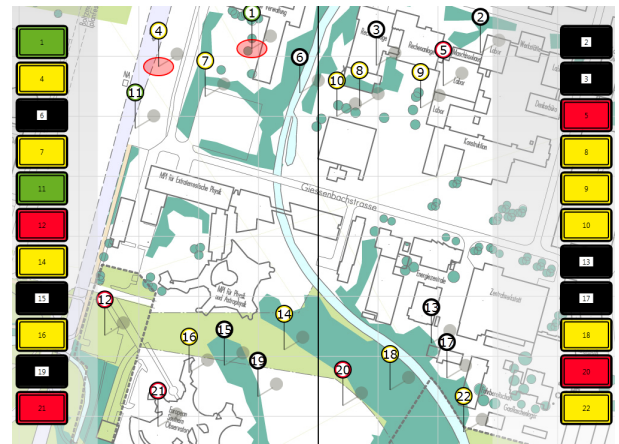


Figure 7: The patients' distribution for round 3 showing the active Automatic Mapping (splitscreen)

As previously mentioned, the rounds was segmented into multiple sub-tasks. The positioning of the 22 patients was the same for each sub-task, but the marked patients to be selected by the participant was predefined to be either clustered or loosely distributed. The goal was to find out if the red bar performs better than the selection quad in both distributions (*Assumption 4*). We expect that, because the red bar moves in one dimension while the selection quad moves in 2 dimensions.

The fourth round. The goal of the fourth round was to emphasize the disadvantage of the automatic mapping. In the fourth round of the first formal evaluation, 22 patients were loosely distributed on the screen, 11 were on the left half and the other 11 were on the right one. The first formal evaluation showed, that this amount was not large enough

to emphasize the disadvantage of the automatic mapping. For this reason, the number of the patients were increased for the second formal evaluation to 32 (see Fig. 8). To be able to place a button for each patient on the screen edge, the size of the buttons were accordingly reduced. Thus, we expect that the automatic mapping will be the worst in terms of performance in this case compared to the other 2 alternatives (*Assumption 5*).



Figure 8: The patients' distribution for round 4 showing the active Automatic Mapping (splitscreen)

7. RESULTS

The results can be classified into three categories: (1) Automatically logged data (speed and clicks), (2) Results from the SUS-questionnaire and (3) Subjective feedback from the interviews. These categories will be respectively described.

Logged Data. The mean values of the time that the participants needed to solve the tasks are illustrated in Figure 9 for the first formal evaluation and in Figure 10 for the second one. In both figures, diagram (a) shows the mean values for the sub-tasks where the patients were clustered while diagram (b) represents the results in the case of loosely distributed patients. Diagram (c) depicts the mean values per round. The overall time duration for all tasks is then summed up in Figure (c). The logged data show that for nearly all setups the Automatic Mapping (split screen) was the fastest selection alternative, independently of the patients' distribution. For instance, the AIOs needed a mean value of 160.1 seconds and 120.2 interaction clicks to solve all tasks with the Red Bar, a mean value of 188.5 seconds and 114.2 interaction clicks in the case of the Selection Quad (controlled with the joystick), and a mean value of 121.8 seconds and 83.4 interaction clicks in the case of the Automatic Mapping (split screen). The mean number of the interaction clicks per round can be obtained from table 1. For all rounds and for both groups the Automatic Mapping has the lowest mean values among the three selection alternatives.

Based on the logged data, the Automatic Mapping clearly and quantitatively seems to be the fastest selection alternative.

Round	G1	G2	G1	G2	G1	G2
2.	29.4	38.0	35.4	33.6	25.2	26.6
3.	39.0	30.4	34.2	28.8	21.5	20.0
4.	34.6	51.8	41.2	51.8	25.6	36.8
Σ	112.4	120.2	110.8	114.2	72.4	83.4
	Red Bar		Joystick		Split Screen	

Table 1: The interactions (clicks) needed for each round and selection alternative. G1 = Group of first formal evaluation; G2 = Group of the second formal evaluation (AIOs)

SUS - Questionnaire. The SUS scores of the first and second formal evaluation are illustrated in Figure 11 and in Figure 12 respectively. For both groups the outcome of SUS for all presented selection alternatives are distributed mainly between 60 and 80. Our values are within the average of the SUS values studied by Tullis at al. in 2008 [18]. Considering the first group, the SUS values of the Automatic Mapping were spread out mainly above 90. According to Tullis at al. [18] a SUS score of 90 puts us in the top 5% of their SUS samples. This means that the users of the first group clearly preferred the Automatic Mapping. However, the SUS score of the second group, the AIOs, is smaller from the one of the first group. Each AIO rated the Automatic Mapping below 80, there was even 1 AIO, who rated it below 50. The joystick controlled Selection Quad and the Red Bar scores were comparable in both groups.

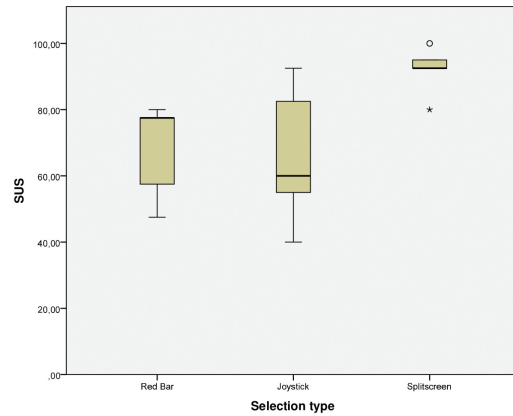


Figure 11: SUS scores for the first formal evaluation - performed with students

Interview. Some feedback was gathered from the recorded interviews. In the case of the Automatic Mapping, one participant of the first group suggested to split the screen in an adaptive way and not always at the half. The adaptivity is to ensure that there are always as many buttons on the left as on the right side of the screen. Another suggestion was to visualize the mapping between the buttons and the corresponding patient for example with a linking line. One of our participants was confused because of the appear/disappear-animation of the Red Bar. An AIO hinted that for mental reasons he would prefer to have just 1 list of buttons in-

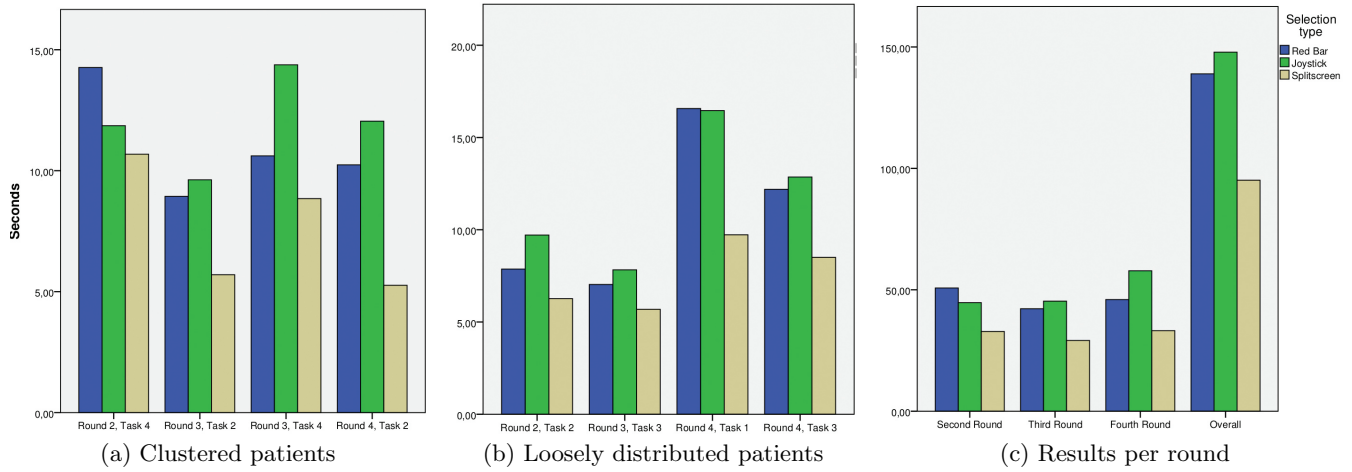


Figure 9: Time Mean values (sec) of the different evaluation setups in the first formal evaluation

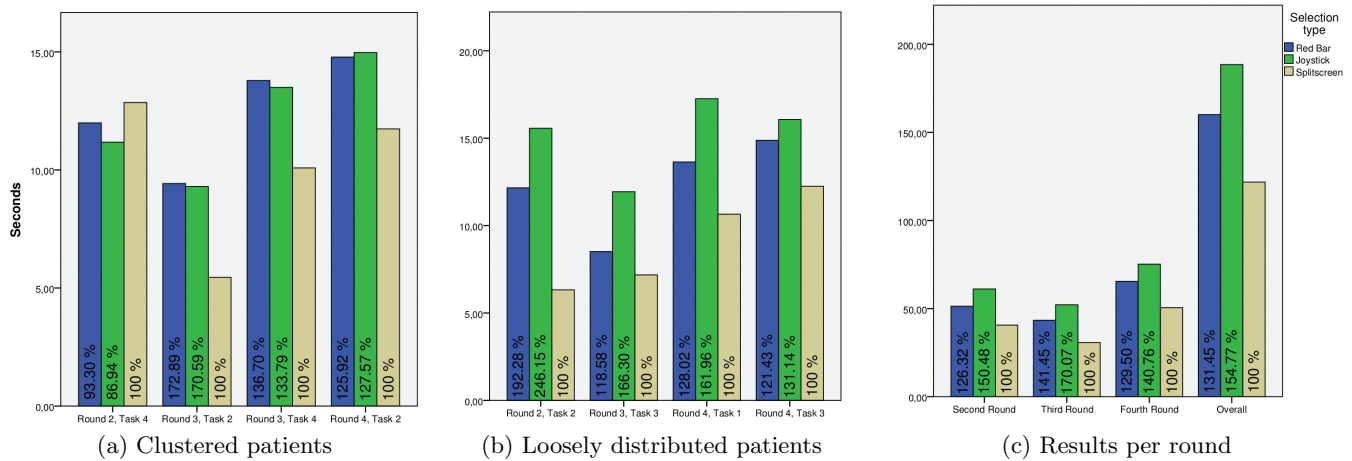


Figure 10: Time Mean values (sec) of the different evaluation setups in the second formal evaluation (AIOs)

stead of 2, as in the Automatic Mapping, since it requires less mental effort to search 1 list instead of 2. For the same reason he preferred the Red Bar: The bar is moved in one dimension which makes it natural to sequentially process all patients from the top to the bottom. The last worth mentioning suggestion is to develop a new selection alternative considering the operational sector of a real MCI. Thus, only the patients of the currently selected operational sector should be mapped to the sub-list.

8. DISCUSSION

Our first assumption was that the performance of the Automatic Mapping decreases when the number of displayed patients increases. The quantitative results could not confirm that, since in both the clustered and the distributed patients with small (22) and large (32) number of patients, the Automatic Mapping performed overall best. The SUS values of the first evaluation group (computer scientists) tend clearly to the Automatic Mapping. However, the second

group (the AIOs) were not completely satisfied with the Automatic Mapping. The interviews revealed that the reason behind that was that the AIOs were all the time associating the presented selection alternatives with a real MCI. And that is exactly the motive behind the second formal evaluation. Although they needed less clicks and less time to solve the tasks with the Automatic Mapping, all of them agreed, that in a real MCI it is more likely that an AIOs selects one patient to interact with it, for example adding and collecting some data from the patient, instead of selecting all of them non-promptly. Overall, our quantitative results show that the Automatic Mapping was the most efficient selection alternative. Consequently, there seems to be a trade-off between efficiency and the acceptance of the target group. One AIO mentioned, that he prefers the Red Bar for the following reason: Since all involved people during an MCI are in an extreme and dangerous situation, he prefers to do one task at once and concentrate on that. With the Red Bar it is possible to process the task step by step from top to bottom.

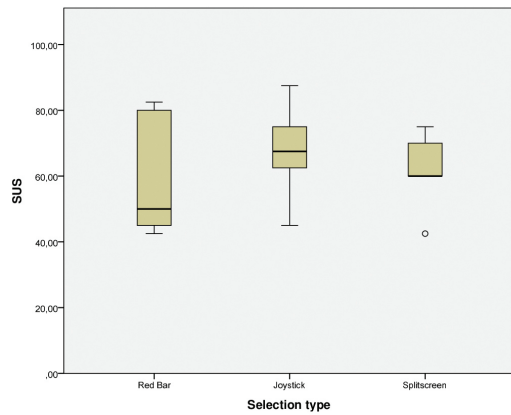


Figure 12: SUS scores for the second formal evaluation - performed with our target group (AIOs)

This is like scanning the map vertically like in a checklist. This may be a strong positive psychological impact of the Red Bar.

Our second assumption was that the Automatic Mapping performs best in round 3. This was true for all of our results. Thus, the Automatic Mapping is very efficient if there are not too many patients. This confirms what we expected.

Our third assumption was, that the feature to manually resize the Red Bar or the Selection Quad will not be used frequently. The video analysis showed, that half of our participants used the resize feature. But in most cases, they just set the size initially and did not change it meanwhile. However, our interviews and our observations could not point out any confusion due to the resize feature of the Selection Quad. Even though our assumption was true in the case of this study, some of the participants mentioned that they would need this feature.

Assumption 4 was that the Red Bar performs better than the Selection Quad, whether the patients were clustered or loosely distributed. This assumption was indeed true in the second group (AIOs) for clustered patients. But the differences between the results of the Selection Quad and the Red Bar were too small to confirm this assumption. For the first group this assumption was not always true. Concerning the loosely distributed patients, even though the results of the second group would confirm this assumption, there were no significant results for the Red Bar, neither through the objective results nor through the subjective interviews and observations.

The last assumption was that the Automatic Mapping will perform worst in round 4, since both edges of the screen were full of buttons. Hence, the participants had to spend some efforts to find the corresponding button representing a patient to be selected. Although we increased the number of patients between the first and the second formal evaluation, to stress test the worst-case scenario for the Automatic Mapping, this assumption could not be confirmed through the quantitative results. However, the feedback from the AIOs on the Automatic Mapping highlighted some mental ef-

forts and work-flow shortcomings: Searching 2 lists instead of 1 increases the mental load of the user which should be avoided.

As far as efficiency is concerned, which in fact is a crucial requirement for electronic devices which are intended to be used in MCIs, the Automatic Mapping seems still to be the best choice among the presented alternatives. However, efficiency is not decisive if the target group does not accept the new device with the UI. This also confirms the fact that a user-centered development design is very important, since the results from the target group can entirely differ from the results of any other group. We had further discussions with 3 of the AIOs to be able to find a solution for this trade-off. The outcome of this informal discussion is an additional assumption: If the evaluation task includes more than just selection UI elements (enabled scrolling and zooming), the advantages of the Automatic Mapping can be reduced while the advantages of the Selection Quad might be emphasized. We believe that because of the fact that the Selection Quad is actually more than just a feature to select items. It additionally allows to scroll the map, center the map to a desired position and even to zoom it. These features were excluded in the current study, since we focused on the selection part to avoid any influences and to be able to have the same conditions for all selection alternative.

9. FUTURE WORK

Although we learned a lot from this study we are not able to just choose one of the developed UI elements. However, we know that the Automatic Mapping was not preferred by the 5 AIOs involved in the current study. The 5 AIOs all agreed on the latter fact, although they performed best in most of our evaluation tasks with the Automatic Mapping. We will design further evaluations of UI elements to scroll and zoom the map and combine those elements. We will also take into account the feedback during the interviews for our future development and improve our concepts. Furthermore, we plan to critically investigate our thumb-interaction-requirement. Finally, one of the AIOs will be largely involved in designing the next user study, focusing on realistic tasks in real MCIs.

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