A Mobile Application for Survey Reports: An Evaluation

Daniel Kohlsdorf, Michael Lawo, and Michael Boronowsky

TZI Universität Bremen, Am Fallturm 1,
28359 Bremen, Germany
{dkohl,mlawo,mb}@tzi.de

Abstract. In manufacturing processes damages occur caused by humans or machines. These damages have to be reported and documented, e.g. to enable a manufacturer to react in quality circles. The first part of this paper describes the process of creating survey reports. Furthermore a customized solution designed for mobile survey reports is introduced. In the second part this paper describes and discusses the advantages and disadvantages of this mobile solution in an automotive industry setting.

Keywords: Smart phone, survey reports, automobile manufacturer.

1 Introduction

Industry is interested to create fast and precise documentation techniques for survey reports as a basis for improved production processes. For this purpose most manufacturers are using paper or notebook based solutions in combination with a digital camera. The disadvantage of paper-based solutions is the need for digitalization, because this information is generally input to additional processes. By using a notebook the user is forced to concentrate on his documentation task and has no possibility to pay attention to the environment around the laptop. In general paper and notebooks are difficult to handle on the shop floor for several reasons.

In cooperation with an automobile manufacturer we analyzed the survey report process and developed a concept for the survey report as an alternative to an existing notebook based solution where MS Word© form sheets are filled in complemented by photos captured by a digital camera. When observing the workers on the shop floor performing these tasks it became clear that this was either unsuitable or inappropriate. Furthermore a notebook and especially its software offer unnecessary features beyond the need of the real usage context [1]. So we decided to create a mobile solution based on a consumer smart phone adjusted to the task and already carried with for communication purposes.

This paper describes and discusses the advantages and disadvantages of the mobile survey report. The smart phone application was compared to the notebook based solution using the NASA TLX acceptance test.

1.1 Scenario

The process of documenting manufacturing damages during car production consists of two parts. It starts with a dialog between the persons reporting and documenting

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the damage. Most information for the documentation has to be extracted from this dialog, like who am I, whom am I talking to, where is the damage and what kind of damage is observed on the car. The second part is to examine and document the damage itself (taking pictures etc.). In the best case the whole data needed for documentation could be collected and saved on the spot, which means on the shop floor at the damaged car. From the user interviews we extracted further information about the requirements given by the environment. Due to interference issues the application environment does not allow any use of Bluetooth© or WLAN but UMTS. Thus during a session data from the phone is sent to the server via UMTS. The other more important point is the need of high-resolution pictures. The users pointed out in the interview that the pictures are the main source for documentation and high quality is thus required. However, analyzing the users work with the image data we found out that high-resolution (five or more mega pixels) was not what the users mend. The survey report is printed on a black and white printer and the resolution really used is what a printer could display in a 10 x 10 cm^2 field. With a lower resolution the latency while operating will also be lower. Furthermore, processing large images on a mid range Smartphone disturbs the workflow of the application as it is a quite lengthy task.

We decided to use a Smartphone instead of a PDA, because the people, responsible for documentation, are all equipped with a smart phone. A smart phone is a personal artifact. It refers mostly to one person and this person is responsible for the device (like keeping an eye on the battery power). By using a PDA the company has to buy new devices, so obviously many users have to share a small amount of devices. In this case it is quite difficult to specify responsibilities.

Furthermore most users already know the normal handling and behavior of smart phones. Scrolling item lists is already known because the users search in their telephone book and working on images many users know from applications for simple image manipulation tools on their phones. In contrast to the smart phone a PDA application is not as mobile and easy to learn. On a PDA text input is mostly connected with an on-screen keyboard (Windows Mobile©) or a special stylus input (Palm OS). It could also be very difficult to operate a PDA application in such an environment like a manufacturing hall because both hands are needed, one for the pen and one for the PDA.

1.2 Related Work

One important field to acquire information unobtrusively on the shop floor is wearable computing. There are many solutions in wearable computing designed to avoid paper. One of them is the "Kato Aircraft Maintenance Application" [2]. This Application supports the maintenance worker in the aircraft maintenance process where, the worker gets information like manuals or lists of technical components by a head mounted display. The system is also designed for hands free interaction [3], realized with a data glove [4].

So the user has not to use any printed documents about his task and has the possibility to focus on the maintenance work and not on interacting with a computer. This would also be a quite good solution for survey reports scenarios but first of all it is expensive due to the hardware used, like the head mounted display, and hard to get. A second obstacle for using a "true" wearable solution for survey reports is that the documentation has to be created on the spot. In case of a wearable solution the user has to wear the devices all the time during a shift.

An advantage of using a smart phone is that most users are familiar with it. Some people, like Joseph Dvorak think that the smart phone will be the heart of the next generation wearable computers [5] and for sure smart phones have many design points in common with wearable computing solutions.

2 User Study

In this study we benchmark the two solutions (smart phone and notebook) in the survey reports scenario in a laboratory setting. We created a task simulating collecting the data for a survey report. With this benchmark we point out the time effort of a mobile worker from using a customized application on a mobile device.

Furthermore the users had to use the NASA TLX form for both devices, to evaluate the mental and physical load of the two interfaces in the mobile scenario.

2.1 Task

Fig.1 shows a survey report. This is the needed output for both, Smartphone and Notebook. The needed data is described in the following. The location of the factory could be extracted from the preselected data. The report number is increased by the backend application. The collection of the other data like damage or pictures is

Survey Report

Location: Bremen	**Report Nr:** 0062	**Damage Reporter:** Peter Noname
Type of Construction:	Front	
Worker: James Nobody	**Workers Tel.:** 0151 12345	**Date:** 24.12.2008
Description: Scratch on fender		

Fig. 1. A Survey report

described in section 2.2. The users had to collect all data needed for a complete documentation [Fig. 1] as:

1. Creating a picture of the damaged area and marking the damage.
2. Creating a picture of the damage itself.
3. Completing who is creating the documentation.
4. Completing who is reporting the damage.
5. Describing the damaged area.
6. Describing the damage.

2.2 Structure

The study took place in a prepared room simulating the shop floor environment. The damaged object was placed in the middle of this room.

The study began with a dialog between the damage reporting person (local staff - reporter) and the person collecting the data and creating the documentation (user). While talking to the reporter the user had to extract the information of the damage and input it on the mobile device. For example the reporter introduced himself while the user had to input the reporter's name on his device. Somewhere in this process the user had to take two or more pictures of the damage. Once with the camera integrated in the smart phone and once with an external camera.

On the shop floor possibilities of sitting down handling different devices are quite limited, so in our study we let the user sit down on a chair but without using a table.

For both devices we took the time the user needed collecting the data with a chronograph saving the recorded time in an excel sheet.

In the following the two applications used in this study are described:

- **The first application** is the notebook based one. The user collects the data in a word form sheet and takes pictures of the damage with a digital camera. The task does not include the download of the taken pictures from the camera to the notebook, because this benchmark only refers to the time needed for collecting the data and not for creating a document. The possibilities on the shop floor to work with a notebook are very limited, so during the study the only office furniture is a chair and the users have to put the notebook on their lap.
- **The second application** is based on a consumer smart phone with the Java Micro Edition installed. The used components will be described in the following [Fig. 2]. For data collection the integrated camera of the smart phone is used. The user interacts with the normal keyboard (Text on 9 keys enabled) and the directional pad. The survey report data is transferred to a backend application on a server. This application saves the data in an archive (File system). The backend application is also able to display the survey report as an html web page or a rich text format [Fig.1] document out of the archived data. For transferring the collected data UMTS is used (see 1.1).

  The application is divided into small steps. The user is working at a time on one part only. All steps together guide the user to create the complete survey report. This is a main concept of mobile interaction [7].

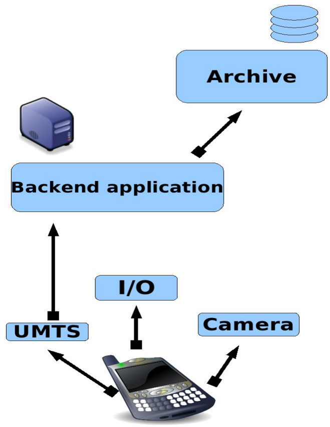

Fig. 2. Architecture of the smart phone application

In the first two steps the user can choose out of a choice of users and reporters. Names and contacts are taken from the smart phone address book. In the second step the user has to take two pictures with the integrated camera, an overview picture of the damaged area and a more detailed picture of the damage itself. Furthermore the user has to assemble the taken pictures to one [Fig. 3]: the first step of the assembly is to move a circle, with the navigation cross, over the damage in the overview picture [Fig: 3a] and after confirming the circle position, the detailed picture appears in the upper left corner of the screen. The user then can place the detailed picture in one of the corners of the screen by pressing the navigation cross to the left or the right [Fig. 3b/3c].

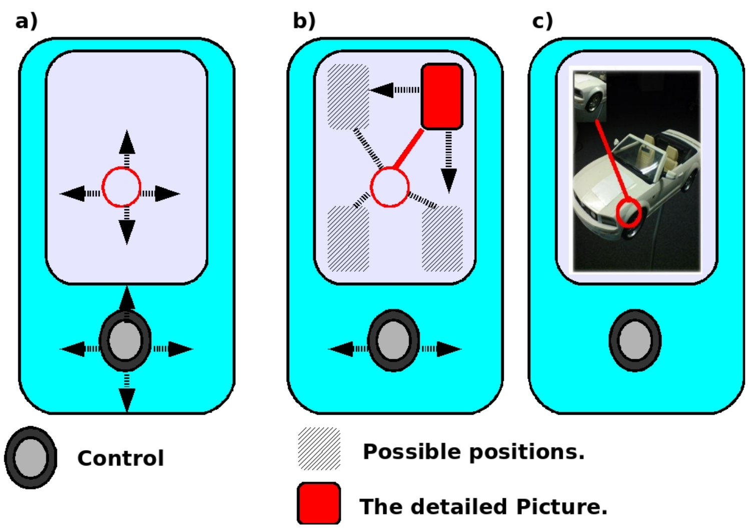

Fig. 3. Concept of creating the assembled picture on the smart phone

The damaged area has to be chosen from a graphic model of the car. By pressing the navigation cross to the left or the right, the adjacent area is highlighted, the previous area switches to normal color [Fig. 4].

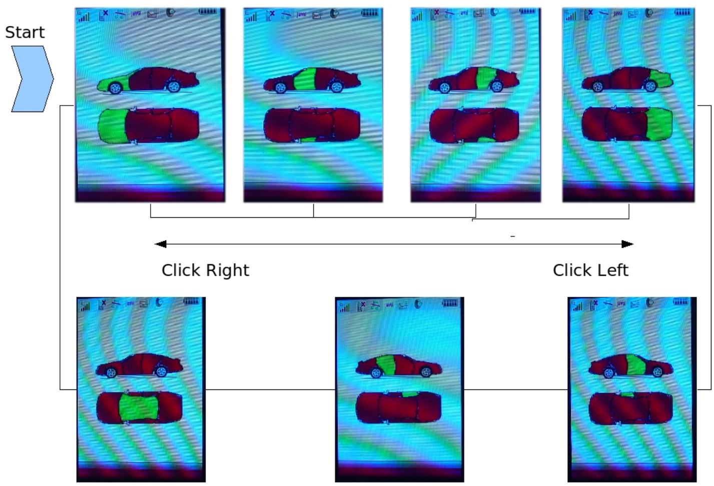

Fig. 4. Choosing the damaged Area

With the information of the area the system is able to extract the damaged components. The damage-describing phrase is built in three steps [Fig. 5, steps 2) Damage to 4) Component]. Every step is displayed as a list of elements or keywords from which the user can choose one. The first step is to choose a type of damage, the second is to choose a preposition and the third is to choose the damaged component. The list with the damaged components consists only of the extracted elements from the area information and not of all elements.

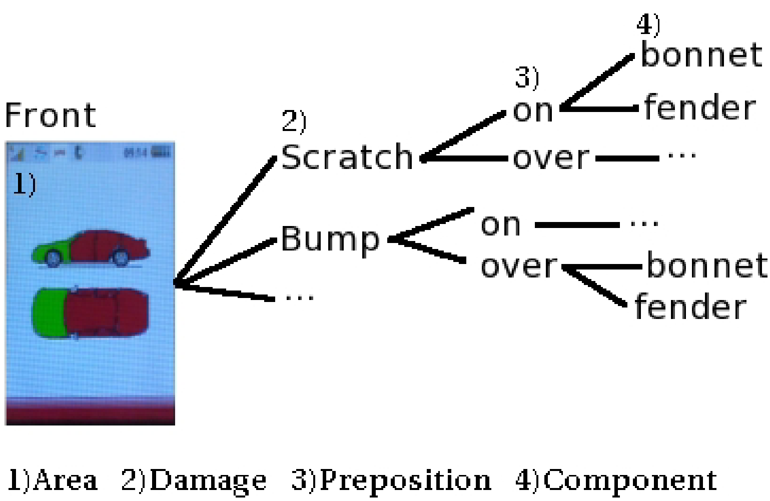

Fig. 5. Menu structure for creating a damage-describing phrase

2.3 Analysis

The study was performed with 15 people for the benchmark and the NASA TLX form. The users were mostly recruited from local staff, family and friends. The difference of the average time needed to collect the data on the smart phone and on the notebook was about half a minute.

The average time on the notebook is 1.6 minutes, and on the smart phone 1.3 minutes. Using the smart phone application is 19% faster. The maximal difference between the two applications for a single user was 1min, quite a long time for handling a task.

The results of the NASA TLX forms meet our expectations (see [Fig. 6]).

The mental demand is a bit higher on the smart phone (Smartphone 2.6, Notebook 2.2). But most users know their Word on the Notebook much better than a new application and have to pay more attention to this application at first. The physical demand is quite lower while using the smart phone application (Smartphone 2.1, Notebook 3.5). Most users named the use of two devices at a time as a reason for the higher physical demand (camera and notebook).

The users also felt a bit more hurried up because of the loss of time while changing the devices. They also considered that their results were much better on the smart phone. The felt effort of the users was also higher on the smart phone (Smartphone 2.3, Notebook 3.4). This may be caused by the user- or process-centered design of the application. The frustration on the smart phone is also lower than on the notebook and the lowest point in the study (Smartphone 1.3, Notebook 2.5). In the whole the Task Load Index of the Smartphone is about 2.7 and of the Notebook solution 4.2. The Smartphone application user interface proofs to be quite smooth and easy to handle; the TLX value is 36% lower. Standard deviations are similar for the different aspects with both devices.

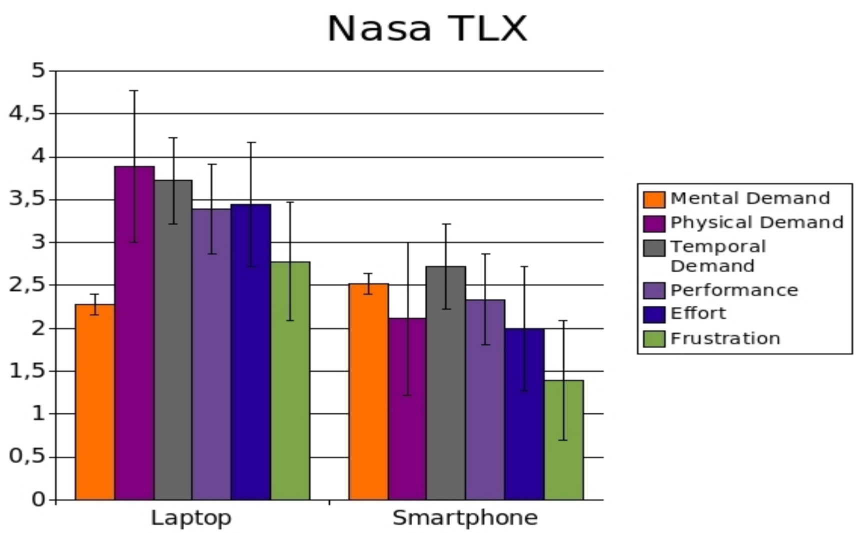

Fig. 6. Result of the Nasa TLX analysis

3 Discussion

The disadvantages of the smart phone application are small input and output devices. Some users criticized the small display and the small keyboard. While designing the application we tried to avoid typical mistakes like placing useless icons or information on the screen, confusion or loss of orientation in huge menu trees [6]. And this seemed to be a key feature of the application. Another strength is that the application is customized for the scenario. Assembling the pictures in Word or searching for the right contact data are only a few obstacles the user has by using a notebook. Also handling two devices instead of one could be quite difficult. These are actions where the users lost time on the notebook during the study.

Creating the final document is not mentioned in the study. But we built a special documentation server where the mobile application mails the collected data. The server creates a word document out of this automatically. On the notebook the user has to copy the pictures from the camera to the notebook and has to assemble the picture. So when implementing the solution the difference between notebook and smart phone would be much larger than shown in this study.

The NASA TLX results point out the advantages and disadvantages the users see in the smart phone application. Most of them had to concentrate a lot on the application during the study. Furthermore many users felt hurried up. On the other hand most of them agreed that this application helps to speed up the task and is easier to handle.

The application is an exhibit of the demo center at the mobile research center Bremen [6] where mobile and wearable solutions developed in research projects can be tested by the public [Fig. 7]. The feedback of many visitors to the smart phone application was quite positive. Most people mention other scenarios for application.

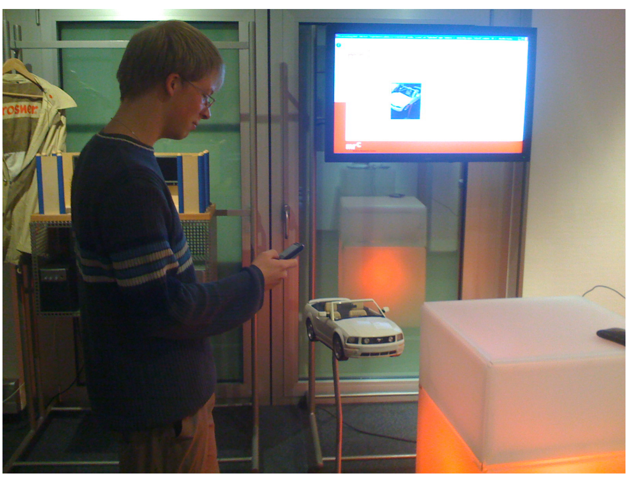

Fig. 7. Visitor of the demo center testing the application

4 Future Work

A further study is planned analyzing and evaluating the data quality of the results from both solutions, as our smart phone solution is expected to improve the quality of survey reports. For this study specialists working with the documentation are recruited. Furthermore the application will be evaluated compared to a solution based on an ultra mobile computer like the OQO.

An Ultra Mobile Personal Computer like the OQO could fix the problems with too small displays and keyboards but is linked to the problem of the camera as a second device. Maybe the most important point to do is a field test. We tried to rebuild a situation in our lab near to what is happening on the shop floor. But this is an abstraction and we have no experiences with this application in a real setting.

The application can be also transferred to other scenarios like survey reports for insurance companies in car accidents. Here adding GPS support for tagging information about where the accident happens could be advantageous. Survey reports for wind turbine maintenance are a further application we have in mind.

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