Freiform: A SmartPen Based Approach for Creating Interactive Paper Prototypes for Collecting Data

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Abstract. The creation of multi-modal data collection is a complex task for all empirically working scientific disciplines. Currently the data is collected using complex audio-video technology and is then manually processed, quite often in a computer supported way. In this project we developed a system allowing to easily create interactive paper prototypes for collecting data. The systems is based on smart pen technology, which allows the user to simply sketch out the form on paper by defining the field type and the field size. Once the sketch is available on paper, data collection can start. The system runs directly on the smart pen. Collected data will be stored in an XML-based, which can be further processed by external programs.

Keywords: interactive paper prototypes, electronic pen, data collection.

1 Introduction

The creation of multi-modal data collection is a complex task for all empirically working scientific disciplines (e.g. social sciences, psychology, linguistics or educational science). Currently the data is collected using complex audio-video technology and is then manually processed, quite often in a computer supported way. In order to collect the data, complex experimental setups have to be constructed, which are in many ways interfering with actual situation under investigation.

In this project we developed a system allowing to easily create interactive paper prototypes for collecting data. The systems is based on smart pen technology. A smart pen is an "electronic" pen that records it's movements and also creates an audio recording. The pen is equipped with a small text display and is able to play back sound files. The tracking of the pen's movement is realised by a micro pattern, which is printed onto the used paper, which is then analysed by a built in camera of the pen. As such, it becomes possible to store the collected data digitally, while having a paper transscript at same time. Applications for the smart pen, so called penlets, are written in java and are being uploaded onto the pen. A demonstration video of the running system can be found at the our media server[1].

[1] ‘‘mms://mediasrv.hs-fulda.de/FBAI/public/MUC2012/freiform_demo_1080.wmv"

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2 Defining Interactive Forms

The *Freiform* application allows to easily sketch out forms for collecting data on paper. Different types of input fields can be defined: text fields, number fields, counting fields, start and stop buttons, timing fields. The user is sketching out tool buttons for drawing the interface of the actual data collecting form.

Fig. 1. A number field containing 4 digits is interpreted as a single value

2.1 Sketching Out the User Interface

In doing so, he is not restricted in any ways, that is, any possible design can be sketched out. The process of creating the data collecting form is a two step process. First a couple of letters or symbols have to be written down. These symbols mark the tool buttons that will be later used to define the actual data collecting interface.

Fig. 2. Startup screen on the pen

The user interface of the Freiform system is maximally reduced, as the electronic pen is only equipped with a single line text display (see figure 2). Navigating through the pen's internal system menu is achieved by pointing the pen at a cursor cross printed onto the paper. Acoustic and visual feedback is given to the user. Starting the Freiform application requires a couple paper clicks.

Once the application is started, no further explicit navigation steps have to be initiated. Instead of providing a complex menu system, we have tried to model an optimal workflow, which will guide the user in an intuive way through the creation process and the data collecting process. Informal usability tests have shown, that users very easily adapted to the proposed interaction concept and were able to use the pen almost without any training.

During the first phase of form creation the user needs to set up the tool buttons for defining the data fields of the actual form. This step is nesseary, as we wanted the system to be as flexible and independent as possible. The user is completely free to use her own language and is able to design the interface using her prefered symbols. This approch allows to design minimal interfaces as well as interfaces with a more detailed design structure. It would have also been possible to print out the tool buttons onto the paper. We put down this approach, as we would to like to support the idea of *sketching out* functional interfaces in this research.

The only limitation to this idea is the design of the user interface on the pen itself. Here textual output had to used for communication, so we had to decide for a system language (currently English). The implementation restrictions make it hard to replace the interface language, as external ressource files are not provided by the smartpen API. Another approach would have been spoken language output through the built in speaker. Again, while this would have supported the workflow and could have lead to a more efficient form design process, yet we discarded this idea. The pen should be used in a non disturbing way, e.g. during an interview session in field work. Acoustic output would have interfered with these kind of delicate research situations.

In the example form we are using letters to mark down the tool buttons. The Freiform system instructs the user to write down the initial letter of an english term describing the tool category. When defining a *label* tool button, the user should write down a capital L (see figure 3).

Fig. 3. Defining a label tool button

Step by step the user has to mark down symbols for all tool buttons. Following the label tool button, the user is asked to define the *text* tool button. Again the inital letter should be used (see figure 4). This process is continued until all tool button are visible.

The user is not restricted to using letters for denoting the tool buttons. Any symbol could be used. In order to identify the end of sketching out a tool button symbol, we needed to define a timeout period. A symbol will be identified by continuously drawing strokes. Once the user stops drawing for more than a second, the strokes will be stored by the system and the user is requested to draw the next tool button. The timeout approach makes it possible to write down words and phrases as part of the user interface. As a result of this implementation, sketching out the tool buttons is very simple and very intuitive.

Fig. 4. Instructions for defining a text field

2.2 Sketching Out the Interactive Form

Once all tool buttons are defined (currently 6 tool buttons are available), the actual data collecting interface can be sketched out. The user clicks onto the tool button he likes to draw and then sketches out the data collecting field. This step is repeated until all fields of the form have been drawn.

In our example form three data fields have been defined: a text field, a number field and a counter field. In addition three labels have been written down, making it easier for the user to identify the semantics associated with a specific data field. These labels are optional.

In order to create a minimal form, only the outline of a data field has to be drawn. The graphical form of the drawing is ignored. Instead its bounding box is calculated. All user input, which is marked down inside this bounding box area will be associated with the data field. In the example an L shaped form is used for the data fields. This form is simple to draw, supports the user during the data collection step and the bounding box of the data field can be easily indentified (see figure 5).

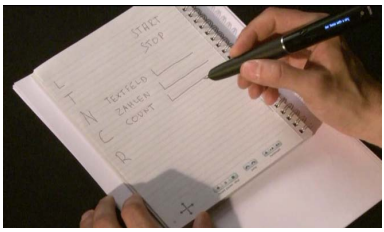

Fig. 5. The final form consists of three labeled fields

More data fields can be added to the form. The system stays in the sketching mode until the user decides to start recording data. In order to get into record mode, the user has to activate the record tool button. It is also possible to return to sketching mode by activating the record button one more time (see figure 6).

Fig. 6. Once the sketch of the form is finished, data can be recorded

2.3 Collecting Data with Interactive Form

At this final step the interactive paper prototyp ist ready to be used. During data collection, the user writes down text into the text fields, sets marks into the counting fields or jots down numbers into the number fields. The pen is able to analyse the data, therefore digitizing it and stores it on the pen. Once the data collecting process is finished, all data can be transfered to a computer. The data is transfered as an XML file, which can easily be processed further by other applications.

In our example form, a counter field had been defined. As the name suggests, counter fields are used to store numerical data, where, in contrast to a number field, the data is stored grafically. The system analyses the user input and tries to identify separate strokes. The visual appearence of the stroke is not relevant. A standard way of marking down counts are simple lines. As can be seen in the figure 7, five strokes have been drawn by the user, four parallel strokes, with one final stroke overlapping all other. Overlapping strokes do not pose any major problems for the system.

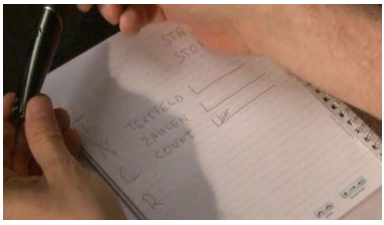

Fig. 7. Five strokes insode the count field

Each data field is internally associated with a specific variable holding its current (interpreted) value. As we have put down five strokes inside the area of the counter field, the value amounts to five. Every time a change in value is detected, the current value will be prompted to the user (see figure 8). No acoustic feedback is given here.

The number field is is used to collect numerical data. Here the internal OCR system of the pen is processing the strokes and provides the appropiate digit to the Freifom system. The final field value will be calculated based on these digits

Fig. 8. Counter has value 5

(see figure 1). The text field works similar to the number field. The internal OCR of the pen tries to identify the letters and joins bigger units like words or phrases. Unfortuneatly, the OCR does not work as robust on letters as it does on digits. Even with block letters the recognition is error prone (see figure 9).

Fig. 9. OCR on text field is not really robust

3 Conclusions

The Freiform system allows to easily sketch out interactive paper prototypes. In order to design a data collecting form, the user is requested to draw a number of tool buttons, that will then be used to sketch out the actual data collecting form.

An important feature of the chosen approach is it's very low technological entry point. Writing down notes with a pen is a common scientific technique and is generally accepted. Defining the paper prototype is very simple and does not require a high level of computer skills.