Physical paper as the user interface for an architectural design tool

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Abstract: Early architectural design is a typical example where traditional design tools such as sketching on paper still dominate over computer-assisted tools. Augmented reality is presented as a promising approach towards developing an interaction style that preserves the naturalness of the traditional way of designing, while at the same time providing access to new media. Using the Visual Interaction Platform (VIP-3), a first prototype tool that supports a combination of virtual and physical paper has been realized. We discuss some of the unsolved problems and potential benefits of a user interface based on physical paper.

Keywords: Augmented Reality, Natural User Interface, Pen interaction, Architectural design

1 Introduction

In current architectural practice, preliminary designs are mostly created on paper and/or in a scale model before being converted into a representation in a CAD (Computer Aided Design) program. Only few computer tools are available to assist designers in this early (or conceptual) design stage. The problem of introducing computer technologies at this stage is that the designer needs freedom, speed, ambiguity, vagueness, etc. to quickly create the (usually only partially specified) objects that he/she has in mind. This absence of strictly predefined rules, which is inherent to the traditional design media, is lacking in currently available computer tools.

Preserving the characteristics of traditional media, while at the same time augmenting them with access to new functionality, is the design philosophy underlying augmented reality. Because of the importance of physical pen and paper in current architectural design, augmenting paper seems a promising approach towards improving architectural design tools. By using augmented reality we can for instance try to establish a direct link between physical paper and a computer, and hence turn pen and paper into the user interface (Mackay and Fayard, 1998). Such “interactive paper” has the potential to preserve the best aspects of both physical pen-and-paper and electronic documents.

The remainder of this text is organized as follows. First we discuss some expected problems and potential benefits for architectural design of a paper user interface. Next, we describe a first prototype tool that supports the combination of physical pen and paper with computer (and network) access.

2 Physical paper as a user interface

Sketching plays an essential role in the architectural design process. Architects produce a lot of sketches and models while they are seeking for a design that satisfies the (sometimes fairly vague) requirements. Existing literature reviews and performed interviews have confirmed the importance of physical pen and paper in this early design stage. Nevertheless, the majority of currently available CAD tools is trying to replace physical paper by purely electronic input media. This does not seem to be the most promising approach, and we have therefore adopted an alternative augmented-reality-design philosophy that aims to preserve physical paper rather then replace it.

The use of physical paper as a user interface also leads to a number of open questions and potential problems. They arise from our lack of understanding
of the differences, especially from the user perspective, between real and virtual paper. A number of the problems are related to creating a convincing combination of physical and virtual paper (Mackay and Fayard, 1998). How should we handle the communication between the user and the system in order to sustain registration between the physical and virtual paper? How can we exploit the strengths and avoid the weaknesses of both media? How can the differences in the characteristics of both media be handled? For example, physical paper has a fixed size and shape, while virtual paper is obviously more flexible. On the other hand, electronic pens do not allow to mimic the full potential of physical pencils for creating flexible strokes. Other questions are related to the functionality and interface that is required by the design tool. How to best move back and forth between physical and virtual media in order to create typical functionalities such as editing, overdrawing, annotation, saving, restoring, searching and selecting, etc?

In the following part we describe our first prototype tool and discuss how some of the above issues have been addressed. Obviously, also in view of the current stage of the project, many of the above questions need further exploration.

3 Tool description

Using the VIP-3 platform (Aliakseyeu et al., 2001) a combination of virtual and physical paper has been realized (fig. 1).

The physical paper contains infrared reflecting tags that can be tracked real-time by a camera above the table. The paper is placed on a digital drawing board and an electronic pen is used to sketch. The sketches made by the user on the physical paper are traced into the computer and then projected onto the paper. In the future we plan to use a combined pen that can be detected by the digital board, while still leaving a physical trace on the paper.

The system currently supports one sheet of physical paper and several sheets of virtual paper. The virtual sheets of paper can contain previous sketches or other relevant material (such as ground plans, etc.) that has been retrieved from a data base. Infrared-coated bricks can be used to scroll through and select from such a data base. The physical page can be saved as a virtual page at any time.

Most architects prefer re-drawing to editing of existing drawings. Therefore, no editing function has been implemented. Instead, the system offers transparency (Trinder, 2000) to assist in re-drawing from existing material. The user can also annotate on a virtual page or on a hardcopy that has been printed.

4 Conclusions

In this paper we have presented a prototype of a paper-based user interface to a computer tool for early architectural design. The current lack of understanding of the different characteristics of physical and virtual paper, especially from the point of view of the user, makes it difficult to design such a tool from a priori requirements. Therefore, we intend to test the prototype tool with users (architects) in order to obtain more insight into the usability and naturalness of the interaction style. More extensive interfaces based on “augmented paper” that are intended to fit into the early architectural design stage will be developed, also taking into account some of the gained expertise.

References

