Tangible Interaction Techniques for Tabletop Architectural Design

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ABSTRACT

We propose tangible interaction techniques for tabletop architectural design that allows laypeople to design their houses on their own. For many people, building a new house is not only a big project, but also difficult to realize without architectural expertise and a high level of computing skill. This system overcomes these challenges by employing tangible user interfaces. For example, users can design a room layout by putting plastic sticks on a design table, and customize the room’s properties, such as walls, floor, or even furniture, by laying out little pieces that display the property’s information on them. In addition, they can naturally take information about furniture they want in their houses from a physical setting, such as a mockup house or furniture store, and utilize it in a single tangible user interface.

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General terms: Design, Human Factors

Keywords: Tangible user interface, tabletop user interface, architectural design, CAD.

INTRODUCTION

The current design process for buildings such as houses is very laborious and complicated. It requires expertise and the consideration of numerous parameters. To address this issue, we proposed an architectural design support system intended for prospective house buyers who typically have limited or no knowledge of CAD systems [1]. That system was based on tangible user interfaces (TUIs) [2] and allowed direct control of electronic objects such as CAD files or CG images through physical artifacts. Users can easily and intuitively handle the system, just as children who do not need to practice playing with blocks can make castles or houses. However, it was pointed out that the system has very limited flexibility and granularity, because the degrees of freedom depend on the number of RFID readers, which was not scalable.

We have been tackling this issue and developing a new system using plastic sticks and vertex markers in order to realize a completely unrestricted room layout without loss in tangibility. Moreover, we incorporated RFID technology for extracting room elements’ information from the real world, such as a mockup room or furniture shop, and configuring room properties with it. This system allows users to intuitively create a new house design, investigate it, and modify it without outside help and with no restrictions.

SYSTEM SUMMARY

Figure 1 shows an overview of our system. The camera under the table detects the positions of vertex markers and plastic sticks between any two markers. For marker tracking, we use the ARToolKit [3] platform. The monitor behind the table displays 2D and 3D images of the house layout being created on the table.

This system has two stages for making a new house. The first step is to design a layout. Users create their house’s layouts using vertex markers and plastic sticks to make polygons (Figure 2). When a polygon is made, the system calculates the vertex positions by sensing the markers, calculates the side positions by sensing the shadows of the plastic sticks, and finally recognizes the polygon as one room. In this way, this system makes it possible to design a whole house’s layout with no restrictions.
The second step is to configure the house’s properties, such as floors, walls, doors, windows, and furniture (Figure 3). The interaction is very simple. All we have to do is place a configuration piece on an appropriate location on the table. Each piece shows its information on the front and has a unique mark on the back for camera tracking. For example, users can configure a room’s floor material by placing a floor material icon on a certain room area surrounded by plastic sticks, or add a window by putting a window icon alongside a corresponding wall stick.

In addition, we implemented a function that extracts information about elements such as furniture or floor material from a real room and uses it on the design table (Figure 4). First, information is extracted by moving an RFID reader closer to the target furniture in which an RFID tag is embedded. Second, the extracted information is transmitted to information containers called Siftables [5], which have a small display and can receive radio transmissions when the RFID reader is pointed at them. Then it will show the furniture’s image, and users can utilize it as they would be a prepared configuration piece. This function allows users to naturally imagine their prospective houses’ interiors because they can directly see and feel the color and texture of design elements.

Once the room layout and its configuration are defined, a 2D image of the house is dynamically created and displayed on the monitor behind the table, which allows the users to confirm what they configured. Additionally, when a camera icon with a specific marker on the back is placed on the table, the system automatically creates a 3D CG image of the house and displays it on the monitor (Figure 5). The users are then able to control the viewpoint and zoom in (or out) of the image through a camera control icon containing a 6-DOF acceleration sensor, to look everywhere around the house.

EXPERIMENT

We conducted a small informal user trial of our system. Initially, examinees were given a brief introduction, shown how to manipulate it, and asked to try out the interface to familiarize themselves with it. After that, they compared it with the previous system as well as a typical GUI program.

Overall, the current system was promising. Most users prefer this system to the previous one and the GUI software. All examinees agreed that this system not only solved the flexibility problem of the previous version, but also was more intuitive than either of the other two. They appreciated the constraint-free layout method using plastic sticks and markers. On the other hand, some experts noted that compared to typical GUI software, our current system has too little variation in furniture or house elements to be configured. However, both beginners and experts admitted that the function of information retrieval from the real world was the most valuable. They could easily imagine their future house and therefore experience their virtual house as if it were real.

CONCLUSION

Our previous system illustrated the possibility of tangible interactions for design support. Tangible interactions such as direct input of preferences and direct manipulation of images in 3D space through tangible objects were well appreciated, and helped users to make their own design decisions. However, it was also pointed out that the layout flexibility was extremely low, and it was impractical to use due to the RFID platform. We solved this issue by using plastic sticks and vertex markers on a camera tracking platform. Furthermore, we introduced a new function that makes it possible to extract information about furniture or housing materials such as floor coverings, wall coverings, and curtains for use in house planning. Finally, we see the next step as evaluating our system in practical use by considering various configuration data.

REFERENCES

3. ARToolKit homepage, on-line resource, URL: http://www.hitl.washington.edu/artoolkit (retrieved 07/01/2008.)