Drawing on and above the Surface

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Abstract

Despite the advances and advantages of computer-aided design (CAD) tools such as Autodesk Revit, ArchiCad and SketchUp, the traditional pencil and paper continue to exist as some of the most important tools in the process of design. We present 'Inktuitive', an intuitive physical design workspace that aims to bridge the gap and bring together the conventional design tools such as paper and pencil with the power and convenience of the digital tools for design.

Keywords: Design tools, paper and pencil, 3D drawing, workspace, connecting physical and digital world.

1 Introduction

The development of computer-aided design (CAD) tools has leveraged the power of the digital world in the process of design by allowing designers to express their creations in new ways. As opposed to the conventional method of drawing primitives on multiple 2-dimensional (2D) representations (views), it is increasingly becoming popular to directly model 3-dimensional (3D) representations of the actual component objects being used and to specify the relationships between them parametrically to design an architectural product. Digital tools such as Autodesk Revit, ArchiCad and SketchUp are examples of tools that support this new paradigm also known as Building Information Modelling (BIM) [BIM]. However, many architects and designers still prefer to use physical tools such as paper and pen to articulate their ideas especially at early stages of the design, where it is critical that your hand motion have direct and immediate effect on the object being designed. As the new design paradigm proliferates, challenges in adopting such affordances of physical design tools into the digital realm will become of increased importance. In addition, as designers start thinking in terms of 3D objects rather than in 2D views of objects, a new set of interactions that augments the conventional use of pen on paper needs to be sought. Instead of replacing the traditional tools, paper and pencil, it will be more fruitful to merge the advantages and functionalities of digital design tools with traditional work practice of using paper and pen, hence connecting the physical and digital experiences.

2 Inktuitive - A physical design workspace

Inktuitive is an intuitive physical design workspace where designers can create and manipulate digital models and representations of ideas in a more direct and natural way. The goal of Inktuitive is to combine the intuitive process of creation that is inherent in paper and pencil with the power of computing that the modern digital design tools provide. Inktuitive also extends the natural work-practice of using physical paper by giving the pen the ability to control the design in physical 3D space, freeing it from its tie to the paper. The following use scenario outlines major features of the 'Inktuitive' platform.

Figure 1 presents the working prototype of 'Inktuitive' system [Mistry and Sekiya. 2008]. The 'Inktuitive' system provides a physical workspace environment where digital content is projected from below onto the paper placed over the frosted-glass surface of the desk. Pen movement on the surface of the paper is tracked by ultra-sonic digital-pen hardware. Two stationary sensors receive ultra-sonic waves that are emitted by the
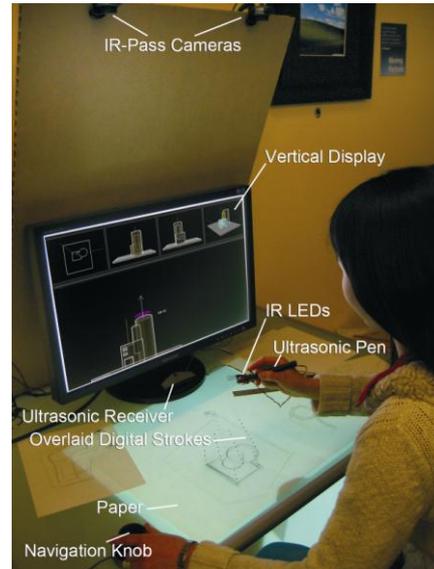

Figure 1. 'Inktuitive' prototype.

transmitter placed at the tip of the pen. The device measures the location of the pen tip on the paper using the calculation of receiving time of the waves received by the two stationary receivers. Further, the pen tip is also augmented with infra-red (IR) LED array for tracking the 3D coordinates $\{X,Y,Z\}$ of the pen above the paper surface using stereo vision mechanism. Two USB cameras with IR-pass filters mounted above the workspace detect the IR light emitted by the IR-LEDs which are used to calculate the $\{X,Y,Z\}$ coordinates of the pen tip via triangulation mechanism. The projector, ultra-sonic pen hardware, cameras and the navigational knob that lets user navigate through 3D space are all connected to a computer. A software program processes the data collected by the digital-pen hardware and two cameras. Image processing of the two camera inputs provides the system with absolute location of the pen tip (IR LEDs) in 3D space above the paper surface while the ultra-sonic components help capturing precise user strokes on the paper surface. The software program uses these two streams of user hand motion in augmenting the paper on the desk with projected digital information. A vertical display screen provides the user with 3D view of the created objects.

3 Conclusion

In this paper, we present 'Inktuitive', an intuitive physical design workspace which brings the power of computing and digital design tools to the traditional work practice for designing using paper and pencil. Furthermore, the platform provides a novel interaction mechanism for drawing and designing using above-the-surface pen movements in 3D.

References

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