3D VIRTUALITY SKETCHING:
INTERACTIVE 3D SKETCHING BASED ON REAL MODELS IN A VIRTUAL SCENE

ABSTRACT

Sketches and working models are without doubt one of the most widely used tools in the architect's repertoire. In the early phases of the design process in particular, they represent an essential part of the exploration process. For the most part, however, sketching and model building are separate and sequential steps. This paper examines how both media can be linked to each other more effectively so that the design process is more continuous and the transition between the two media more fluid. Using a multitouch table with additional 3D real-time object recognition, a prototypical system was developed and realized as part of a research project in which an interactive 3D sketching tool was linked with a real 3D working model.

Gerhard Schubert
Chair for Architectural Informatics,
Technische Universität München

Eva Artinger
Chair for Augmented Reality,
Technische Universität München

Violin Yanev
Chair for Architectural Informatics,
Technische Universität München

Frank Petzold
Chair for Architectural Informatics,
Technische Universität München

Gudrun Klinker
Chair for Augmented Reality,
Technische Universität München,
Chair for Augmented Reality

1 INTRODUCTION

In an interdisciplinary project we examined new approaches for using computers and information technology in the early creative phases of the design process. The aim is to develop digital tools that strengthen rather than hinder the design process so that a continuous workflow results, in accordance with the motto "the simpler the tool is to use, the less it gets in the way of the actual process of designing." As a result, established design tools are not entirely replaced by digital methods but instead are combined with a view to making the most of both worlds: by combining the advantages of each realm, we expand the possibilities of designing in real and virtual environments.

Building on the pre-existing Collaborative Design Platform (CDP) (Schubert et al. 2011a, 2011b), we examined aspects of human-computer interaction and the use of computers in the early design phases.

The subproject described in this paper is a 3D sketching tool for the early architectural design phases that makes it possible to annotate, extend, and label real working models in a virtual environment in real time. We examine how linking together established design tools—the sketch and the working model—can contribute to supporting a continuous design process and what advantages this may have for the designer.

2 DESIGN TOOLS

Imagining future situations has been a fundamental part of the work of an architect since the end of the Renaissance. As building projects became ever larger and more complex, it became necessary to find methods for envisioning the building process and to verify the design and construction in advance: "The whole point of having the process of design separated from the process of making is that proposals for new artefacts can be checked before they are put into production" (Cross 2008; Buxton 2007). Or as Fish and Scrivener describe it: "The use of words, pictures or models to stand for objects, scenes or events not physically present enormously increases the mind's ability to visualise" (Fish and Scrivener 1990).

Over the years as culture progressed, different tools have been used to support the design process. Surprisingly, despite the widespread use of computers in architectural practice, computers have not become an established tool in the early design phases. Working models and freehand sketches, on the other hand, remain fundamental design tools at the beginning of the design process. Depending on the design brief and the specific design problem, architects use one or the other as a tool to assist thinking. Numerous academic papers and books have examined the topic of design tools, creativity, and finding ideas, as well as what characterizes design problems and processes. The findings can be broadly summarized as follows: design tools are used to represent and to test one's own ideas. They help designers to create an externalized image of their thoughts—that is, they render designers' thoughts visible and accordingly support the creative process of designing. The architect "holds a conversation with the drawing," as Schön describes it (Schön 1983). The process of drawing helps engage in what Schön calls "the reflection in action process": first, architects frame the problem in order to come up with an idea. They try to understand and to define the problem. Secondly, they draw the idea. While drawing the idea the architect simultaneously reflects on the idea, evaluating its consequences and implications, a process that can lead to a new or refined idea. The process then repeats. This process, which has also been termed "visual thinking," is a key characteristic of the architectural design process (Arnheim 1971).

In response to the above, the freehand sketch and working model have become standard tools. If one takes a closer look at each of these tools, one can note the following characteristics:

Table 1: Comparison of freehand sketch and model

Freehand Sketch 2D	Working Model 3D
Quick and flexible	Better spatial impression
Can represent any scale	Can be explored and revised with both hands
Tactile feedback	

The differences noted here are actually qualities that speak for one or the other tool, and if one looks closely it is apparent that they hardly relate to one another. Although both tools are used in the design process, they are rarely used in combination. As a result, switching between the different media interrupts the design process and creative workflow. This research project takes this as its starting point and examines the possibilities offered by linking the sketch to the working model with the help of computer technology. The aim of this project is to connect existing and established design tools with a view to optimizing the use and advantages of both.

3 THE SKETCH

Freehand sketching is a design method that has been widely used for hundreds of years, and more so than perhaps any other method. Its popularity is, of course, not a coincidence but rather a factor of its special qualities. Fish and Scrivener list four important attributes of sketches (Fish and Scrivener 1990). Of particular interest are the ability to depict abstractions at different levels (Cross 2008), to embody indeterminacy (Buxton 2007), and with it to allow ideas to emerge—these are among the most fundamental attributes of a freehand sketch. But why is this?

In the early design phases, the information available is often vague and incomplete. The ideas that float around in the designer's mind are not yet well formed. A design tool needs to be able to accommodate these kinds of imprecise thoughts and vague information. This is essential for a dialogue between the designer and the drawing to arise, which in turn serves as a basis for refining and developing the idea.

Closely related to this is the concept of emergence. The term emergence describes the process of making qualities and things visible that cannot be explicitly formulated or depicted (Gero, Damski, and Han 1995). In the context of designing, this is essential as it helps designers to perceive something in a drawing that may not be what they originally drew. The sketch as a design tool and its capacity to accommodate emergence represents a catalyst for stimulating not yet conceived interpretations of an idea put down on paper (Buxton 2007). This applies particularly when drawing on top of existing images, renderings, and sketches. In contrast to a sketch drawn on an empty piece of paper without any reference image, drawing over existing sketches stimulates the process of emergence—and therefore visual thinking—much more strongly. The combination of image and sketch, in particular, can bring forth entirely new forms resulting in the emergence of new ideas and inspiration.

4 USER SCENARIO: AN URBAN DESIGN COMPETITION

An architect is tasked with developing a design for an urban environment. Rather than working on-screen with a mouse and keyboard, he or she uses a large multitouch table equipped with real-time object recognition that will "see" the objects in the model. To begin with, a site plan of the competition site and surroundings can be seen on the table.

The architect begins by cutting blocks to size out of a material of his or her choice for use with the model so that the positioning of approximate building volumes can be tested. After some experimentation, the architect settles on a first potential constellation. The next step is to examine how the vertical articulation of the blocks and facade design will influence the design. The architect places a SpaceMouse with a camera symbol on the multitouch table, and an "ego perspective" of the design idea appears on a touch screen arranged next to the model (3Dconnexion). He or she positions the

mouse on the multitouch table in such a way that the design idea is shown fully in the perspective view on-screen and then picks up a pen and starts to draw ideas for the facade design on the perspective view on the screen. In the background, the system maps his or her sketches in real time onto the surfaces of the 3D volumes.

After a while, the architect asks a colleague for input on the design as it stands. The colleague has a few ideas and shifts some of the blocks in the real 3D model on the multitouch table. The perspective view on the screen updates accordingly to correspond to the new arrangement of the real model. Because the facade designs have been intelligently mapped to the building surfaces in the virtual model, they shift along with the blocks.

To show his or her idea more clearly, the colleague shifts and tilts the SpaceMouse to adjust the perspective view. Turning to the touch screen, the colleague picks up the pen and annotates the changes to the urban situation in the perspective view on-screen with comments, arrows, text, and hatching. The two colleagues continue to refine and improve their idea, discussing alternate means of facade articulation and urban constellations.

5 RELATED WORK

The use of sketching tools for the early design stages is not a new area of research. Some simple to use, geometry-based approaches to making virtual modeling tools include Sculptor and DDDoolz (Kurmann 1995; Achten, de Vries, and Jessurun 2000). By replicating established ways of working, e.g., from model building, these tools make it simple to create simple 3D volumes in digital space. Further approaches can also be found in the realm of VR and AR—for example, 3DM, a very early approach for modelling 3D environments (Butterworth et al. 1992). By use of a head-mounted display and sketching while being immersed in a virtual environment, it combines techniques from CAD as well as drawing programs. A contrasting approach can be seen in "the augmented round table," which provides an interactive AR environment where users can create and manipulate virtual 3D objects in a real environment (Broll 2003). However, the adaptation of real processes into a digital environment removes the direct relationship to what is being designed and likewise any haptic feedback. The result is unintuitive and not well suited for reflexive creative processes. Approaches such as that used by Sculptor, which implements an additional physics engine so that the objects in the scene act as naturally as possible, can help compensate for this deficit. The idea of the CDP is a response to the problem of porting analog ways of working to the computer. Rather than replacing these analog design tools, it links them with the computer so that they retain their elementary qualities but are also extended through additional digital support.

Another approach can be seen in the use of sketch-based tools. The first tool to use pen input was Sketchpad, by Ivan Sutherland (Sutherland 1963). Sketchpad made it possible to "directly" manipulate graphical objects on screen using a light pen. Johnson took this concept further and developed Sketchpad III, a tool for creating 3D volumes using a stylus (Johnson 1963). In the field of 2½D sketching, a design tool called "sketch book" was developed and tested in 2009; the tool makes it possible to hand-sketch in a virtual 3D scene. For this analog to the real world a transparency layer—much like real sketching paper—is laid over the entire virtual scene (Schneider and Petzold 2009). In a commercial environment, a similar texturizing tool is BodyPaint 3D by Maxon (MAXON). Using a UV mesh, the software can apply textures directly to a 3D volume or the object's net shape. These solutions require one to construct a virtual 3D model first. Due to the complex interfaces of current 3D CAD software, the creation of a virtual model is complex and time consuming. This intermediate stage represents an undesirable interruption in the design process. Two well-known examples of 3D sketching tools are Teddy and Digital Clay (Igarashi, Matsuoka, and Tanaka 1999; Schweikardt and Gross 1998). Both facilitate the generation of 3D freeform shapes from freehand sketches. In addition, Teddy supports drawing and sketching in three dimensions directly onto the generated surfaces, including coloring them in.

Although these tools offer an intuitive means of operation using a stylus pen, the fact that they handle just one field of activity means that one has to change tools for different tasks, interrupting the process. By directly linking the physical working model with the interactive scene and by combining different drawing methods, our project provides a near-seamless fusion of two well-established design tools but without replacing them. The core properties of the tools—rapid and intuitive handling, fuzzy precision, haptic quality, and a direct connection to what is being designed—are maintained. By coupling the two directly, they can work hand in hand, making it possible to work at multiple levels. The interactive platform opens up new ways of designing in the architectural design process.

6 THE SKETCH TOOL

The project shown here builds on work done last year on a developed design environment for urban planning at a scale of 1:500. By directly coupling a real, volumetric model (a working model as traditionally used for urban design projects) with interactive digital content, the gap between the real model and interactive content is bridged, expanding the information that is stored with the otherwise purely physical model (Schubert et al. 2011a, 2011b). The technical basis for the design platform is a large-format multitouch table. Coupled with real-time 3D object recognition, the table acts as a "tangible interface" that, in addition to reacting to touches and markers, can sense objects on the table. The 3D data from the model on the multitouch table can serve as the basis for simulations, analyses, and rough calculations. The designer is provided with an additional information layer containing simulation data and analyses that are displayed directly on the model and help him or her evaluate the consequences of design decisions. The physical model and the computer, previously two separate realms, are now united, resulting in a continuous design process without interruptions when switching between media.

This basis has been extended in this subproject to include an interactive drawing tool. In this situation, the multitouch table functions as the input device for the real, volumetric model. A separate touch screen is set up parallel to this. The scene on the table (consisting of GIS data structure and the 3D data of the scanned real model, as well as supplementary simulation data) is displayed as a real-time perspective view on the touch screen. The direct and synchronous connection between the model environment and the touch screen makes it possible to interactively connect both tools. The designer works with the working model on the table. Further options can be added in real time on the additional touch screen using a pen applied to a perspective view of the design scenario. The user can draw on and in the design scenario, annotating and interacting.

6.1 Paper Mode / 2D

This function is in a manner similar to tracing paper: a semitransparent layer is laid across the entire scene onto which one can draw and sketch without having to adhere to any particular geometry. As such this mode is very similar to the traditional method of using tracing paper with a drawing beneath it. The sketch and the relationship to the 3D scene are dependent on the viewing position and are always parallel to the front face of the camera. A mapping function can be used to "bake" the drawing onto the texture of the 3D volumes.

6.2 Object Mode / 2½D

In Object Mode, individual objects, buildings, and surfaces are recognized, independent of whether they derive from the real working model or from the underlying GIS data of the surrounding buildings. This makes it possible to draw directly onto individual objects and buildings in the model. For this, the drawing is computed into a vectoral texture, referenced in 3D space, and displayed on the respective surface in the scene. In other words, the sketch is mapped to the envelope of a building and makes it possible to draw in perspective onto the scene shown on the screen. The relationship to

figure 1

System setup: multitouch table with integrated 3D object recognition and directly linked 3D drawing tool in the background.

In contrast to an analog sketch on paper, this system allows one to draw directly in the 3D scene. The architect can, for example, draw the facade directly onto the surface of the model.

Due to the digital basis and parity with the real volumetric model, the digital sketch and the real model can be thought of as a single entity. This direct coupling makes it possible to work in a familiar way (move, rotate, cut) with a real model in three dimensions. At the same time, any digital notes or sketches remain related directly to the respective real object.

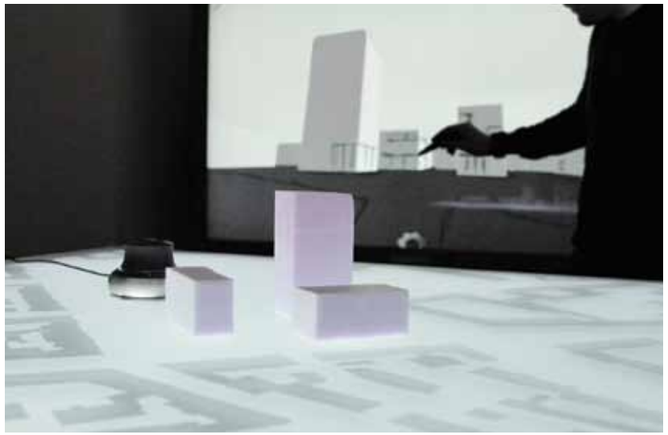

figure 1

figure 2

Working model and sketch directly coupled with one another.

This 3D linkup between model and digital content means that the user can draw in the digital scene using different modes: paper, object, extended, and 3D sketch.

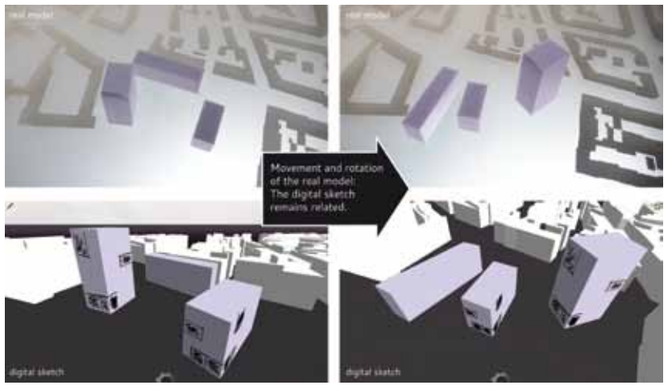

figure 2

the object is maintained, which means that the mapping remains in place when the building volume or the camera position changes.

6.3 Extended Mode / 2½D

As with Object Mode, the surfaces in the model are automatically recognized, and the sketch is directly mapped to the object's surface. What differs in this mode is that by clicking on the current surface, a new infinitely wide 3D plane is created, based on the clicked-on layer, that spans the entire scene.

This makes it possible for the user to draw semifreely in 3D space, to extend building geometries or connect buildings to one another.

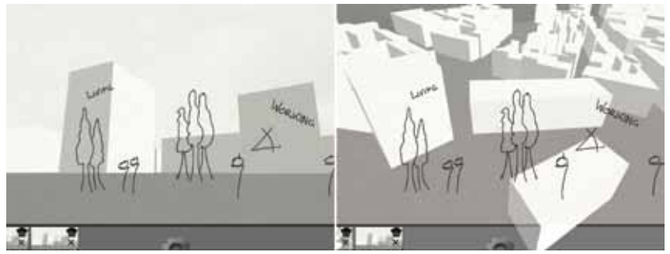

figure 3

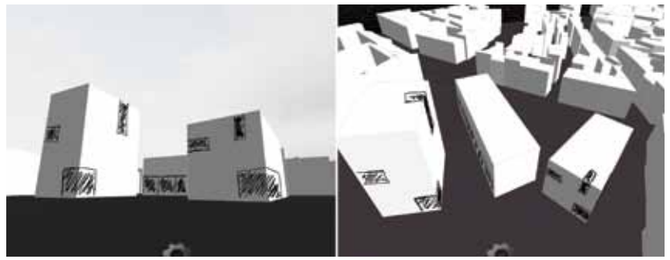

figure 4

figure 3

2D paper mode: sketching on a semitransparent layer (left image). No relationship between real model and sketch (right image). Drawings can be mapped onto the objects, and therefore linked to them, using a "bake" function.

figure 4

Object Mode: 2½D sketching on the surface of objects (left image). Direct connection between sketch and real model: the sketch remains connected to the model even when the real model is moved or turned (right image).

6.4 3D Sketch / 3D

In addition to the purely 2D and 2½D modes, a 3D mode has also been implemented. Using the existing 3D data as its reference and environment, this drawing mode makes it possible to create 3D mesh models. Three-dimensional structures can be drawn in two dimensions and then automatically converted into 3D objects that sit within the existing 3D structure of the model.

7 USER INTERFACES (UI) FOR CREATIVE PROCESSES

Based on the findings of several researchers working on creativity research in human-computer interaction, we describe how user interfaces can enhance creative processes (Shneiderman 2000; Resnick et al. 2005; Terry and Mynatt 2002). Resnick et al. have found design principles for tools to support creative thinking. Terry and Mynatt also recognize creative needs in user interface design and provide guidelines for UIs used in creative work. Their main focus is on the creation and evaluation of an idea. Based on their findings, we identified the following important requirements for the user interface in our architectural context.

7.1 Provide the Ability to Sketch

Hand-drawn sketches and diagrams are essential tools for architects' creative reflection (Resnick et al. 2005), and we therefore provide a sketching tool. As we have seen in section 3, the visual appearance of a sketch plays a central role in the ideation phase, and the creativity tool should not change its nature. The original sketch is preserved along with all its inaccuracies, irregularities, and wobbly lines that may serve as a spark of illumination in the ideation stage, when a new idea arises.

The sketchy, unpolished appearance has a further advantage in that it does not give the impression of being complete. There is no illusion that a lot of effort has been given to carefully elaborating the

figure 5

Extended Mode: 2½D sketching on a freestanding surface in space. Supporting layers can be created simply by clicking on a surface. The sketch is linked to the selected real object and changes its position with respect to the position of the real model when it is moved or turned.

figure 6

3D Sketch Mode: freehand 3D sketching linked directly to the real object.

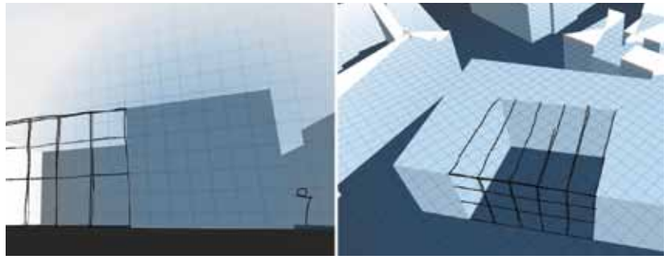

figure 5

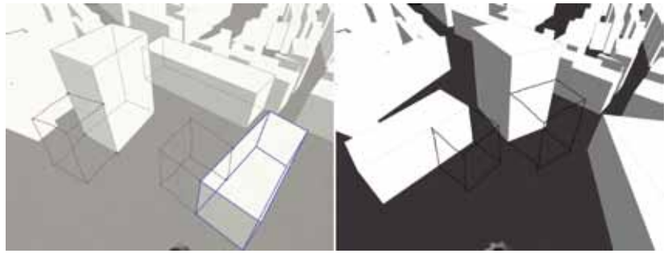

figure 6

idea. Purcell and Gero call this phase design fixation (Purcell and Gero 1998). The presentation of an idea in a form that is too polished hinders the creation of new ideas and fosters premature fixation on a certain idea.

7.2 Cycles of Ideation and Evaluation—Exploration of Alternatives

The generation of a large amount of ideas that are constantly being evaluated is a characteristic of the creative process cited by many researchers (Shneiderman 2000; Resnick et al. 2005; Robertson and Radcliffe 2009; Terry and Mynatt 2002). Terry and Mynatt examine the exploration of alternatives and their evaluation in detail (Terry and Mynatt 2002) and note that "interfaces should offer a dedicated space in which to perform near-term experiments, without needing to modify the document or its data. This capability is sometimes called a 'what-if' tool."

Many user interfaces, however, force the user to progress linearly through a task where each step replaces the current state with a new state (Terry and Mynatt 2002). In the paper mode of our 3D virtuality sketching tool (see section 6), we have avoided this additional burden to the user and do not require the user to explicitly create copies of their data to create multiple versions. In this mode it is possible to generate variations sequentially (one after the other) or in parallel (multiple ideas at the same time). A new "sheet" of paper is simply added to the scene by dragging one out, while the previous version is shown in miniature on-screen. Multiple miniature views of the same scene are visible at the same time. By clicking on one of the miniatures the user can return to an earlier variant. Variants can also be deleted at any time. Once the user is satisfied with a sketch, he or she can incorporate it by "baking" it into the scene. The sketch becomes an integral part of the 3D scene and is always shown with further new variations.

7.3 The Influence of the User Interface on the Idea

Robertson and Radcliffe describe the ways in which a CAD tool can influence the design problem when used to solve creative problems (Robertson and Radcliffe 2009). Software limitations, in particular, along with bugs, can cause significant disruption during the problem-solving process.

The creative solution can also be influenced by the designer's proficiency with a given tool. Time pressure may result in generating ideas that are easy to make with a particular tool. Ideas that may be more suitable but are more difficult to make may not be investigated. Conversely, when a designer is particularly proficient with a tool, it can also result in the production of sophisticated but sometimes unnecessarily complex solutions.

Resnick et al. argue that a creative user interface should have a "low threshold" for beginners but also a "high ceiling" for experts to create outstanding projects (Resnick et al. 2005). In addition, interfaces should offer "wide walls" in order to be able to explore a wide range of different ideas.

In order to create a system with maximum freedom for the user, the interaction needs to be intuitive and simple. Users draw directly in 3D on the multitouch screen as they would do with pen and paper (see section 6), a simple and intuitive means of interaction with the tool.

7.4 Support, Collaboration, and Discussion

A large part of the architectural design process is accompanied and propelled by conversation between members of the design team and between the design team and their clients, the building's users, or other participants (Lawson and Loke 1997). Small group meetings with rapid sketching and discussion are particularly effective (Robertson and Radcliffe 2009). Ideas can be reviewed collaboratively, and new ideas may arise as a product of the diverse backgrounds of the group's members. A CAD tool on a normal personal computer is not conducive to this process. Aside from the software limitations, people cannot work collaboratively standing in a crowd around the operator.

Our setup consists of a multitouch table and a touch screen, which fosters collaborative work by enabling several participants to work at the same time on the same scenario. Currently, multiple people can work with the physical model on the multitouch table or change the camera view, while at the same time up to two people can work on the touch screen. The number of touch screen operators could be extended if the hardware were able to detect more than two touch points simultaneously. Additionally, it would be possible to collaborate remotely, because the scenario and the sketches are digitally transferable.

8 CONCLUSION

The concept shown in this paper describes an interactive sketching environment based on a real volumetric model and combines established design tools in a new and intuitive way. The direct coupling of a physical working model with an interactive 3D sketch tool opens up totally new ways of approaching architectural design problems. Taking into account ergonomic aspects and the patterns and workflow of architectural design problems, an interactive 3D sketch environment was developed and realized in prototypical form. The resulting system overcomes many of the interruptions caused by switching from model to sketch to computer visualization, creating the conditions for a continuous design workflow. In addition, the ability to sketch over other sketches or to sketch inside other sketches provides immediate distortion-free feedback and facilitates the process of visual thinking in a completely new way.

An initial assessment of the evaluation undertaken shows how the tool presented here can be used. Most notably, the intuitive ease of use—a product of their direct coupling, the continuous workflow, and the resulting integrity of idea, model, and sketch—changes the way people think and work. What was particularly apparent is that real-time feedback makes it possible to make more changes, see

more things, and project more, resulting in the production of a greater number of design variants. "You have the paper, you have the foam, you have CAD ... but when you have all of them together, this helps you to focus on creativity." If one observes collaboration within a group of people, one can see that the roles are more clearly distributed. People draw simultaneously in a model, or divide up the work to each of the different media, model and sketch. In future evaluations we will use a design task to compare established analog ways of working with designing using the CDP, with a view toward revealing the weaknesses and benefits of the system in practical use.

REFERENCES

3Dconnexion SpaceMouse Pro. http://www.3dconnexion.com/products/spacemousepro.html.

Achten, H. H., B. de Vries, and J. Jessurun. (2000). DDDOLZ: A Virtual Reality Sketch Tool for Early Design. Proceedings of CAADRIA 2000, Singapore, May 2000: 451–460.

Arnheim, R. (1971). Visual Thinking. Berkeley, CA: University of California Press.

Broll, W., MSCM. (2003). The Augmented Round Table: A New Interface to Urban Planning and Architectural Design. In Human-Computer Interaction—Interact '03, Rauterberg et al. (Hg.), 1103–04.

Butterworth, J., A. Davidson, S. Hench, and T. M. Olano. (1992). 3DM: A Three Dimensional Model Using a Head-Mounted Display. In Symposium on Interactive 3D Graphics. Proceedings of I3D '92. New York City: 135–38.

Buxton, W. (2007). Sketching User Experience. Getting the Design Right and the Right Design. San Francisco: M. Kaufmann.

Cross, N. (2008). Engineering Design Methods. Strategies for Product Design. 4th ed. (2008), reprinted. Chichester: John Wiley & Sons.

Fish, J., and S. Scrivener. (1990). Amplifying the Mind's Eye. Sketching and Visual Cognition. In Leonardo Electronic Almanac 23 (1): 117–26.

Gero, J., J. Damski, and J. Han. (1995). Emergence in CAAD Systems. Proceedings of CAD Futures. Singapore: Centre for Advanced Studies in Architecture, National University of Singapore.

Igarashi, T., S. Matsuoka, and H. Tanaka. (1999). Teddy: A Sketching Interface for 3D Freeform Design. Proceedings of the Siggraph 1999 (26): 409–16. Los Angeles: ACM.

Johnson, T. E. (1963). Sketchpad III: A Computer Program for Drawing in Three Dimensions. Proceedings AFIPS '63: 347–53.

Kurmann, D. (1995). Sculptor—A Tool for Intuitive Architectural Design. In CAAD Futures 1995. Proceedings of CAAD Futures: 323–30.

MAXON. Why This Package? http://www.maxon.net/en/products/bodypaint-3d/.

Lawson, B., and S. M. Loke. (1997). Computers. Words and Pictures. Design Studies 18: 171–84.

Purcell, A. T., and J. S. Gero. (1998). Drawings and the Design Process. Design Studies 19 (4): 389–430.

Resnick, M., B. Myers, K. Nakakoji, B. Shneiderman, R. Pausch, T. Selker, and M. Eisenberg. (2005). Design Principles for Tools to Support Creative Thinking. In Science 20(2), ed. Ben Shneiderman, 25–35.

Robertson, B. F., and D. F. Radcliffe. (2009). Impact of CAD Tools on Creative Problem Solving in Engineering Design. Computer-Aided Design 41, 136–46. Newton, MA: Butterworth-Heinemann.

Schneider, S., and F. Petzold. (2009). A Virtual Design Platform: Bridging Barriers When Designing with Computers. Proceedings of eCAADe 2009, Istanbul 27: 205–11.

Shneiderman, B. (2000). Creating Creativity: User Interfaces for Supporting Innovation. In ACM Transactions on Computer-Human Interaction 7, 114–38. New York: ACM.

Schön, D. (1983). The Reflective Practioner: How Professionals Think in Action. London: Temple Smith.

Schubert, G., E. Artinger, F. Petzold, and G. Klinker. (2011a). Bridging the Gap: A (Collaborative) Design Platform for Early Design Stages. Proceedings of the eCAADe (29), 187–93. Brussels, Ljubljana: eCAADe, Faculty of Architecture.

Schubert, G., E. Artinger, F. Petzold, and G. Klinker. (2011b). Tangible Tools for Architectural Design: Seamless Integration into the Architectural Workflow. Proceedings of ACADIA 2011 (31): 252–59. Stoughton, WI: Printing House Inc.

Schweikardt, E., and M. D. Gross. (1998). Digital Clay: Deriving Digital Models from Freehand Sketches. Proceedings of ACADIA 1998 (18): 202–11.

Sutherland, I. E. (1963). Sketchpad: A Man-Machine Graphical Communication System. Proceedings AFIPS '63, 1963. New York City.

Terry, M., and E. D. Mynatt. (2002). Recognizing Creative Needs in User Interface Design. Proceedings of the Fourth Conference on Creativity Cognition, CC 02, 38–44.

DANCING ON THE DESKTOP:
GESTURE MODELING SYSTEM TO AUGMENT DESIGN COGNITION

Chih-Pin Hsiao
School of Architecture,
Georgia Institute of Technology

Nicholas M. Davis
School of Interactive Computing,
Georgia Institute of Technology

Ellen Yi-Luen Do
School of Industrial Design,
Georgia Institute of Technology

ABSTRACT

During the design process, architects have traditionally used a range of media and tools, including sketches and physical models, to create external representations that communicate design concepts. These representations are rapid, support quick testing and advancement of ideas, and allow new patterns and ideas to emerge. However, building these models in computer-aided architectural design (CAAD) programs is cumbersome and disembodied. In this paper, we take a cognitive perspective to explore how designers distribute part of their spatial reasoning onto the materials and tools with which they work. From this cognitive theory, we have created a unique gesture-based modeling system, Dancing on the Desktop. In this prototype, two interactive displays are projected on a desktop and the adjacent wall to show the plan and perspective views of an architectural model, respectively. Visual images and text are projected on the user's hands to provide different types of feedback for the gestural interactions. A depth camera detects gestural interactions between these two displays to create an immersive gestural interaction space for model manipulation. We argue that Dancing on the Desktop helps users develop an embodied understanding of the spatial and volumetric properties of virtual objects that the current CAAD systems cannot afford. The details of the low cost, yet effective, gesture recognition technique are also described in this paper.