As if You Were Here - Intelligent Annotation in Space: 3-D Sketching as an Interface to Knowledge-Based Design Systems

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Abstract

This paper presents a framework for 3D knowledge-based sketching tools for design and the software prototypes built to illustrate sketch-based interaction with intelligent systems in 3-D domains. Space Pen supports user annotations in the form of sketching, virtual post-it notes, and sketch object insertions. Spot supports direct sunlight simulation and visualization in a selected time period. Light Pen supports placement of lamps to light an intended area in space. In all three examples, a 3-D sketching front-end is coupled with a back-end knowledge-based system. This enables a designer to pose problems by drawing onto a 3-D model to which the knowledge-based systems offers a solution by either providing quantitative data analysis or modifying the 3-D model. Although the specific domain of architectural lighting is implemented, it exemplifies a more general class of 3-D pen-based interaction with intelligent systems.

Motivation – Tools for Design in 3D

Many design domains – industrial, mechanical, civil engineering, and architecture involve designing and manufacturing 3-D artifacts. Design collaboration in these domains often is executed with 2-D representations of the artifacts (e.g., diagrams, plans, sectional, and perspective drawings) and textual communications (e.g., phone, fax, instant messaging, email, etc). Comments like "That's not what I meant!" or "This is not where I wanted…" and "What problem area are you talking about?" are abundant in any such communication logs. Many problems arise because we can't see the 'views' of our collaborators or the exact locations they are pointing at in 3D. The "wish you were here" problem can easily be solved with a 3-D annotation system. Furthermore, decision support systems can play a role as a collaborating partner, a helpful assistant or an expert advisor in a design process. A 3-D annotation coupled with knowledge-based design systems would be helpful to support design activities. Therefore, we implemented several systems to explore the idea of 3-D sketching as an interface to knowledge-based design tools.

Many pen-based computing projects investigated generating and editing three-dimensional models (Do 2002, Igarashi and Hughes 2001, Igarashi, et al. 1999, Schweikardt and Gross 1998, Zeleznik, et al. 1996). However, the focus is in the geometry generation and its immediate behavior. On the other hand, diagram interfaces for intelligent systems have mostly supported two-dimensional drawing (Davis 2002, Egenhofer 1996, Lakin, et al. 1989, Stahovich 1996). However, in physical design domains the artifacts that designers manipulate are typically 3-D computer graphics models. Therefore, we propose to bring applications that operate on 3-D models into the designer's working environment to more seamlessly integrate design and analysis. Designers often begin work with informal sketches and diagrams. That is why we want to employ pen-based interfaces to interact with the intelligent systems that serve as computational assistants in three-dimensional design domains. To explore this idea, we built Space Pen to support annotation in 3D and then we built the Spot and Light Pen prototype systems to demonstrate how such an interface can be used in the domain of architectural lighting design.

3-D Annotation Environment in Space Pen

Our platform for 3-D sketching is Space Pen (Jung, et al. 2002) software we built to support Web based design collaboration with annotation capabilities in 3-D. The Space Pen server converts any VRML model posted by the architects into Java 3D model in a standard Web browser. Collaborating team members can then browse and annotate by drawing on model surfaces. For example, a team member reviewing a proposed architectural design draws on a wall—graffiti style—to indicate a proposed location for a new window. Space Pen also supports text annotation, with threaded discussions linked to Post-It® style tags left in the model and automatically sends emails to inform all related stakeholders of such feedback.

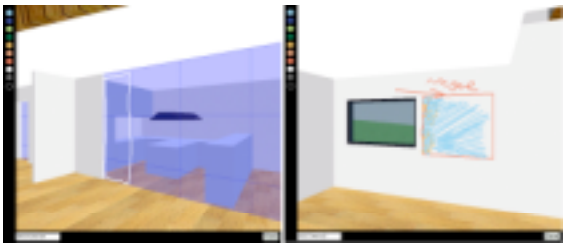

Figure 1. Sketch annotation in Space Pen on temporary surface (left) or existing surface in the model (right).

Designers mark on existing model surfaces or on a temporary drawing plane to add geometry to the model. Space Pen employs simple stroke recognition to identify

figures such as arrows, rectangles, and circles, which it can then rectify as model geometry or interpret as commands. In short, Space Pen provides a platform for drawing onto and into 3-D models.

Sunlight Visualization in Spot

To initiate lighting visualization in Spot, designers first sketch a boundary shape on the 3D model indicating the area for simulation. Spot then generates a representation of the spatial distribution of the illumination level on a selected surface over time. Spot also enables designers to visualize the temporal information of light distribution over time for a given point. For each point tapped by pen on the 3D model, Spot generates a calendar diagram of a chart where the X and Y axis represent the months of the year and the time of the day. The color of each calendar cell is the result of the calculation of the light amount reaching this specific point.

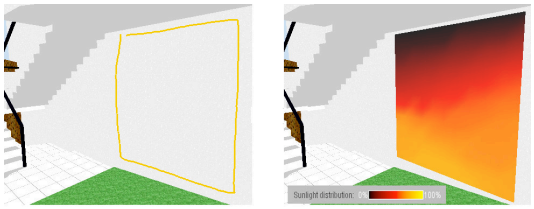

Figure 2. A boundary area sketch (left) on the wall activates sunlight distribution simulation (right).

Spot is a system consists of the 3D sketching front end to a rule-based sunlight simulation. The implementation of Spot contains two complementary components: 1) Time Projection and 2) Navigable Animation. The spatial variables (x, y, z) of 3D geometry are implemented using Space Pen in JAVA 3D for easy navigation with standard interface (mouse, arrow keys or joystick) and text annotation and sketching (pen and tablet). The temporal variables (date and time) are displayed in additional views with a look and feel of a 2D graphic calendar. The resulting sunlight simulation is displayed on the 3D environment. Spot also supports collaboration over the web. Simple modifications on the model's geometry can be made with freehand sketching input for daylight simulation.

Lighting Fixture Advisor in Light Pen

Light Pen is a system consists of the 3D sketching front end to a rule-based electrical lighting fixture advisor. The designer interacts directly with Space Pen, which provides tools for 3-D browsing and sketching. After importing a three-dimensional (VRML) model the designer marks up the model to indicate desired lighting effects. The model geometry and the designer's lighting sketch marks are passed to the Lux lighting design advisor. Lux is Light Pen's 'back end' intelligent system, coded as a set of lighting design decision rules. Lux accepts the lighting sketch marks and building geometry as inputs. Based on the desired lighting and the model geometry Lux recommends solutions, selecting fixtures from a catalog based on their desired characteristics. Finally it passes these recommendations back to Space Pen, which adds the fixtures to the 3-D model to indicate Lux's proposed design solution.

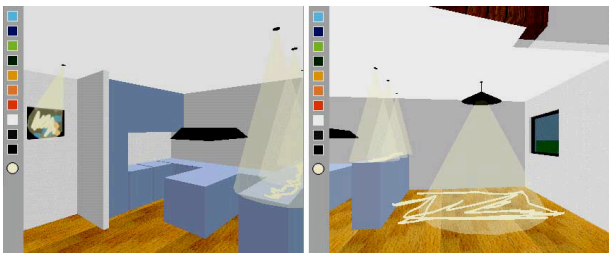

Figure 3. Light Pen places lamps after recognizing the intended sketch lighting.

Discussion

Sketching on a 3-D model to identify desired lighting effects—sparked the development of the Light Pen. More generally, we saw that sketching in 3-D could be a direct and natural means to interact with systems that reason about and calculate on three-dimensional models.

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