Sketching annotations in a 3D Web environment

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ABSTRACT
Collaborative design review is an important part of architectural design work. The Space Pen system supports annotation and drawing on (and inside) 3D VRML/Java models using a regular Web browser to exchange text and sketched annotations for review.

Keywords
Annotation, Collaboration, 3D models, VRML, sketch in 3D, pen-based interface, Java 3D

INTRODUCTION
Architects often meet with collaborators or clients to discuss design-related issues using 2D documents like floor plans or sections. This part of the design decision process is essential and involves concerns of three-dimensional space or artifact. Often people must imagine the 3D space from the 2D documents, which introduces confusion and misunderstanding in the meeting discussion. As many design projects involve geographically distributed groups, these face-to-face meetings become more difficult to organize. Moreover, during meetings, many important design decisions are made but may remain unrecorded.

Space Pen is a web-based system that allows any participant in a design project to 'walk-through' the work in 3D and annotate it with location-specific text comments (like post-it notes) or by drawing directly on the 3D model. Space Pen's 2D (in 3D environment) sketch recognition supports gestural commands to modify the model. Space Pen also allows quick generation of form in space by creating, and then drawing on temporary translucent surfaces. Comments and drawings are stored on a server for later review by others.

Space Pen combines several ideas that individually have been previously demonstrated—annotation of 3D models, drawing on 3D surfaces, gesture recognition and 3D form generation, and immersive spatial walkthroughs. Space Pen's contribution is integrating these four components in a system to support asynchronous design collaboration.

RELATED WORK
Web annotation and annotation in 3D environments has recently become an important area of work. Cadiz et al. [1] and Marshall [8] focused on text document annotation on the Web. ToolSpace [3] proposes muliti-user participation for synchronous viewing of interactive VR objects Loughlin and Hughes [7] investigated embedding annotating marks on a 3D fluid flow model. Harmon et al. [5] developed the VAnno system to leave voice annotations in an immersive virtual environment. The DDRIVE [2] broadcasts audio input by participants for 'virtual conversation,' but keeps no record of the collaboration session for later review.

Autodesk's Voloview allows redline and markup of 2D or 3D documents, but it has a long learning curve In contrast, Actify's annotation system has an 'easy to use' interface for annotating small 3D objects but does not provide a walkthrough capability into the design artifact.

Recently developed 3D drawing tools such as Sketch [10], Teddy [6] and Stilton [9] focus on generating 3D models from a pen based gestural interface. Alias Upfront in 1993 included a "virtual graffiti" feature for drawing freehand on 3D surfaces, and commercial product SketchUp offers a pen-based interface for modeling. Space Pen also provides simple 3D form generation to aid design review. However, in contrast to these systems Space Pen's primary goal is annotation for asynchronous collaborative design.

SYSTEM FUNCTIONALITY

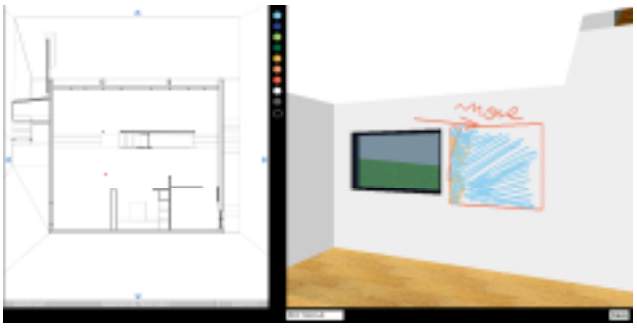

Figure 1. The Space Pen applet window.

Figure 1 shows a screenshot of Space Pen. A 3D building model (right) exported in VRML from a standard modeler has been placed on the server (without any manipulation). A dynamically created floor plan (left) helps orient visitors and provides a 2D view that is conventional in architectural design. A designer has suggested moving a window by sketching an arrow and indicating the proposed new position. A click on any surface pops up a text comment window for attaching explanations or suggestions and

leaves a yellow post-it note. All drawings and text comments can be saved on the Space Pen server and later retrieved by others.

A collaborating designer may propose design changes by sketching them into the model. First the designer generates a temporary drawing plane (figure 2) by drawing a quick straight line gesture, then pausing for two seconds. Space Pen recognizes the gesture and generates a temporary translucent plane along the direction of the line perpendicular to the existing surface. The designer then draws a new shape on this plane. This shape can retain its sketchy form or (in some cases) be rectified. The new 2D shape remains after the drawing plane disappears. The designer can also scribble handwritten annotations on a temporary drawing plane to comment on a general concern or region so that the comments float in space instead of attaching to any existing surface.

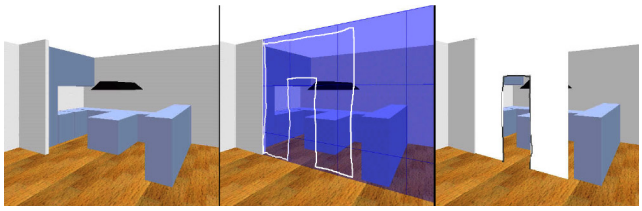

Figure 2. Proposing an addition to the model. Initial state (left); sketching a new wall on a temporary drawing plane (center); suggested model changes (right) posted to the server for comment.

Space Pen incorporates a 2D sketch recognizer, used to interpret pen marks made on model surfaces. Its purpose goes beyond beautifying rough sketches. Once recognized, geometric shapes can be added to the VRML model, and may be replaced by more complex configurations. For example, a rectangle drawn on a wall may be interpreted as a window or door, and corresponding 3D geometry inserted. Other marks such as arrows can be interpreted as commands to edit the model, establish a viewpoint or otherwise interact with Space Pen's annotation system.

Visitors to 3D virtual worlds often become lost so we added a 2D representation of the model (Figure 1, left). A floor plan is automatically generated by the Space Pen engine at the user's eye level. The floor plan is regenerated as the user moves to different level (e.g., up to the 2nd floor). A red dot on the plan indicates the user's position.

IMPLEMENTATION

Our system supports intuitive use by various participants in design (designers, clients, engineers) and also it is platform independent. The Space Pen applet uses Java3D to handle the 3D interactivity and Java2D to represent floor plans and sections. Models are in standard VRML format and require no special preparation to be annotated in Space Pen. Commercial VRML browsers impose a barrier for novice users so we built a simpler browser with navigation controls similar to those used in first person video games.

Sketch recognition employs a template-matching scheme used in our BoE system [4]. Each drawing gesture is described by its path within its 3x3 grid bounding box, the number and path of its inflection points, and its coplanarity. Each input gesture is matched against a library of previously trained templates.

The 2D floor plan is calculated by finding the intersection between the model and a horizontal surface (of user eye level), then by arranging all existing uncut objects in order of height and drawing a white filled, gray edged polygon from the farthest object to the closest one.

Geographically distributed users can review the design simultaneously, but they won't see each other's changes until they check in to the database later. Server-side CGI Perl scripts handle saving text annotations and drawing characteristics in separate files, which employ a rudimentary check-in/out scheme.

SUMMARY

Space Pen is intended to support asynchronous design collaboration: specifically annotation and markup in walk-throughs of three-dimensional models. We plan to test the system in user studies with students and professional practitioners, as well as look into applications to other fields like medical research or industrial engineering where immersive drawing annotations could facilitate web-based collaborative work.

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