We work as design teachers in a school of architecture and our area of research is design computing. We're about making tools and methods for architectural design, based on study of design process, that take advantage of the power of computation. Our goal is to make better tools to make better built environments.

PHYSICAL & VIRTUAL ARCHITECTURAL DESIGN

We find commercial computer aided design tools available to architects today sadly conventional and limited in that they automate only the most superficial aspects of design process. They replicate in a computational medium the activities that architects traditionally carry out in the physical world, for example, drafting 2D drawings and constructing 3D models for visual inspection. For the most part they fail to integrate computation or information into the process, thereby missing an important opportunity to enhance the experience and improve the products of design.

One persistent shortcoming in computer aided design (CAD) software has been precisely that the tools for making virtual representations of designs fail to accurately reflect reality. For example, one can easily make a three-dimensional computer graphics model of a building that defies gravity, whereas a physical model will not allow one to do that. Even some sophisticated CAD systems do not check for physical interference (two objects occupy the same space), or do so only as a post-processing step. Although it is sometimes valuable in design to ignore real-world or physical constraints, CAD tools have made it easy for a designer to forget about the most basic performance criteria that the artifacts being designed must meet. Even in the realm of realistic rendering and high performance computer graphics—an area where spectacular results have revolutionized the motion picture industry—architectural daylighting experts prefer to work with instrumented physical models rather than computer simulations. Design offers many such opportunities and challenges for integrating computation into the physical world.

Architects are also increasingly becoming interested in the design of places in cyberspace, and how institutions (such as libraries, municipal buildings, schools, and museums) can maintain and integrate their physical and on-line spaces. Architects are beginning to examine how and whether what we have learned about the design of physical buildings can be applied to the design of their virtual counterparts. For one extreme example, one current Master student is exploring how to evoke appropriate affective response in the design of a chapel in cyberspace. Although her proposal is not about integrating the physical and virtual, it does raise questions about how these two worlds relate.

THREE RELATED PROJECTS

We have worked on several research projects relevant to the DARE 2000 conference topics. For several years we have worked on freehand drawing as an interface to intelligent systems for design. We have studied the way people use drawing during design and we have built working prototypes of systems that support drawing as an interface to knowledge and image retrieval, building performance simulation, and three dimensional model making.

In one prototype we programmed hand made diagrams with interactive behavior to maintain topological and geometric relations among parts of the drawing, simulating aspects of the drawing domain. We combined the direct experience of making and manipulating a drawing with the computational
effect of interactive graphics. In another prototype we developed a simple sketch recognition system that inferred three-dimensional models from two-dimensional sketches, with the idea that the models could be output to numerically controlled manufacturing machinery or rapid prototyping hardware. Our digital drawing prototypes depend on conventional digitizing technology for input and LCD / CRT for output but we anticipate the integration of pen input with digitally enhanced paper or similar technologies that would augment the ordinary world of drawing with interactive behavior.

We recently began a second project that explores annotation in 3D virtual reality environments for collaborating architects and other participants in the design process to review a proposal and accumulate comments. The working prototype stores a VRML model of the design on a central server and participants browse the model and attach textual comments on virtual Post-Its on surfaces in the model. We conducted an empirical study aimed at understanding the design issues of such systems, which involved parallel physical and virtual versions of the same annotation process. We asked the members of a research group who had recently moved into a new workspace to use physical Post-Its to record comments about the arrangement of furniture and uses within the space and also to use the Immersive Redliner system for the same task.

Although we first intended the Redliner for review of proposed designs, in our study the Redliner model replicated an existing physical space, which has some interesting applications. For example, in post-occupancy evaluations of buildings architects gather comments of inhabitants to improve future designs. In an augmented reality version of the Redliner, inhabitants would record comments on digitally enhanced Post-Its, which would be assembled into a virtual model of the building for later review at any time. (In an initial version, we would use GPS-aware palmtop computers in place of digital Post-Its). Conversely, designers could walk through the physical building and review the spatially located inhabitants’ comments, either with a head-mounted display or on the palmtop devices.

In Sketch-VRML the designer draws a floor plan of the 3D model to be browsed.

A third project bridges the other two: the idea is to use drawing to construct virtual built spaces. Our current prototype enables a designer to draw a floor plan with walls, columns, and furniture elements and the program produces a 3D model. In the next version the designer will draw “into” the 3D model to add walls and carve windows. In an augmented reality, the designer would walk through a physical building, drawing on a position sensing transparent tablet to modify the machine’s internal model of the building, and perhaps the physical building as well. As we learn to embed intelligence into the physical building (e.g., through distributed communicating microprocessors), the designer’s walk-through tablet, the virtual model, and the physical building would work together in ways that we are just beginning to think about.

We ask our students—the future designers of built environments—to grapple with these questions, from integrated digital and physical design media to computationally enhanced building construction materials and the design of homes, workplaces, and civic institutions that take advantage of networked ubiquitous computing, whether in the form of wearable or in-situ devices.