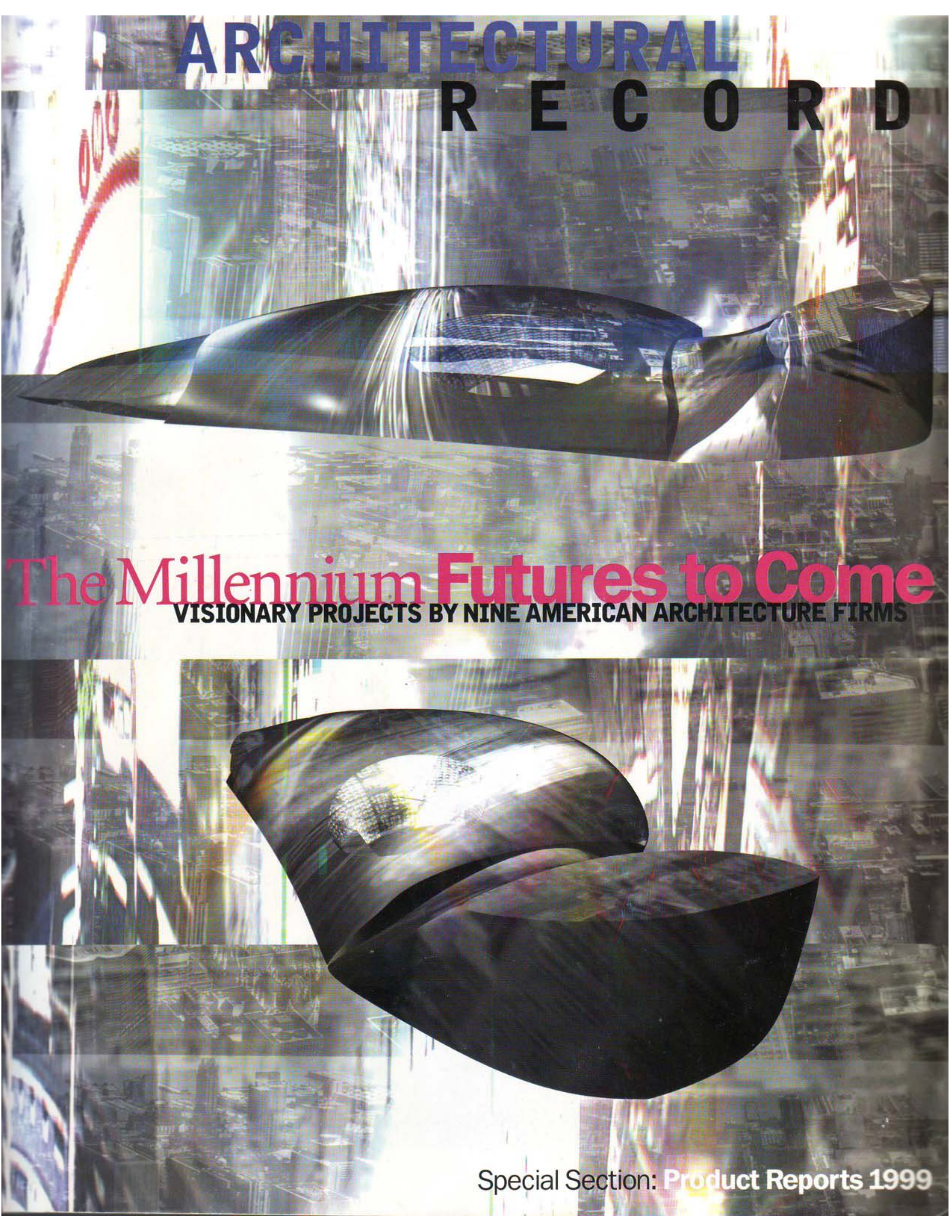
ARCHITECTURAL RECORD



The Millennium Futures to Come

VISIONARY PROJECTS BY NINE AMERICAN ARCHITECTURE FIRMS

Special Section: Product Reports 1999

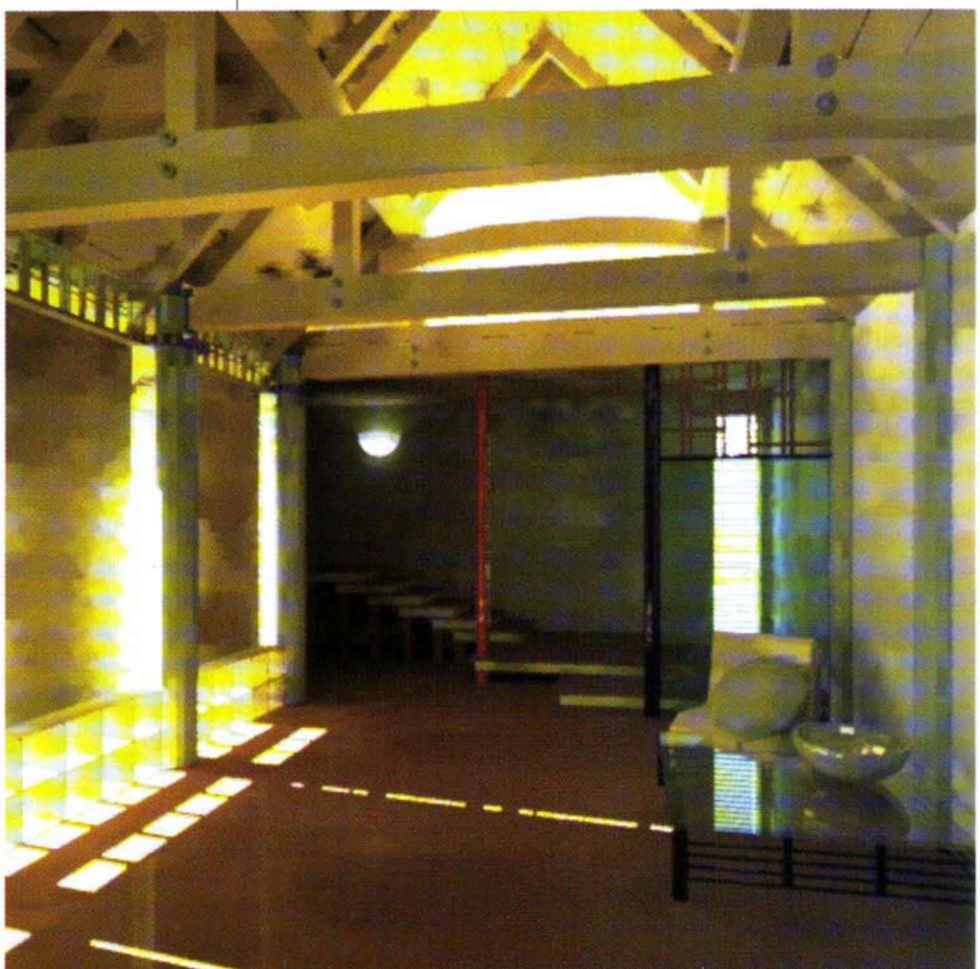
Today's Research, Tomorrow's Software

FOUR DOCTORAL DISSERTATIONS DEMONSTRATE THAT THE MOST CREATIVE NEW PROGRAMMING FOR ARCHITECTS WILL COME FROM SCHOOLS.

by B.J. Novitski

There is a crystal ball that can show us the future of architectural software. It depends not on gimmickry but on the fact that tomorrow's technology goes through years, sometimes decades, of development before it becomes commercially available. All over the world, architecture professors and their graduate students are engaged in innovative software research and experimentation. For many, the goal is to produce inspiring design tools, such as those that make 3-D modeling more intuitive, in contrast to the production tools offered by most commercial software developers. For others, the goal is to improve the integration between applications, promising efficiency benefits to the entire construction industry.

Examples of student research-turned-product include the conceptual modeler DesignWorkshop, from Artifice Inc., which architect Kevin Matthews (matthews@artifice.com) began developing as a master's thesis at the University of California at Berkeley and further developed while teaching at the University of Oregon. Lightscape rendering software has its roots in Cornell University's Program of Computer Graphics. Countless other pieces of commercial software have their theoretical or computational origins in the volumes of academic journals from the last several decades.



Modeled with Design Workshop, from Artifice Inc., this interior of a home in Japan demonstrates lighting patterns and effects. The program was developed by Kevin Matthews, an architect who worked on it originally as part of his master's thesis at the University of California at Berkeley. It is one of the few student-developed software programs to reach the commercial market.

Unfortunately, it takes more than a good idea to make a marketable product. According to Matthews, the obstacles are both technical and institutional. In academia, he says, a narrowly focused solution is acceptable as a "proof of concept," in other words, the concept is valid, so fully developing it is unnecessary. Direct interaction between researchers and users makes manuals and technical support unnecessary.

"But to succeed in the marketplace, software has to be part of a complete solution for problems in real-world jobs," Matthews says. "That means you have to develop flawless software plus accessory information, documentation, training materials, packaging, delivery systems, marketing, sales, and support." Although professors can receive academic kudos for generating good ideas, they are less likely to be rewarded for all the work required to bring a program idea to market. Furthermore, work that's done in a university setting is subject to disputes over copyright or patent ownership—does the university itself or do the students and professors retain these rights?

Even so, university researchers tirelessly pursue their innovative work, assuming that the obstacles can be overcome. The following glimpse of four current doctoral dissertations shows some tools that practitioners may be using in the future. Whether all of these will be successfully brought to market is a matter of speculation and luck.

Design by physics

In the architecture department at Texas A&M University in College Station, Tex., doctoral student Scott Arvin (arvin@viz.tamu.edu) is developing a system for "physically based space planning." In other words, the computer prototype accepts building program parameters, such as square footages and adjacency and separation requirements, and uses them to construct a range of viable floor plans. It is the digital equivalent of moving around scaled pieces of paper to create plan configurations, except that the individual pieces can change shape, many complex considerations can be simulated at the same time, and the resulting footprint has exterior walls that are logically aligned.

IF HUMANS CAN INFER DESIGN INTENT FROM SKETCHES, COMPUTERS CAN, TOO.

Imagine that each space in a bubble diagram is attached to other spaces by springs. The architect assigns a relative strength to each spring proportionate to the need for adjacency between the two spaces. Arvin's computer program applies the laws of physics to the springs to pull some spaces together and push others apart, until the configuration reaches equilibrium. Similar physical simulations are performed for moving spaces that require particular views to particular orientations, for moving interior spaces toward the center of the overall footprint, for aligning the boundaries of adjacent spaces, and for maintaining the necessary area or proportion of each space. For example, a kitchen and dining room would be pulled together while a concert hall and a noisy loading dock would be pushed apart. All of this occurs in an animated format, allowing the designers to observe the effects of the parameters they specify.

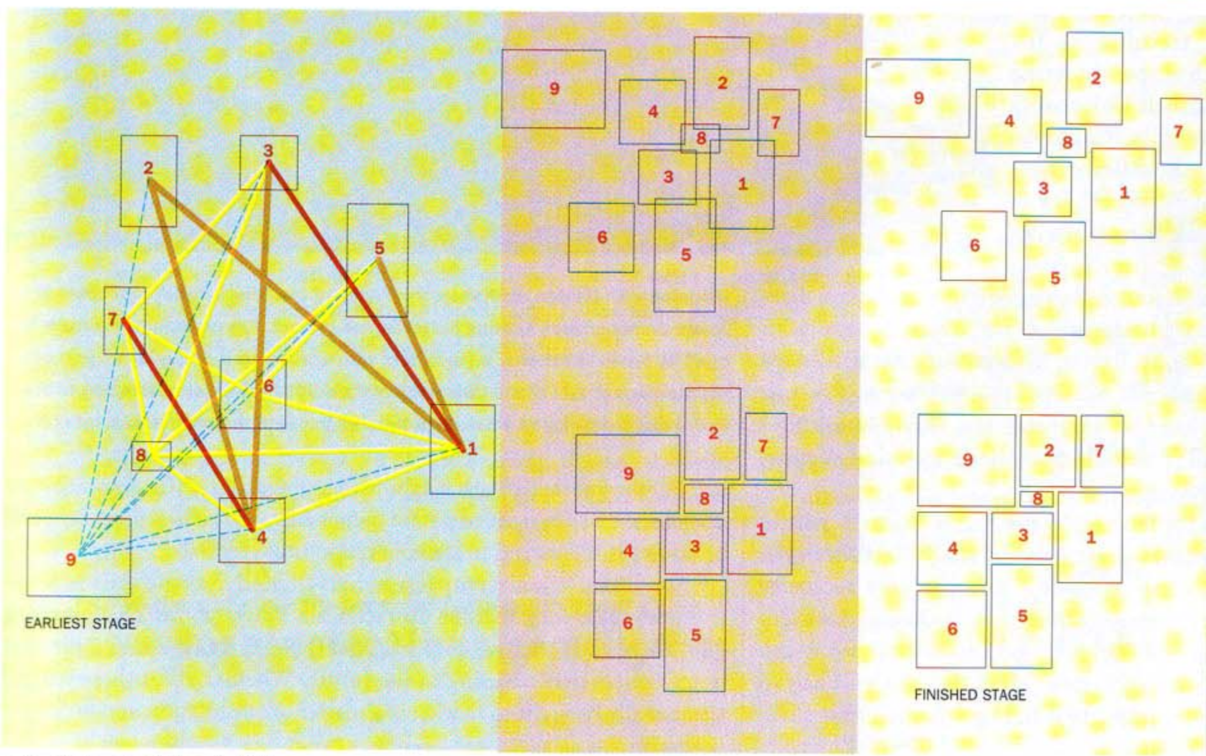
What makes the software a design tool, one that could become part of a larger design system rather than an exercise in physics, is that it allows the designer to interact with the various parameters and make continuous adjustments. This adds the designer's intelligence to the simulation and affords multiple plan configurations from which to choose. "This interactivity," Arvin says, "evokes the feeling that one is working with a living design, one that responds to the user in ways consistent with the programmatic objectives, though it still provides intuitive designer control."

Right tool at the right time

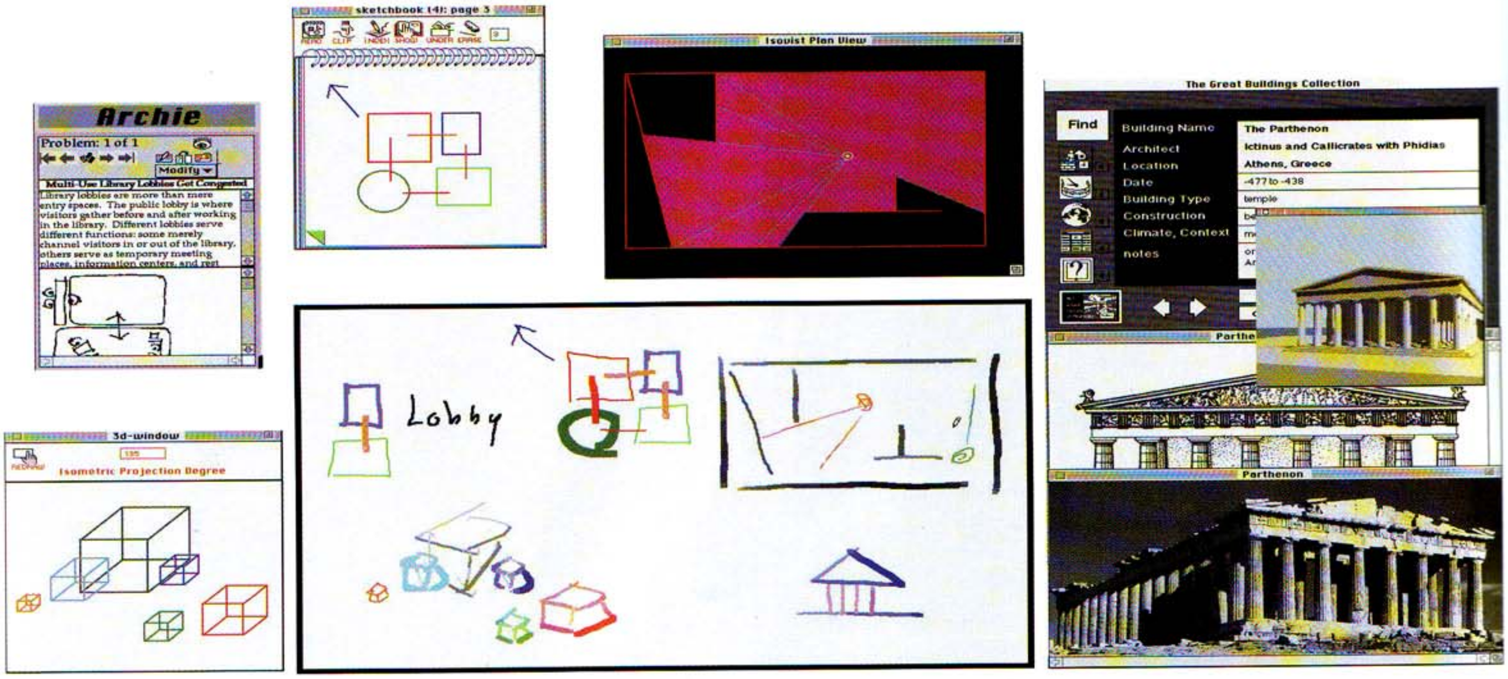
Many architects remember a favorite design professor who could, after merely glancing at a drawing, pull down the perfect reference book to help develop the idea. If humans can infer design intent from sketches, maybe computers can, too. So reasoned Ellen Yi-Luen Do, (ellendo@u.washington.edu) now a professor at the University of Washington. For her recently completed doctoral dissertation from the Georgia Institute of Technology, she developed a prototype sketch environment in which the computer software recognizes drawn shapes, determines the drawing type, and interprets symbols to derive design intent. It then launches other software applications that perform reference searches or provide some analysis of the drawing.

For example, a certain configuration of lines can be construed to be a floor plan. If the architect draws a few arrows emanating from a point, Do's software infers that he or she is thinking about views within the plan. This launches a program called Isovist, which highlights the portion of the plan visible from the viewpoint, taking into consideration walls, windows, and partitions. The architect then continues designing without having to think about software mechanics.

Do's prototype, dubbed "The Right Tool at the Right Time," or RT^2, depends on a foundation of sketch recognition software which, like Isovist, was developed at the University of Colorado's Sundance Laboratory for Computing in Design and Planning. RT^2 can identify whether a drawing is a bubble diagram, floor plan, section, or 3-D view; it can recognize commonly understood symbols such as windows, walls, ground lines, sun angles, and numbers. In addition to Isovist, RT^2 can launch Archie, a library of post-occupancy evaluation case studies developed at Georgia Tech; the Great Buildings Collection from Artifice Inc, an encyclopedia of hundreds of famous buildings; a numeric calculator; and a geometric modeler that converts sketched rectilinear massing into a



In Scott Arvin's space-planning prototype, randomly positioned rooms undergo a series of simulations that pull them apart and push them together according to program requirements. In the final stage, the spaces are grouped in a viable floor plan with properly aligned exterior edges.



Ellen Yi-Luen Do, a professor at the University of Washington, developed reference software while pursuing her doctorate at the Georgia Institute of Technology. The Right Tool and the Right Time, dubbed RT^2, provides a sketch environment (bottom center) in which certain symbols automatically call up appropriate reference and simulation tools. Shown clockwise from the bottom left, the tools include a 3-D modeler; Archie, a library of post-occupancy evaluation case studies; a digital notebook in which the irregular sketch is translated into the equivalent, rectified figures; Isovist, for displaying a view analysis, and several images from the Great Buildings Collection.

3-D model that can then be turned and viewed from other perspectives. In theory, RT^2 can link to any number of support applications, Do says, including commercial design software such as AutoCAD or form*Z.

Hand-crafted digital models

Good news from Brazil for everyone who has ever felt like they had one hand tied behind their back when trying to manipulate 3-D forms with a 2-D drawing instrument. University of Brasilia architecture professor Edison Pratini (pratini@usp.br) is developing a program he calls 3-D SketchMaker. It relies on natural, expressive hand gestures for creating 3-D computer models, a process that removes the discontinuity between conceiving a form and translating it into a digital model. Pratini began the project as part of his dissertation at Pennsylvania State University's Department of Architecture and has since refined it.

NEW SOFTWARE RELIES ON NATURAL HAND GESTURES TO CREATE 3-D MODELS.

"Pointing devices [such as a mouse] and menus in existing software do not allow the freedom, quickness, and spontaneity needed to establish a continuous cycling of information between eye, brain, hand, and paper," Pratini says. He wanted to take advantage of the natural gestures used when describing the shape of objects. His first prototype relies on a 3-D mouse that transmits x, y, z data to the computer instead of the x,y data that's transmitted by a conventional mouse. The designer waves the 3-D mouse through space to create two curves or lines. The software translates one curve into a sectional profile and the other into a path. Then it creates a surface model of that profile being extruded along the path. The resulting rough model is further refined with normal 3-D modeling software.

A second version relies on a data glove containing numerous sensors that interpret finger position and movements in space. Gestures for describing cubes, spheres, and other shapes are translated into corresponding digital forms. They can also be edited in a similar fashion; opening the hand wider, for example, makes the form larger. Beyond creating primitive forms, it is easy to imagine this interface expanding to enable architects to literally mold their schematic designs.

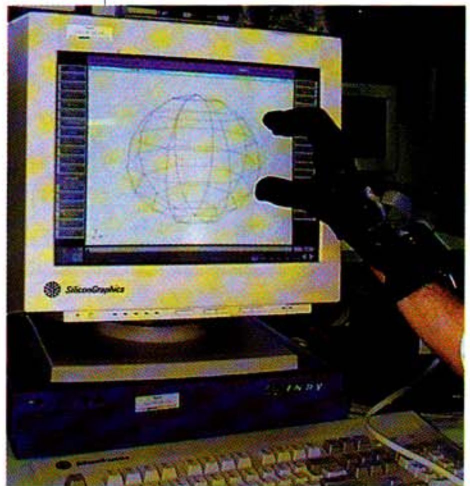
Linking design and science

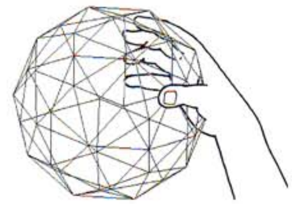
For decades, research scientists have been developing extremely sophisticated analysis tools to study the energy performance of buildings. These tools are typically unsuitable for architects, however, because the interface is cumbersome, the output is largely numeric, and the input requires mechanical engineering data that comes at the end of the architectural design process. To make simulation tools useful in schematic design, when important energy-related decisions about building form are made, Konstantinos Papamichael (k_papamichael@lbl.gov), of the Lawrence Berkeley National Laboratory at the University of California at Berkeley, created the Building Design Advisor (BDA). This software is close to becoming commercially available. A beta version can be downloaded from kmp.lbl.gov/BDA.

The BDA maintains graphic and numeric definitions of a building that is under design, and links the design data to various simulation tools, such as DOE-2 for energy performance calculation, Radiance for lighting calculation and rendering, and DElight for daylight and electric lighting analysis. (These three programs are in the public domain.) The input needed to run each of these programs is different, and the BDA makes the necessary translations.

In cases where a building's design is still sketchy, the BDA creates "smart defaults" to fill in the gaps of missing data. For example, it retrieves performance data from the Department of Energy and ASHRAE to specify wall insulation levels even before the wall material has been selected. Thus, the architect can look at high-level performance evaluations even during schematic design. Moreover, the BDA supports different building assemblies simultaneously so that the architect can compare these configurations—wood studs placed at 16 or at 24 inches on center, for example.

The BDA sports its own Schematic Graphic Editor, which allows a designer to input and edit a simple sketch. But Papamichael expects very soon to replace this with links to commercially available object-oriented CAD systems, such as Autodesk's new Architectural Desktop. In the future, the BDA will link to any number of architectural applications, such as cost estimating, environmental impact analysis, and electronic product catalogs.

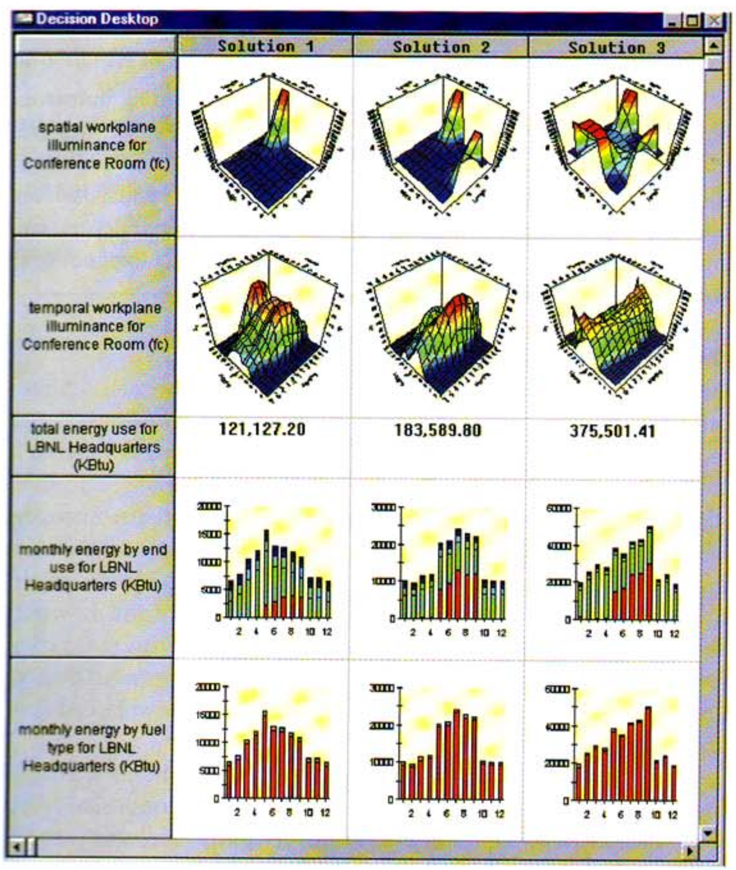




With Edison Pratini's 3-D SketchMaker, various forms, such as cubes and spheres, can be shaped by ordinary hand gestures with the help of a data glove. Once the basic forms are created, they can be combined and edited with conventional CAD modeling software.

Putting it all together

These four examples are isolated approaches to architectural design computing. Each demonstrates a narrowly focused capability that is desirable but missing from current practice. However, each prototype is founded in the belief—ubiquitous within academia, it seems—that the ultimate goal is to connect all tools of drawing, design, analysis, simulation, and visualization to a single, cohesive, complete model that contains everything that can be known about the building under design.



Konstantinos Papamichael's Building Design Advisor features three schematic building designs that are rated on each of five criteria. At a glance, the architect can evaluate the amount of daylight present throughout a space, on a daily basis, throughout the year. The program also portrays annual and monthly total energy consumption for each estimate.

Bringing these ideas into the commercial software market is made even more difficult by this singular approach, which represents a mismatch between the structure of the construction industry and what is needed for the single building model approach to be accepted, says Robert Aish (Robert.Aish@Bentley.com), a research scientist with software vendor Bentley Systems.

Fifteen years ago, Aish worked on an English design system called RUCAPS, which later came to the U.S. and was renamed Alias Sonata. The system allowed multiple users from all disciplines, or "enterprises," within the construction industry, to work on a single model with parametrically defined components. Drawings are generated from the model, thus guaranteeing their consistency.

Sonata was a commercial disappointment. One reason, Aish says, is that its concept of "enterprise computing" required a restructuring of teams within the industry. For example, it required more detailed input by architects for the benefit of the engineers and contractors downstream. But there was no motivation or compensation for the increased workload upstream. As a result, the now-familiar drafting systems that run on low-cost personal computers won over the U.S. market because drawing efficiency could be improved without requiring major readjustments in the way business is done.

Now software developers are joining academic researchers in calling for the professions to make these adjustments, revamping the relationships between architect, engineer, builder, and owner and rethinking how various players are compensated for their contributions. Until that happens, Aish says, Bentley is working on methods for easing the transition. Their new ProjectBank technology creates a central data repository that looks much like a traditional CAD environment, but is accessible to the entire team.

At the same time, software developers, including Bentley, are working with architectural and sociological researchers who study collaboration. Their goal is to understand the key social and technical barriers that have prevented a restructuring of the design-to-construction process. This time, Aish says, "we want to get both the technology and the business conditions correct—and correctly matched."

This adds an optimistic note to the story of architectural software research. With sufficiently powerful hardware and support software, all the clever research ideas—automating space planning, hand-crafting forms, calling up reference materials with sketches, and performing complex energy simulations early in design—will eventually become part of a practitioner's everyday toolkit. The obstacles may be many but the rewards are compelling. ■