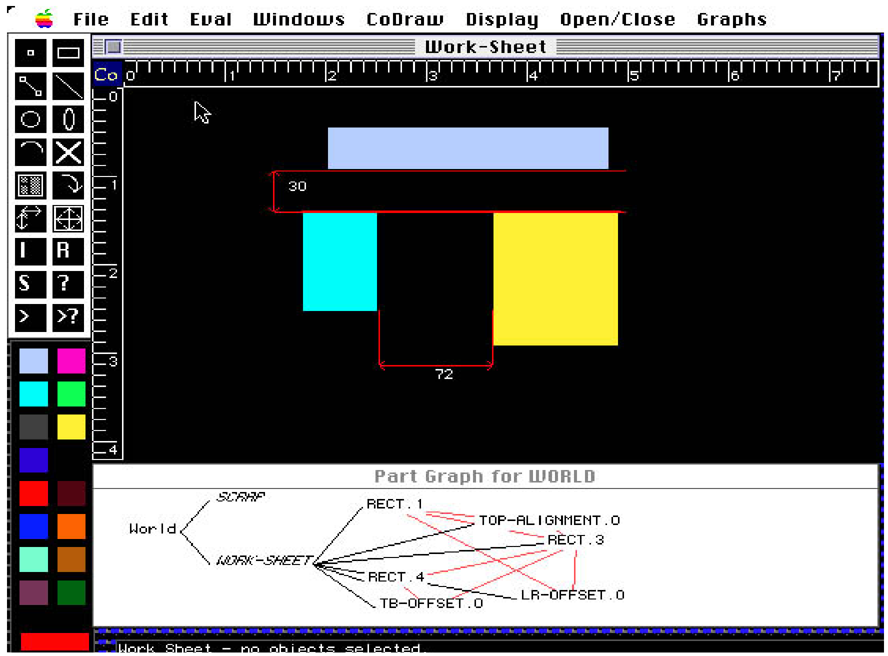
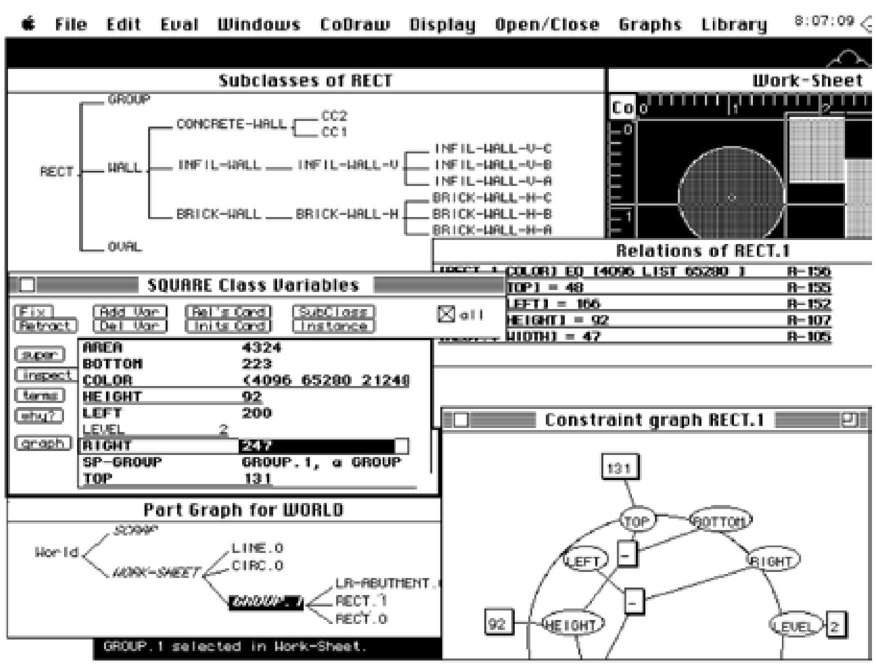
Projects

Courses

MARK D GROSS
some work: 1986-2009





CONSTRAINTS

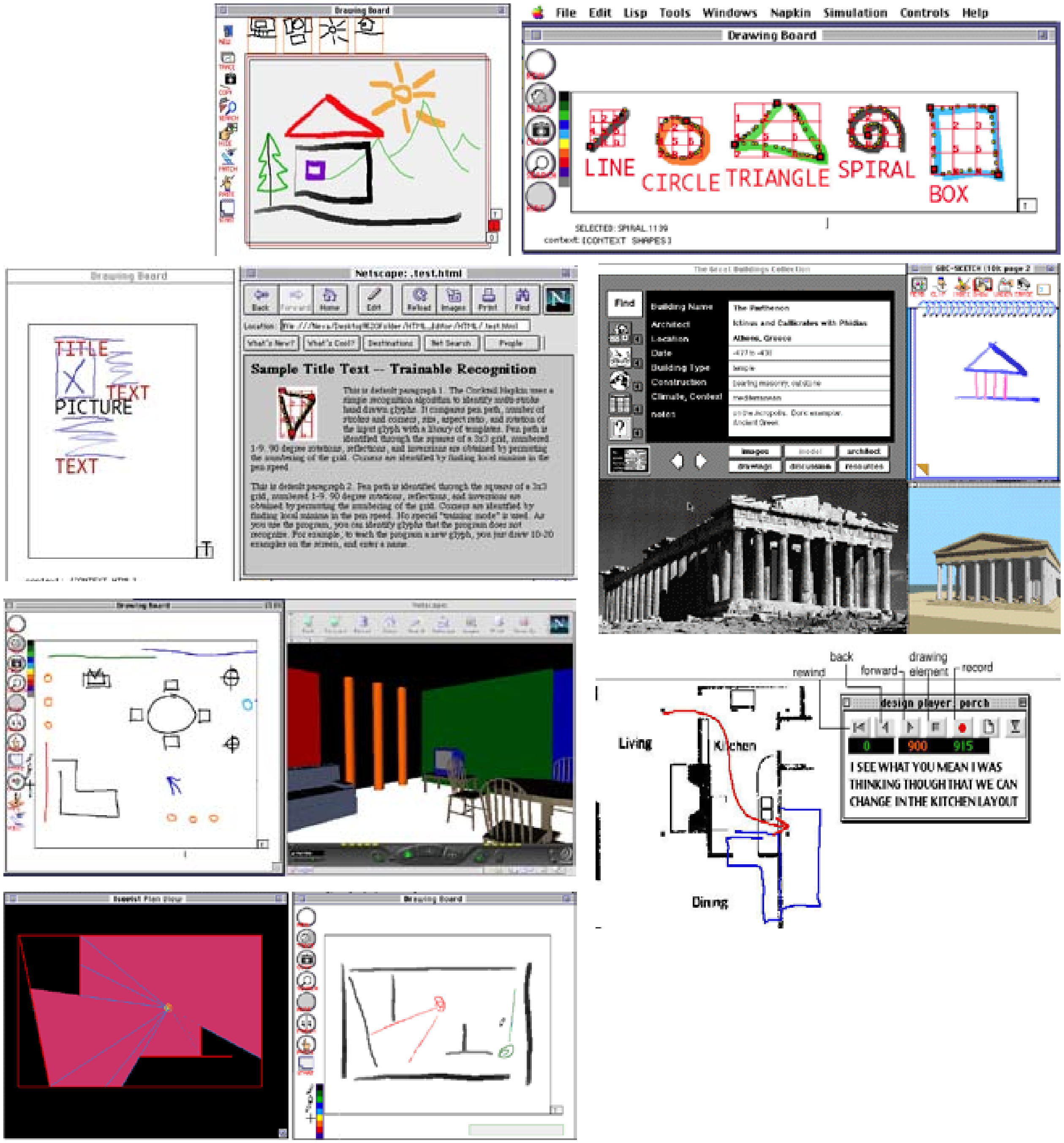
Design tools should manage relationships, not just objects. CoDraw, an end-user programmable graphical editor, uses a constraint solver to maintain spatial relationships the user asserts. The CAD tool keeps track of and enforces desired distances, offsets, tangencies, proportions, and any other desired relationships, relieving the designer of tedious low-level interactions.

Graphics objects and spatial relationships are first-class objects, editable and extendable, and end-users design the icons that add these objects to the tool palettes.

above: graphic editor, showing tool palette, working area, and part-graph browseres for current layout.

below: programming language interface with diagram editors for inheritance, part hierarchies and constraint graph; spreadsheet cards to define objects and relations.

1992 Graphical Constraints in CoDraw, Gross, M.D., *IEEE Workshop on Visual Languages*
1990 Relational Modeling: A Basis for Computer-Assisted Design, Gross, M.D., in *The Electronic Design Studio,*: MIT Press.
1987 Designing With Constraints, Gross, M.D., J. Anderson, S. Ervin, A. Fleisher, in *The Computability of Design*, Wiley and Sons.
1986 Design as Exploring Constraints, *PhD dissertation, MIT.*



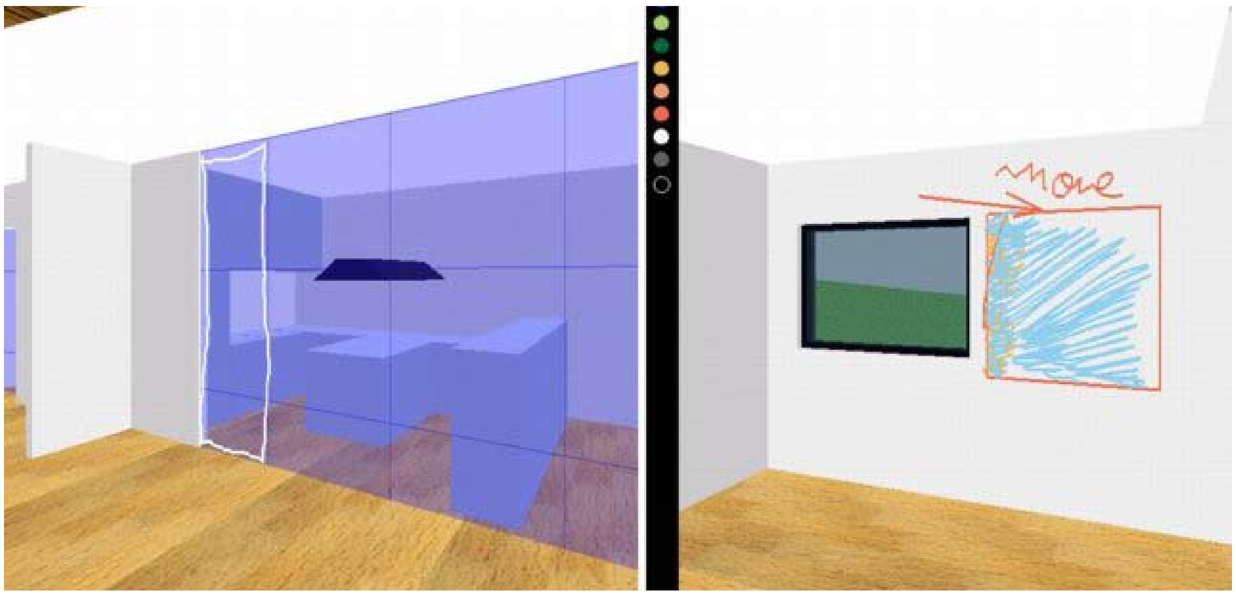
DRAWING

Designers draw. What if computers could recognize, interpret, and understand our drawings and diagrams? The Electronic Cocktail Napkin project investigated a software framework, interaction, and applications for sketch and diagram recognition as an interface to knowledge-based systems.

The Electronic Cocktail Napkin comprised a trainable template-matching symbol recognizer and visual language parser. It formed the platform for various investigations: diagram interfaces for image database retrieval, simulation, web-page layout, three-dimensional modeling, multimodal (speech and graphics) recording and playback of design conversations, 'shape emergence', constraint-based diagramming, and more.

Research Assistant & Partner:
Ellen Yi-Luen Do

2009 Visual Languages and Visual Thinking: Sketch Based Interaction and Modeling, Gross MD, *Eurographics Workshop on Sketch-Based Interaction and Modeling* (keynote address)
2001 Thinking with Diagrams in Architectural Design, Do, E. Y-L and M.D. Gross, *Artificial Intelligence Review*
2000 Drawing on the Back of an Envelope: a framework for interacting with application programs by freehand drawing, M.D. Gross and E. Do. in *Computers and Graphics Journal*
2000 Intentions in and Relations among Design Drawings, Do, E. Y-L, Gross, M.D., Neiman, B., Zimring, C., *Design Studies*.
1994 Stretch-A-Sketch, a dynamic diagrammer, Gross, M.D., *IEEE Symposium on Visual Languages.*
*1994 Recognizing and Interpreting Dia*grams in Design, Gross, M.D., *ACM Advanced Visual Interfaces*
1994 Using Diagrams to Access a Case Base of Architectural Designs, Gross, M.D., C. Zimring, and E. Do. *Artificial Intelligence in Design*



ANNOTATION

Designers annotate designs with problems, opportunities, and proposed changes.

With Immersive Redliner *(above)* design team members and stakeholders visit a 3-D design on the Web and leave markers (colored circles) with text annotations, stored for others to review.

Space Pen *(center)* makes annotation graphical and spatial. It enables design team members and stakeholders to mark up a 3-D design on the Web and to augment the design by sketching on it.

With Light Pen *(below)* a lighting designer 'sketches with light' on the surfaces where light is desired; an rule-based expert system recommends lamp and location choices.

Research Assistant: Thomas Jung

2004 As if You Were Here – Intelligent Annotation in Space: 3D Sketching as an Interface to Knowledge Based Systems, E. Y-L. Do, M. Gross, *American Association for Artificial Intelligence (AAAI), Fall Symposium*

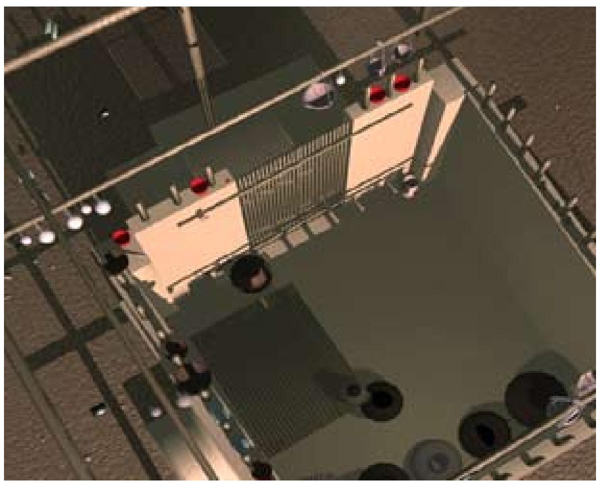
2003 Light Pen: Sketching light in 3D, Thomas Jung, Mark D. Gross, Ellen Yi-Luen Do, Computer Aided Architectural Design Futures

2002 Sketching Annotations in 3D on the Web T. Jung, E. Do, and M. Gross, *ACM Conference on Human Factors (SIGCHI).*

2002 Annotating and Sketching on 3D Web Models, T. Jung, E. Do, and M. Gross, *ACM Intelligent User Interfaces (IUI)*

2001 Space Pen: Annotating and Sketching on 3D Models on the Internet, Jung, T., Gross M.D., and Do, E., *Computer Aided Architectural Design Futures.*

1999 Immersive Redlining and Annotation of 3D Design Models on the Web, T. Jung, E. Do, and M.D. Gross, *Computer Aided Architectural Design Futures*



VISUALIZING

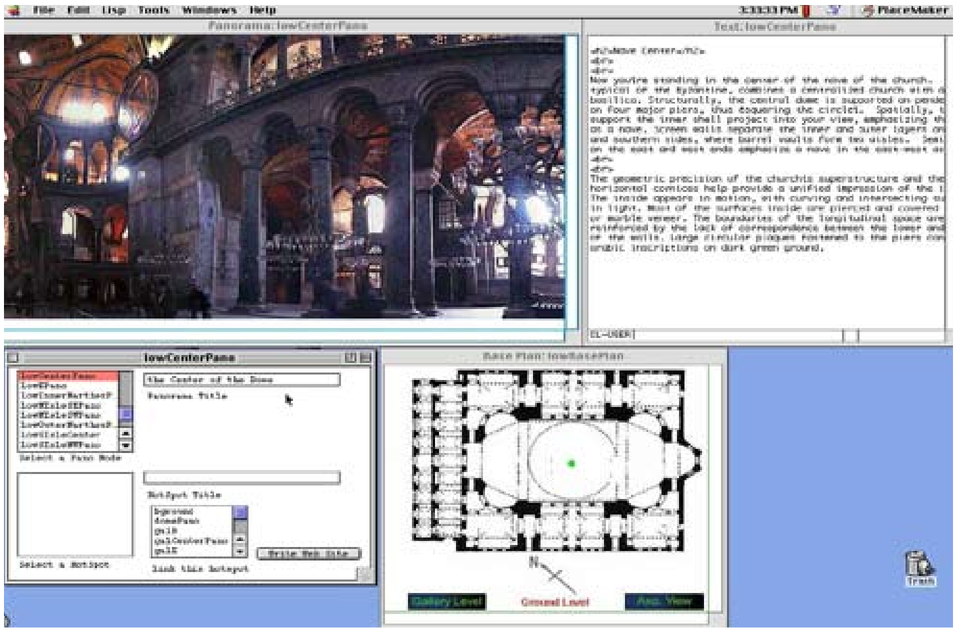
Visual thinking plays an important role in many design domains. Sometimes the image is marshaled as part of an argument.

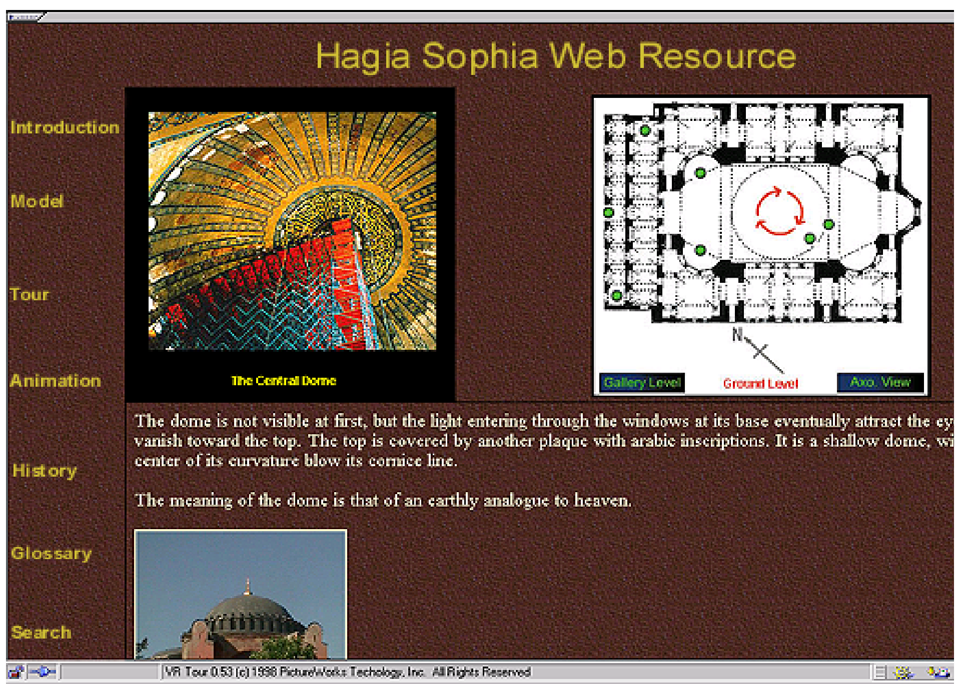
Working with cultural anthropologists at the University of Colorado, the Ceren Virtual Archaeology project visualized field data from a Mesoamerican village buried by a volcanic eruption 1400 years ago. Made from 3-D computer models, the panoramic images include structures, household utensils, and artifacts. Making these 3-D models was more than creating "artist's renderings" and led to serious arguments about how to interpret the archaeological data.

The Ceren Web site serves as a visual and spatial interface to a database of field specimen records. It was used to teach an introductory course in cultural anthropology to give students a sense of the physical layout of the site and published as a CD-ROM accompanying a textbook on the excavations.

Research Assistant: Jeniffer Lewin

2002 Before the Volcano Erupted: *The Ancient Cerén Village in Central America. Sheets*, P. (editor). University of Texas Press, Austin.
1998 The Ceren Web Resource: Enabling Students to Become Anthropologists In A Virtual Site, Lewin,J. Ehrhardt, M. and M.D. Gross, *ACM Conference on Computer Graphics (SIGGRAPH 98)* Educators Program.
1997 Not Just Another Pretty Face: Image and argument in an archaeological web site, Lewin, J., M. Erhardt, and M.D. Gross, *Computer Assisted Architectural Design Futures*





SENSE OF PLACE

Web sites that convey a sense of place, used for education and tourism, require assembling textual and graphic materials to provide a sense of place. We learned in constructing the Ceren Web site that the mechanics of this can be tedious and time-consuming.

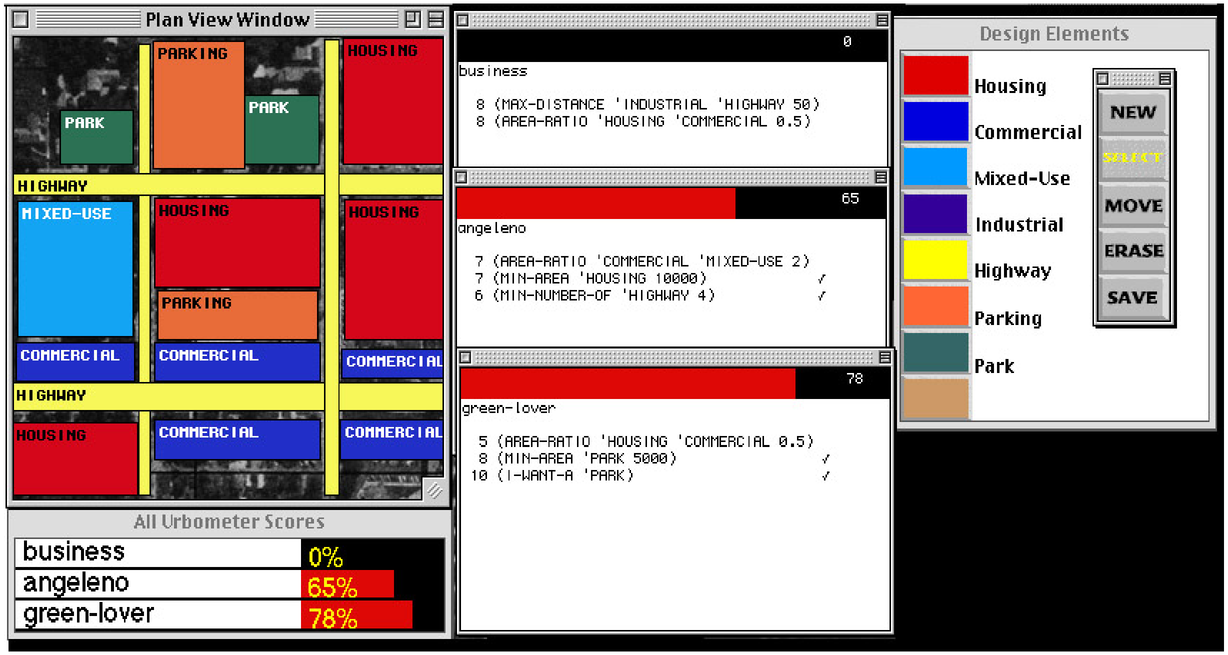
The Placemaker toolkit helps non-teachers or other non-technical users construct interactive 'place-based' Web resources like the Ceren Virtual Archaeology site. Beginning with a ground plan, panoramic or ordinary photos of the site and explanatory text, a user stitches these materials together, with hot-spots on the panoramic pictures and a 'you-are-here' interactive floorplan map.

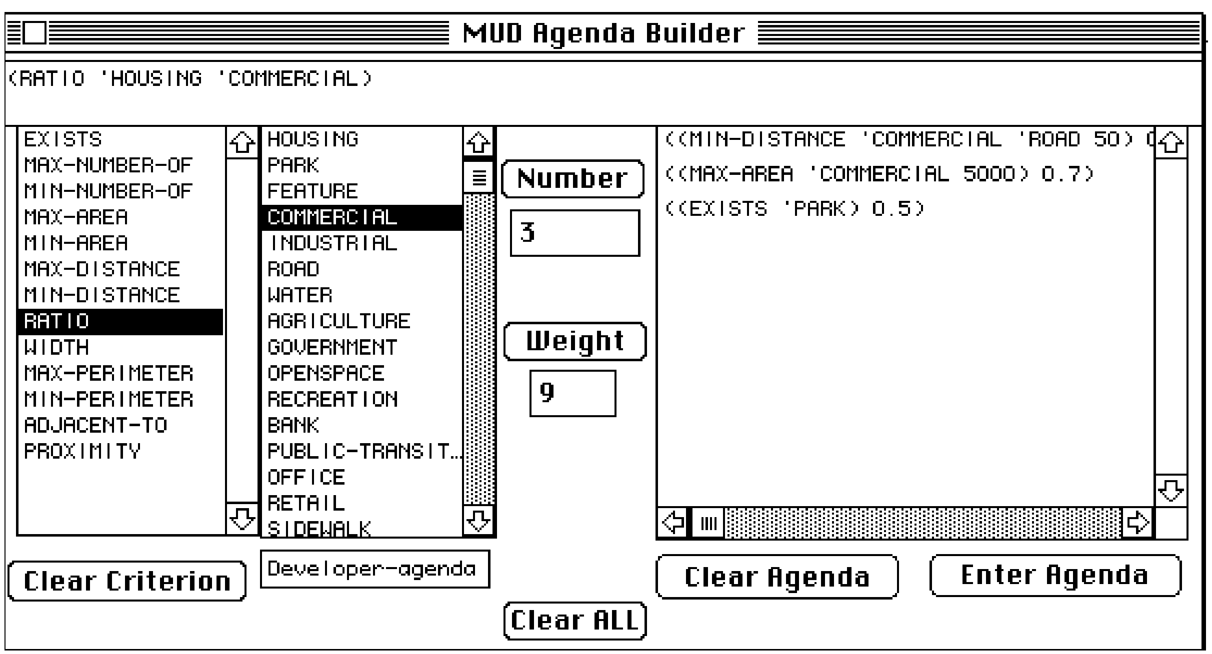
above: The Hagia Sophia interactive Web site under construction in Placemaker.

below: The Hagia Sophia virtual visit.

Research Assistant: Mark Ehrhardt

2000 Place Based Web Resources for Historic Buildings, M. A. Ehrhardt and M.D. Gross, *Education in Computer Aided Architectural Design in Europe (eCAADe)*





TRADEOFFS

Design decisions always involve tradeoffs; each stakeholder has different values, and prefers different tradeoffs.

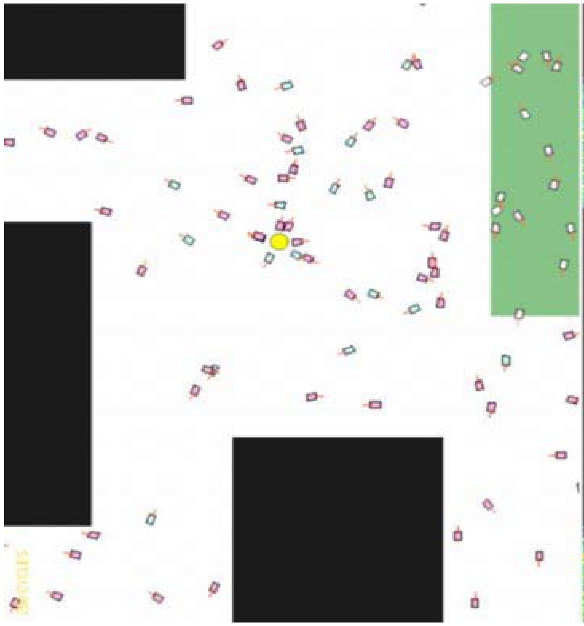
The Multi-user Urban Design (MUD) program visualizes this process, first asking stakeholders to articulate preferences using a simple language that describes desired design features and their relative importance. Then, as design elements are added to the site, the program displays the design's score for each stakeholder, on "urbo-meters".

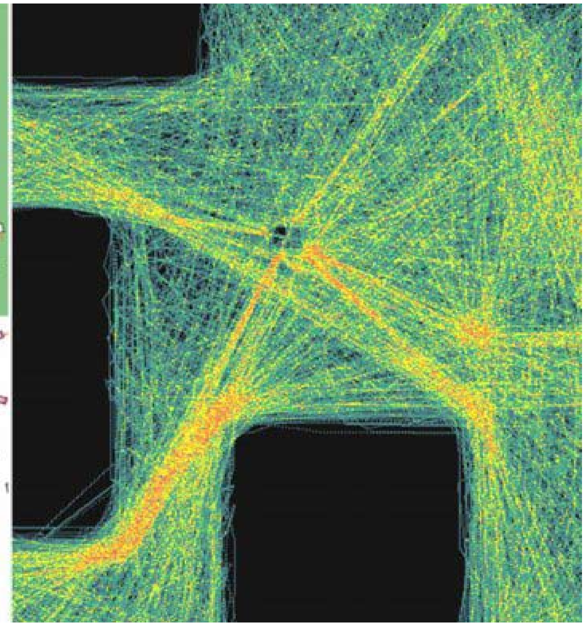
above left: urban site with three urbo-meters for different stakeholders; above right: tool palette.

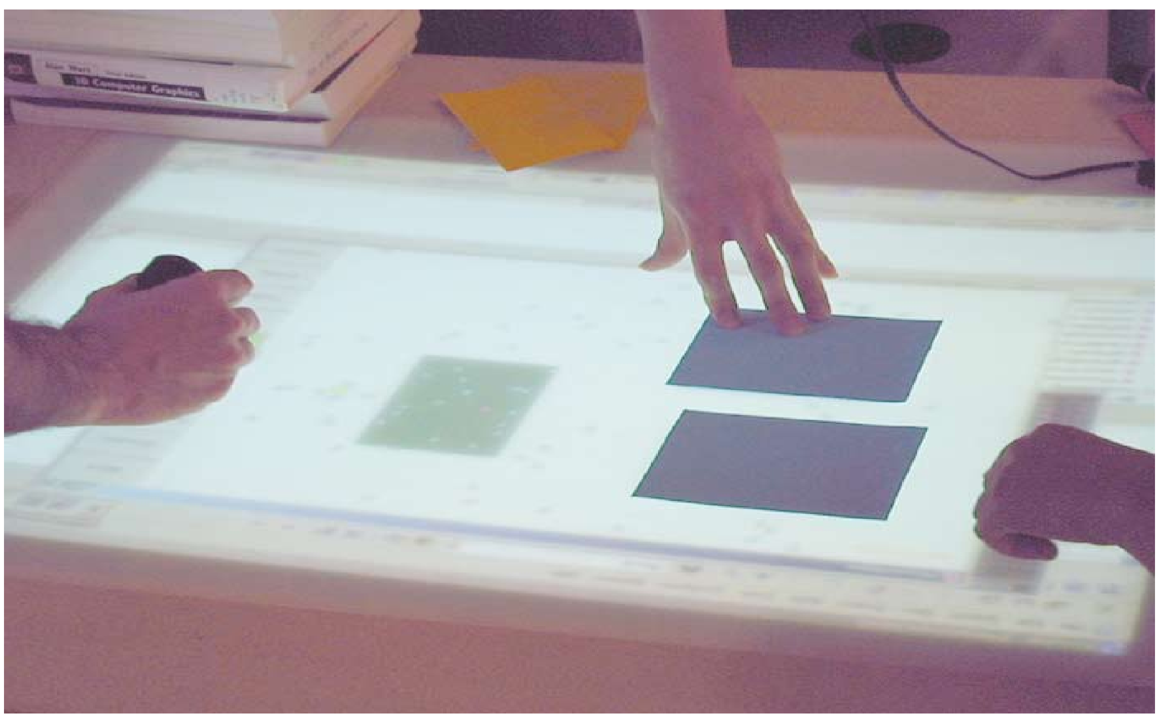
below: stakeholder dialog for expressing design preferences.

Research Assistants: Laura Parker, Ame Elliott

1997 MUD: Exploring Tradeoffs in Urban Design, Parker, L., A. Elliott, and M.D. Gross, *Computer Assisted Architectural Design Futures*







SIMULATING

Architects and urban designers must pre-duct how people will move in the built environment.

The “MouseHaus” project *(above)* models decisions of individual pedestrians as they move about a simulated built environment. The pedestrian model includes goal-seeking and obstacle-avoiding behaviors, moving and resting, and produces emergent phenomena such as laminar flow.

The “MouseHaus Table” *(below)* is a tangible interface to the MouseHaus simulation. Users cut out and arrange colored paper rectangles, representing buildings and parks, to interact with the simulated pedestrians projected on the table.

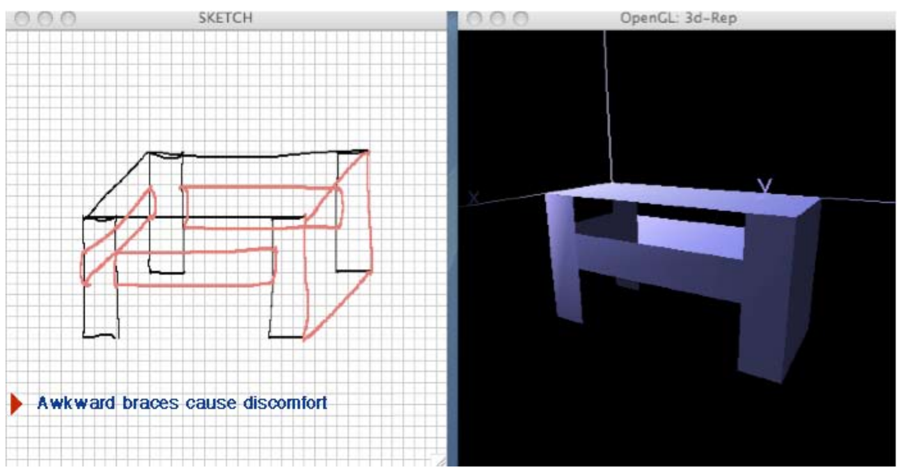
Research Assistants:
Preechaya & Sitt Therakomen, Chenje Huang

2003 MouseHaus Table, a Physical Interface for Urban Design (poster), Chen-Je Huang, Ellen-Yi Luen Do, Mark D Gross, *User Interface Software Tools (UIST)*

2003 MouseHaus Table (poster) Chen-Je Huang, Ellen Yi-Luen Do, Mark D Gross, *Computer Aided Architectural Design Futures*

2003 Mouse.class: Pedestrian Behavior in Urban Places, Preechaya Therakomen, Master of Architecture thesis, University of Washington

CRITIQUING



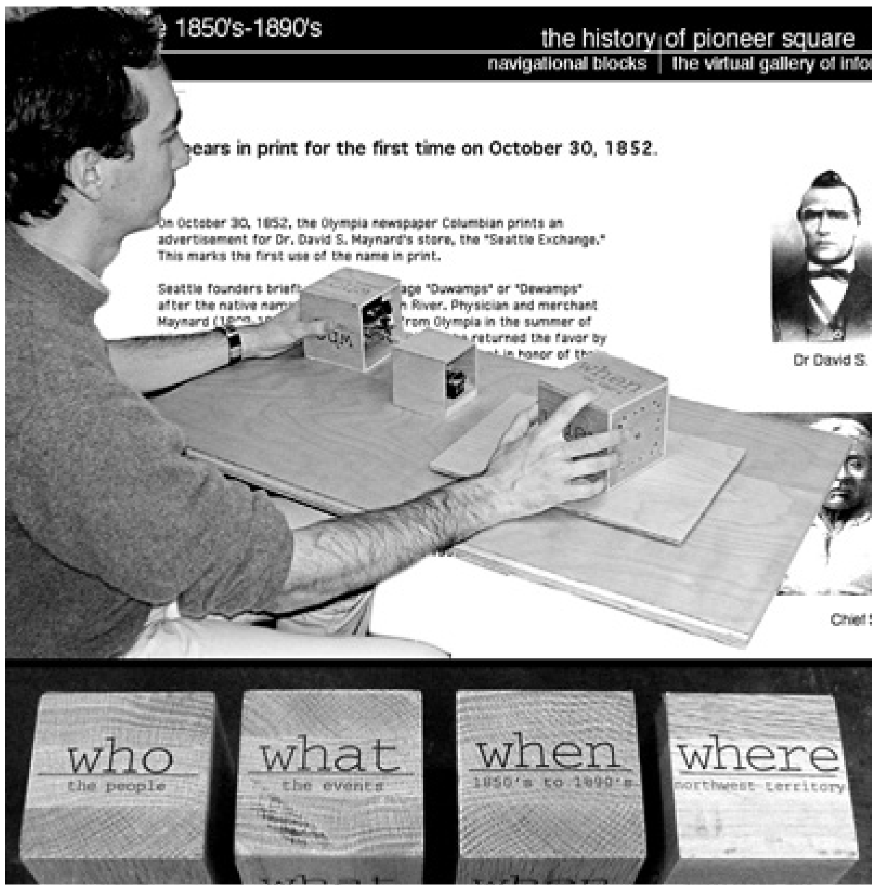
Critiquing is an essential part of teaching and learning design. Computer based critics can aid teaching and learning by providing task-relevant information to a designer making decisions.

above: The Design Evaluator compares a sketched 'bubble diagram' design against previously stored rule patterns, and identifies design problems, annotating the sketch graphically, displaying them in an immersive 3-D model, and presenting text descriptions.

below: The Furniture Factory Design Critic offers critiques on sketched 'flat-pack' furniture design, choosing a method (graphic, text, directive, examples) of presenting critiques based on a model of the student's strengths and weaknesses and past history.

Research Assistant: Yeonjoo Oh

2009 Delivery types and communication modalities in the furniture factory design critiquing system, Oh Y, Do, EY-L, Gross, MD, Ishizaki, S, *Computer Aided Architectural Design Futures (CAAD Futures)*
2008 Computer-aided Critiquing Systems: Lessons Learned and New Research Directions, Oh, Y., Gross, M.D., and Do, E. Y-L., *Computer Aided Architectural Design Research in Asia (CAADRIA)*
2004 Critiquing Design Sketches, Y. Oh, E. Y-L. Do, M. Gross, *American Association for Artificial Intelligence (AAAI), Fall Symposium*
2004 Design Evaluator, Critiquing Freehand Sketches, Y. Oh, E. Y-L. Do, M. Gross, in *Generative Computer Aided Design Systems*



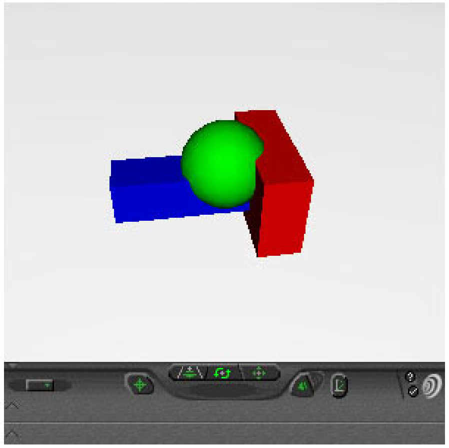
TANGIBLE QUERY

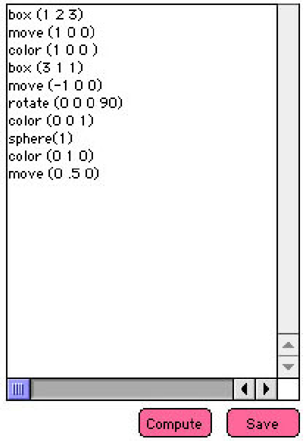
Hands-on interaction can be more engaging than screen-based interfaces, especially for young users and those not accustomed to interacting with computers.

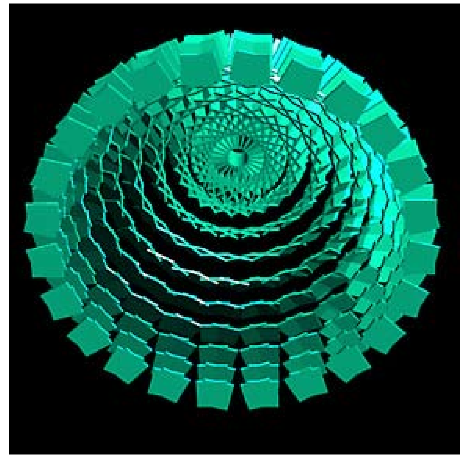
The Who, What, When, and Where Navigational Blocks invite tangible interaction with a database of historical information about Pioneer Square in Seattle. An orientation sensor in each block identifies which face is up. The blocks contain microcontrollers and communicate with a host using infrared light. Each arrangement of blocks produces a query to the database; results are displayed on a screen. The blocks contain electromagnets, which attract to snap the blocks together when a query yields results, and repel to indicate a nonsense query, or that no result is available.

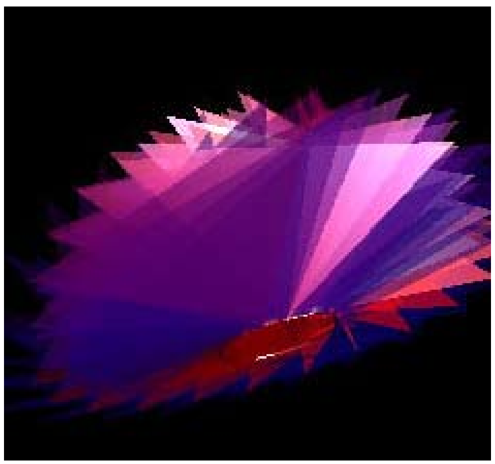
Research Assistant: Kennith Camarata

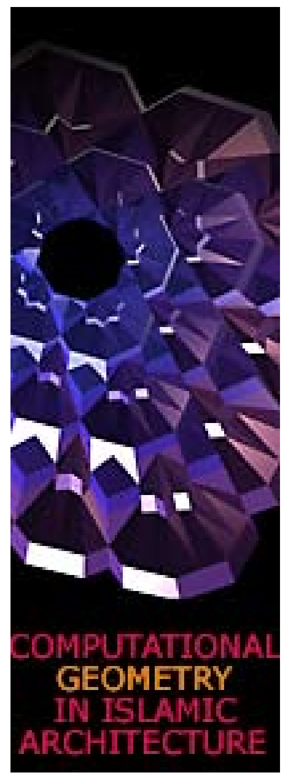
2002 Navigational Blocks: Tangible Navigation of Digital Information, K. Camarata, E. Do, M. Gross, B. Johnson, poster, *ACM Conference on Human Factors (SIGCHI)*
2002 Navigational Blocks: Navigating Information Space with Tangible Media, K. Camarata, E. Do, M. Gross, B. Johnson, *ACM Intelligent User Interfaces (IUI)*
2001 Navigational Blocks: an interplay between the physical and the virtual, Kennith Camarata, Master of Architecture thesis, University of Washington

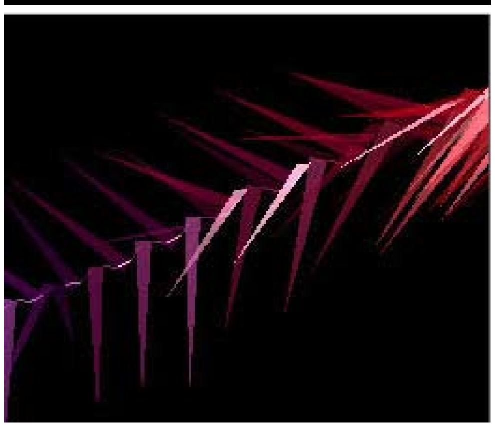


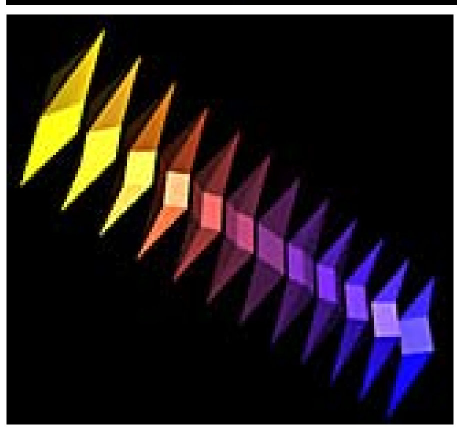












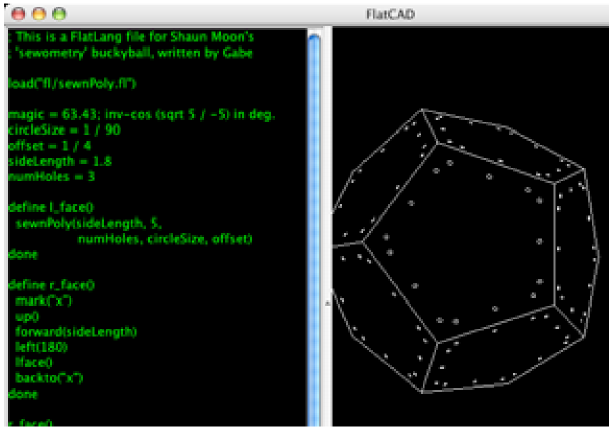
ALGORITHMIC 3-D

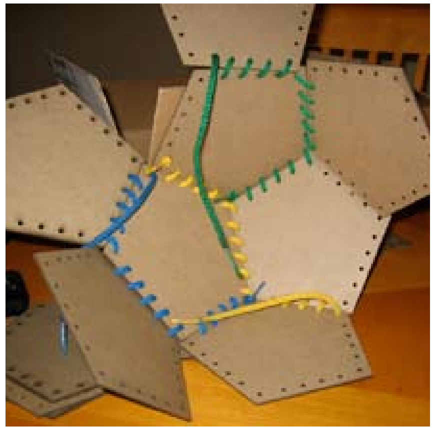
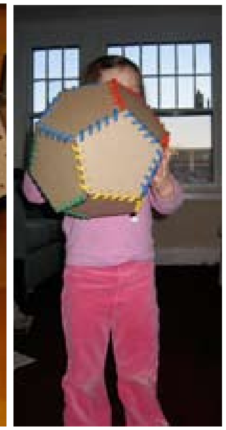
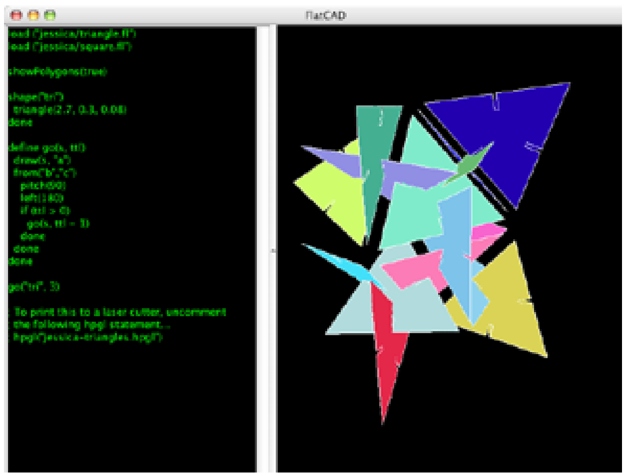
Three-dimensional shape, or 'form' can be understood and generated algorithmically, as a sequence of instructions. This ancient idea underlies traditional art and architecture as well as recent parametric excursions in architectural design.

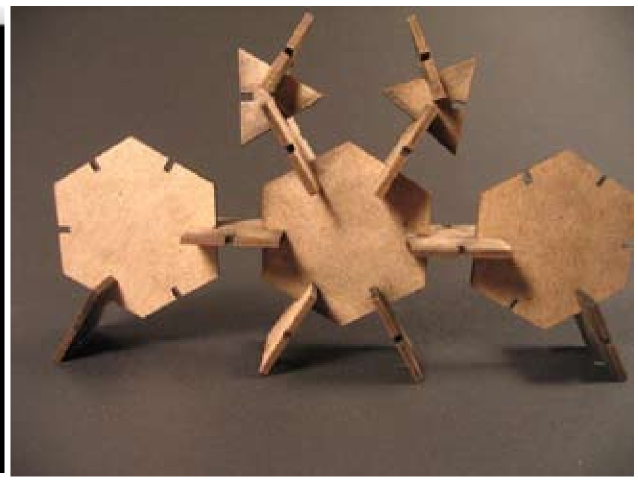
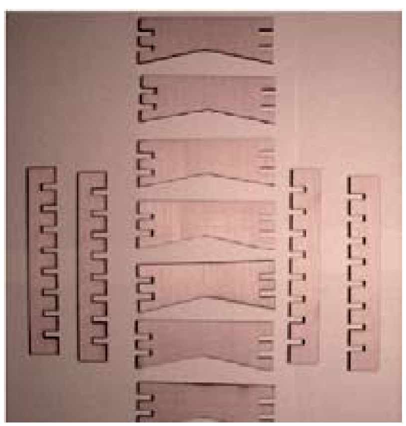
FormWriter, a simple 3-D turtle geometry language enables students with no programming experience to algorithmically generate three-dimensional shapes and forms. Users write simple scripts to create geometry, and the intepreted language immediately displays the forms. FormWriter was used to teach a class on computational geometry in traditional Islamic architecture at the University of Washington.

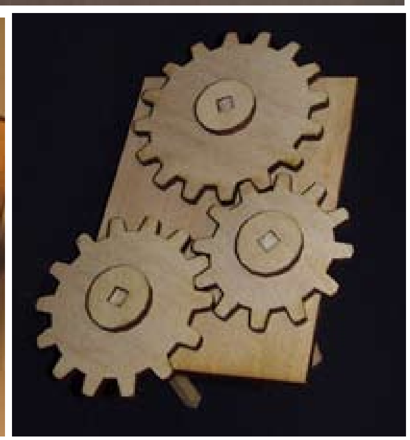
Research Assistant: Mamoun Sakkal

2001 FormWriter: A Little Language for Generating Three-Dimensional Form Algorithmically, Gross, M.D, *Computer Aided Architectural Design Futures*





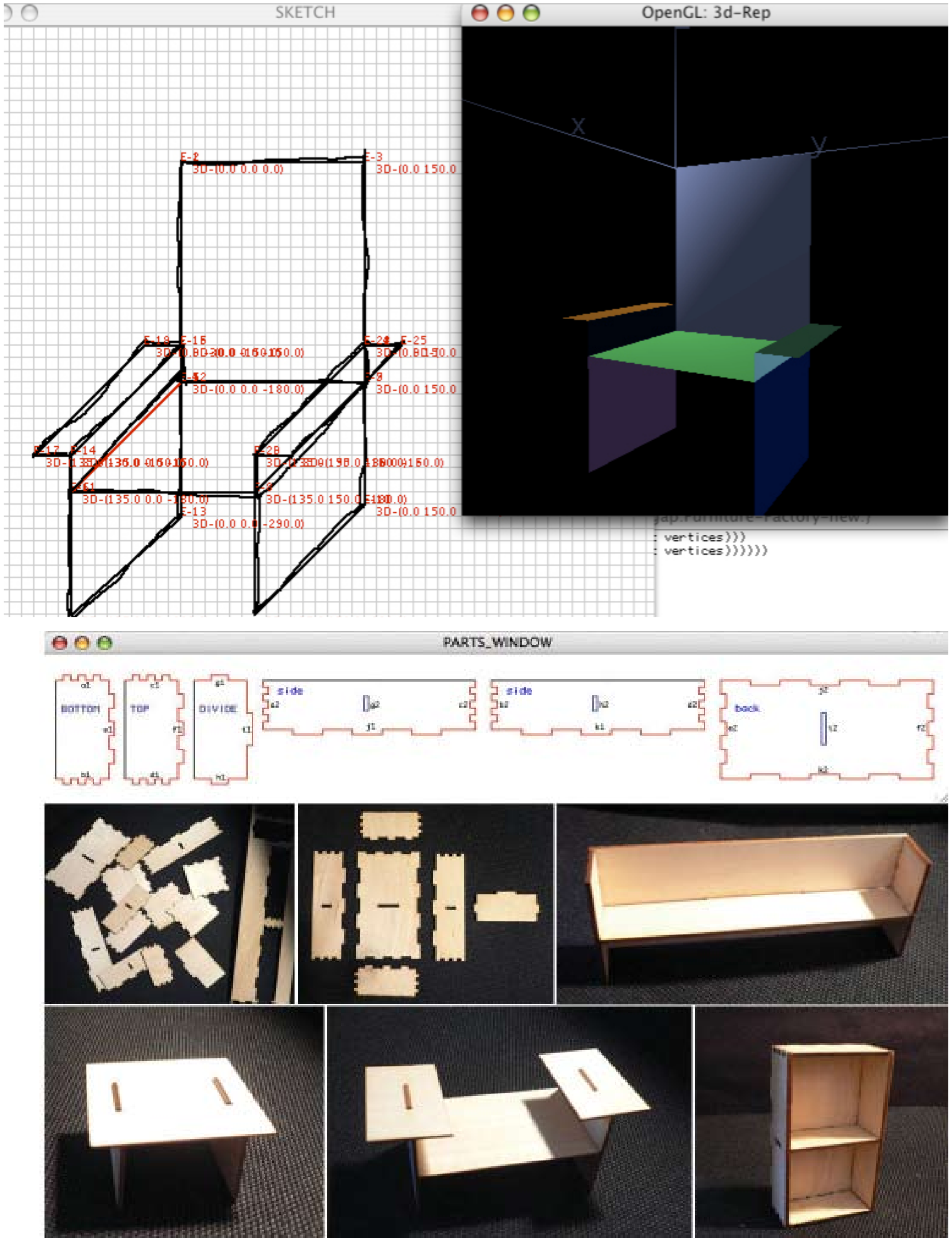
CODE-TO-FABRICATION

Going beyond mere computer graphics, new computer-numerically controlled machinery such as a laser cutter offers rapid manufacturing of physical forms.

Using the simple FlatCAD programming language, anyone can generate and visualize three-dimensional forms made from flat material pieces, then use a laser cutter to fabricate the model. FlatCAD uses a 3-dimensional turtle geometry model similar to FormWriter as the basis for the end-user programming language.

Some objects made with FlatCAD:
Top: the Sew-ometry polygon kit.
Center: a slotted construction kit.
Bottom left & center: a slice-form soap dish.
Bottom right: a simple gear mechanism.

Research Assistant: Gabe Johnson



SKETCH-TO-FABRICATION

Sketching offers a quick way to envision a 3-D form, and rapid-manufacturing machinery such as the laser cutter can produce it almost as quickly as you can draw it. But there is more to the design of an object than its appearance. For example, the flat materials that make up an object cut on the laser cutter must be properly jointed.

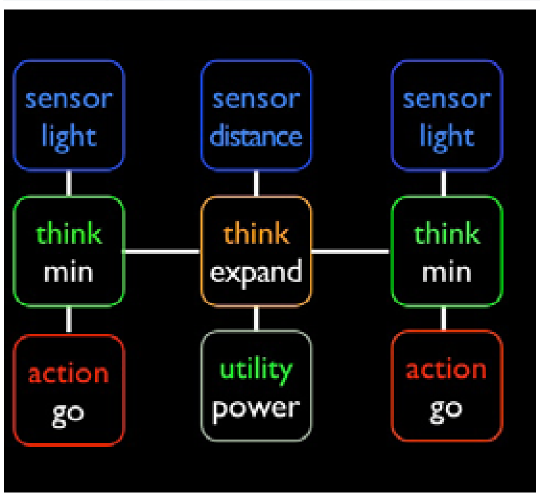
The Furniture Factory program supports design and construction of flat-pack furniture. The designer begins by drawing an isometric diagram, which the program renders and parses into flat planar parts *(above).*

The Furniture Factory identifies the joining conditions and adds appropriate details to the parts *(below).*

The designer then sends the parts file to a laser cutter, then assembles the cut parts into a piece of furniture.

Research Assistant: Yeonjoo Oh

2006 The Designosaur and the Furniture Factory, Yeonjoo Oh, Gabe Johnson, Mark D Gross and Ellen Yi-Luen Do, in *Design Computing and Cognition*



BUILDING BEHAVIOR

Design is not only about physical form, it is also about interactive behavior.

The roBlocks modular robot construction toy is made of black sensor blocks, white actuator blocks, and colored operator blocks. You don't write code to program your robot; the arrangement of blocks produces its behavior. Information flows through faces of the robot construction to produce behaviors. You can build a light-following robot with only three blocks: a battery, a light sensor, and a tractor-drive block.

Research Assistant: Eric Schweikardt

to appear Experiments in Design Synthesis when Behavior is Determined by Shape, Schweikardt, E and Gross, MD *J Personal and Ubiquitous Computing*, special issue on Material Computing

2008 Learning About Complexity with Modular Robots, Schweikardt E. and Gross, M. *IEEE Digital Game and Intelligent Toy Enhanced Learning (DIGITEL)*

2008 The Robot is the Program: Interacting with roBlocks, Schweikardt, E., and Gross, M.D., *Tangible and Embedded Interaction (TEI)*

2007 A Brief Survey of Distributed Computational Toys, Schweikardt, Eric and M.D. Gross, *IEEE workshop on Digital Game and Intelligent Toy Enhanced Learning (DIGITEL)*

2007 roBlocks: Understanding Emergent Complexity from the Bottom Up, Schweikardt, Eric and M.D. Gross, *RSS 2007: Robotics Science and Systems Workshop on Research in Robots for Education*.

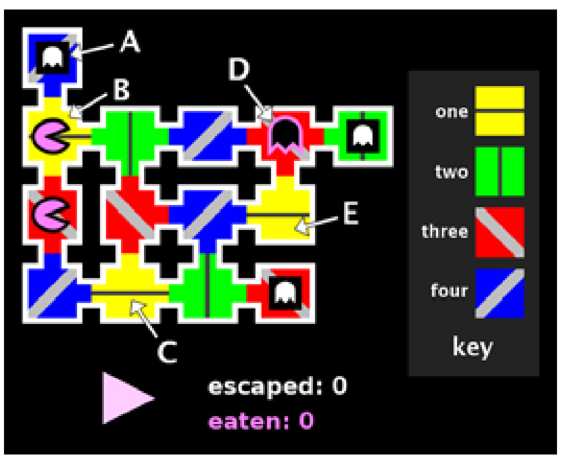
2006 roBlocks: A Robotic Construction Kit for Mathematics and Science Education, Schweikardt, Eric and M.D. Gross, *ACM International Conference on Multimedia Interaction (ICMI)*

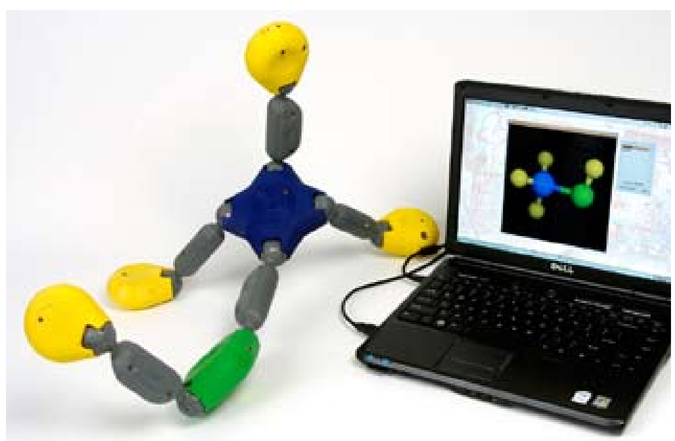
MODELING

A hub-and-strut construction kit dynamically senses the configuration and geometry of its parts and conveys these to an application running on a host computer. Inside each plastic piece is a microcontroller, electronics to realize the optocoupled joint sensing and wireless reporting to the host PC.

Demonstration applications include a puppet-show application *(top)*, a molecule explorer in which the hubs represent atoms and the struts represent bonds *(bottom right)*, and a Pac-Man-like puzzle game *(bottom left)* in which users construct and manipulate a physical finite state machine in order to program the behaviors of game characters.

Research Assistant: Michael Philetus Weller





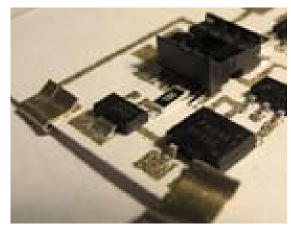
2009 State Machines are Child's Play: Observing children ages 9 to 11 playing Escape Machine, Weller, M., Do, E. Y-L., Gross M., *ACM Interaction Design for Children (IDC)*

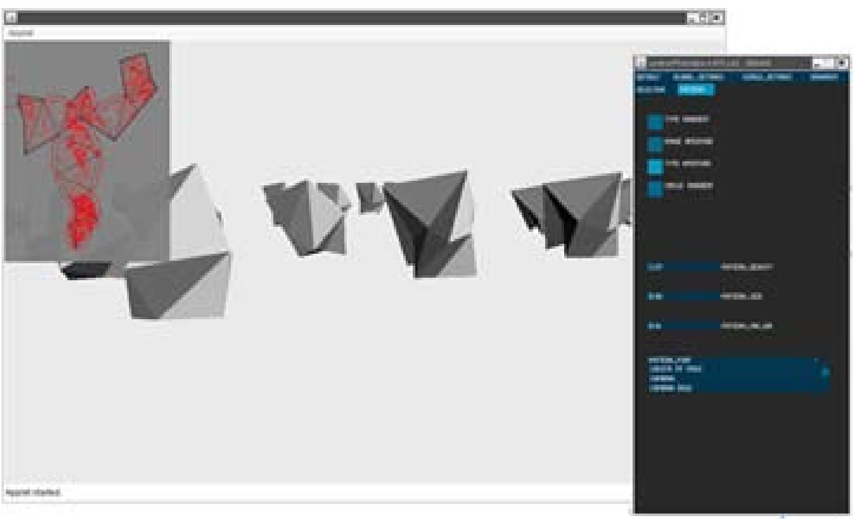
2009 An Optocoupled Poseable Ball and Socket Joint for Computationally Enhanced Construction Kits, Weller, M.P., E YL Do, and M. Gross. *ROBOCOMM, IEEE 2nd International Conference on Robotic Communication and Coordination*

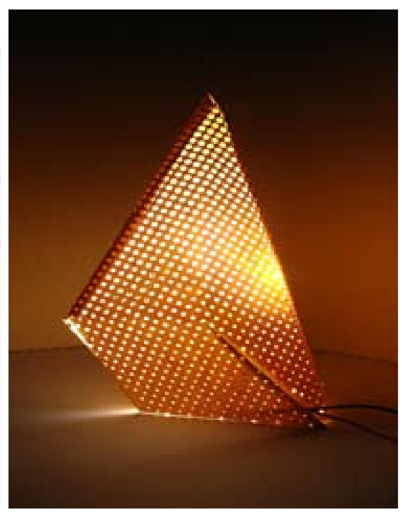
2009 Tangible Sketching in 3D with Posey, Weller, M., Do, E. Y-L., Gross M., *ACM Human Factors in Computing (CHI) Interactive Demonstrations*

2008 Posey: Instrumenting a Poseable Hub and Strut Construction Toy, Weller, M.P., Do, E. Y-L., and Gross, M.D. *ACM Tangible and Embedded Interaction (TEI)*

2008 Escape Machine: Building a tangible state machine game controller with Posey, Weller, M.P., Do, E. Y-L., and Gross, M.D. *ACM Conference on Interaction Design for Children (IDC)*







DIY PAPER ROBOTS

Paper robots are simple hand-made interactive devices made of folded paper actuated by nitinol (shape-memory alloy) wire and electronics mounted on paper with circuits made of gold foil *(above)*. They are controlled by a microprocessor to respond to environmental conditions — to bob to music or to indicate when an online buddy is available to chat. They are easy to make with inexpensive materials. Paper lamps *(below right)* are designed using an evolutionary algorithm *(below left)* that employs the end-user as a fitness function to obtain designs that satisfy design desiderata.

Research Assistants: Greg Saul, Cheng Xu

2010 Interactive Paper Devices: End-user Design & Fabrication, Saul G, Xu C, Gross, MD (to appear), *ACM Tangible Embedded and Embodied Interaction (TEI)*,

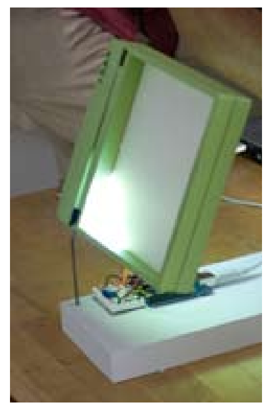
HOME 2020 (CMU design studio)

In 2005, the Home 2020 architecture studio co-taught with Ellen Yi-Luen Do invited students to propose and prototype visions for a 'home of the future'. Home 2020 showcased as a 2005 CMU Carnival booth for a weekend of over 3,000 visitors. The exhibit of interactive projects included a kitchen counter that reads RFID tags on food items and offers nutritional and recipe advice; a set of rotating stools that turn together; a hanging ceiling that responds to people's movement below; telepresence tables; an interactive portrait that snaps a photo of you and reveals it gradually as you fingerpaint over it; color-controlled interior lighting and a collection of videos showing past home-of-the-future visions. The Home 2020 booth also won the CMU Carnival Environmental Award for its use of recycled and recyclable materials.










MAKING THINGS INTERACT(ive)

An interdisciplinary project course at CMU attracts students from diverse disciplines from first-year undergraduates to PhD candidates. Students learn basic analog electronics, microcontroller programming, simple mechanical design. They exercise these skills through a series of assignments, followed by an open-ended term project that results in a working physical prototype.

top row: Air Chair senses body temperature and cools when needed — Mark Manzke (Architecture); Rideable Hexabot robot — Rich Pantaleo (Mechanical Engineering)

second row: Talking Playroom Floor; — Ronit Slyper (Computer Science); Energy kitchen wall shows energy use with color—Andrea Irwin (Design); WireSpy handheld house energy monitor — Ethan Goldman (Civil Engg)

third row: BoomBox color cube seating connects to iPod — Jesse Chorng and Paul Castellana (Architecture); Sonic Bookshelf as musical instrument —Beste Nazilli & Imran Sobh (Design); E-book reader — Nadeem Haidary (Design)

bottom row: ColorFields GPS goggles color the scene based on location in the city— Tiago Rorke (Design)

DIGITAL FABRICATION

Blending new and old materials and methods of manufacture, students in this course used a laser cutter, plastic casting and molding, 3-D printing, and a machine shop in a series of eight exercises and a term project that explored the design space of new ways of making things.

top row; Color-changing LED lamp—Grace Whang ; Perforated sculptures — Sam Espada

second row: Handmade zoetrope — Michelle Lopez; Metal Construction Kit: — Adam Lackett

third row: Laser-cut paper hoop skirt — Lea Albaugh; Plastic/magnet construction kit —John Thornton; Laser cut wood gear toy — Stephanie Fonticoba

bottom row: Paper lamp — Jeff Bourke; Undulating surface — John Thornton