

# Sketching Interfaces for Conceptual Design and Analysis in Architecture

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## Introduction

In the early design process, designers draw diagrams and sketches to explore ideas and solutions. Designers are trained to use paper and pencil to develop conceptual designs. They draw to develop ideas and communicate their thinking through the act of drawing. Design drawing is an iterative and interactive act involving recording ideas, recognizing functions and meaning in the drawings, and finding new forms and adapting them into the design.

In this workshop, we will report my research on empirical studies of design drawings and computational tools built to support designing.

## Empirical Studies

We have conducted several empirical studies on design and drawing to determine whether, and to what extent, it is possible to infer, interpret, or even guess what a designer was thinking about by looking at the drawing she has made. The studies include 1) data analysis of 62 architecture students' concept diagramming, 2) video transcripts and protocol analysis of four architects conducting design of an architect's office, and 3) a retrospective analysis of a pavilion house design that was carried over the period of 15 years by an architect.

From the diagramming experiment and design protocol analysis we found that designers use graphic symbols to represent certain physical objects and design tasks and concerns. For example, when thinking about lighting concerns, designer would draw a configuration consisting of a symbol for the sun and an arrow representing a light ray in a sectional view. When thinking about fitting a piece of furniture in a conference room, designer would not only draw graphic symbols for furniture but also dimensional markers and numbers to reason about dimensions.

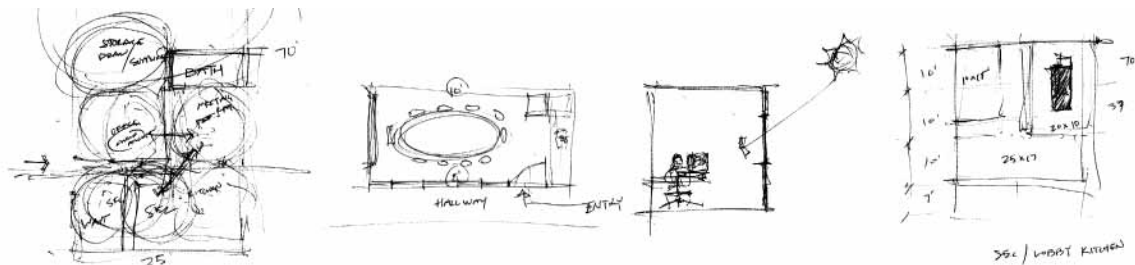


Figure 1. Drawing conventions: (a) bubble diagram for spatial arrangement, (b) graphic symbols for furniture layout, (c) lighting concerns in sectional view, and (d) dimensional reasoning.

The analysis of the pavilion house design drawing resulted a conceptual framework to account for connections among the drawings. We looked at 110 drawings selected by the architect and developed a coding scheme to classify these drawings into different categories. For example, the scheme codes properties of the drawings such as the elements depicted as well as projection type and view angles of the building. For any two drawings, the coding scheme also accounts for the transformations of the design elements such as geometric translations of shapes, locations and color.

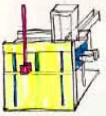
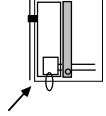
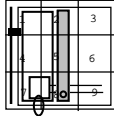
ID #	Drawing	Title	Intention Annotation	Drawing Type	View angle	Elements	Location /scale	Medium
P1-30 (P1-9a) P2-16 (P2-15)		wall & projected volumes (variations on the theme)	isometric front  • slots in wall • marking internal grid system on the facade	3D Frontal Isometric (D3+D4)		E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E12, E12, E12, E13, E14, E15		pencil (M1)  yellow, blue, red markers (M4)

Figure 2. A drawing in coded table according to different classifications.

## Computational Tools

We have worked on several research projects relevant to the topics of this workshop. For example, we have worked on freehand drawing as an interface to intelligent systems for design such as knowledge and image retrieval, building performance simulation, and three-dimensional model making for early stages of design. In the workshop, we would demonstrate two sketching interfaces for supporting design and analysis: 1) GIDA – Graphics Interpreter of Design Actions and 2) VR Sketchpad – an interface for creating instant 3D worlds by sketching.

The GIDA prototype allows user to diagram over a picture underlay of design drawing and to generate analysis of the drawing itself and with other drawings. For example, a diagram’s topological and geometric relations among parts of the drawing can be recorded and used in comparison to another diagram traced from a different design drawing to reveal the spatial transformations among the elements.

Element	Drawing #1	Drawing #2
Thick Wall	(7 4 5 6 9 8 7)	(7 4 1 2 3 6 9 8 7)
Chimney Box	(4 5 4)	(7 4 5 8 7)
Chimney Pipe	(1 4)	(1 4)
V-window 1	(6 9)	(3 6 9)
V-window 2	(5 1)	
V-window 3	(4 7)	
Hood	(6 3 2)	
H-strip 1	(4 5 6)	(4 5 6)
H-strip 2	(4 5 6)	(4 5 6)
H-strip 3		(4 5 6)
H-strip 4		(7 8 9)

Figure 3. GIDA’s location identifier (3x3 grid) over two design drawings (left) and the resulting table showing location transformations as list for each element (right).

In VR Sketchpad we developed a simple sketch recognition system that inferred three-dimensional models from two-dimensional sketches. 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 VRML (Virtual Reality Modeling Language). Designer can also draw arrows to indicate locations of interests and therefore define a viewing path into the 3D world.

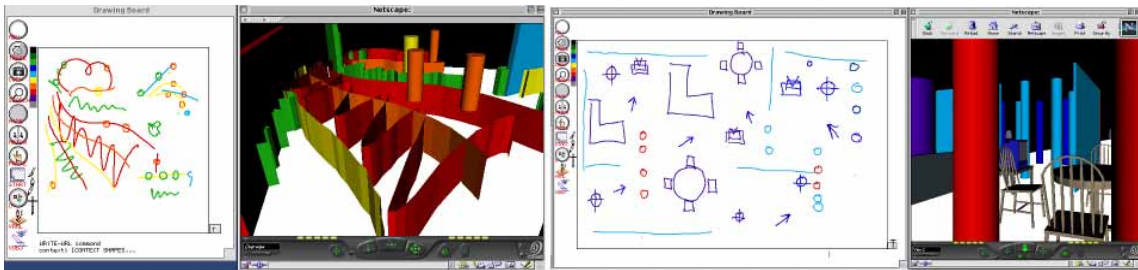


Figure 4. Curve shapes and lines are extruded to make partitions (left). Furniture layout sketch (TV, couch, dining table set, columns, and walls) creates 3D VRML world (right).

## Discussions

Sketching is important in the early, conceptual stages of architectural design. Therefore, computational tools should support sketching activities. The empirical studies examined the intentions in and relations among design drawings. Our prototype systems demonstrate how freehand drawing interfaces can support analysis and design.

## Acknowledgements

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## Biography

Ellen Yi-Luen Do is an assistant professor in the University of Washington's Department of Architecture. She received a Bachelor degree of architecture (Honors) from National Cheng-Kung University in Taiwan, with a minor in Urban Planning, a Master of Design Studies from the Harvard Graduate School of Design, and a Ph.D. in design computing from Georgia Tech, with a minor in cognitive science. Her research work focuses on the development of computer aided design tools to support freehand drawing as an interface to knowledge based tools. She has conducted empirical studies of design drawing and constructed computer software to integrate knowledge based applications with freehand drawing. She has also worked in the areas of computer based visual analysis tools. She currently co-directs a design computing research lab called the Design Machine Group.