The Right Tool at the Right Time

-- investigation of freehand drawing conventions as an interface to

knowledge based design tools

1. Introduction (3 min.)

a. The question:

can we tell what designers are doing by looking at what they draw? Hypothesis

Method

b. Motivation (if we could,

then we could build better computer-based advisor programs)

c. Outline of proposal, and structure of talk (literature, empirical study, leads to computational implementation)

2. Literature & Related Work (7 minutes)

- a. DESIGN STUDIES: design studies of role of DRAWING and design,
- b. CASE STUDIES: what architects say about drawing & design process;
- c. PROTOCOL ANALYSIS: protocols of architects drawing & designing

3. Empirical Studies (7 minutes)

- a. "What's in a diagram" the previous study & its results
- b. Proposed new study (why a new study?), pilot results, experiment setup
- c. expected results (what i hope to find and what it would mean)

4. Implementation RTRT (7 minutes)

- a. motivation (Archie provides knowledge, but not in context of design)
- b. Cocktail Napkin platform (not building a program from scratch)
- c. pieces of the RTRT implementation ("version 1.0") already built

5. Discussion, Plan for the dissertation (3 minutes)

- a. summary, the question, the experiment, the implementation
- b. time line for the project and outline of the dissertation document
- c. questions for discussion: (course of the debate)

1. Introduction (3 min.)

Good afternoon, everyone. I am very happy to be here today to defend my proposal. Let me start it now.

(TITLE SLIDE)

The proposed topic for my dissertation is "**The right tool at the right time.**" What I am really talking about is an investigation of **freehand drawing conventions** as an interface to knowledge based design **tools**".

HYPOTHESIS

The BIG question is **CAN** we tell what designers **are thinking** by looking at what they draw?

The hypothesis is that **designers share** drawing conventions when they design. **Also, they draw different symbols** and diagrams when thinking about different design concerns.

(SLIDE Laseau)

For example, when thinking about spatial arrangements, designers draw bubble diagrams, here is an example from Laseau's "Graphic Thinking". and

(SLIDE Piano)

when thinking about **natural** lighting, designers draw a symbol of **sun** and **light** rays that penetrate the building. here is an example of Renzo Piano's

diagram for museum design taken from Ed Robbin's book, "Why architects Draw."

MOTIVATION

Why is this important?

Because if the hypothesis is true, then we can program a computer to infer design intention based on the drawing.

And THEN we can use this **inference of design intentions** to suggest appropriate **design tools for the task at hand.**

For example, many intelligent computer aided design **tools**, in particular knowledge based systems, are built to provide advice to designers **such** as critiquing, cases, and simulation.

How can **these systems** decide when and what advice to **provide** to the designer? Is there a way we can provide the right tool at the right time?

METHOD

The drawing conventions that designers use in designing might be a good indication of the design concerns.

If so, this raises the question: **what drawing conventions** should a computer understand?

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Is it even possible?

That's why **part of my proposed work** is conducting empirical studies to find out about this.

(SLIDE, talk structure)

STRUCTURE

I am going to divide the rest of my time into 4 parts, **EACH PART CORRESPONDS TO A future CHAPTER OF THE DISSERTATION.**

First, I will review the literature and related work. Second, I will talk about empirical studies I have performed and a new experiment set-up.

The finding of the empirical studies leads to **SOFTWARE implementation**. Therefore, the next part will be about design computing, the Right Tool at the Right Time application I am working on.

And finally, I will talk about **the plan for dissertation** writing and I will leave time for discussions and comments.

2. Related Work on Drawing Importance (7 minutes)

Now, before I show you my empirical studies, let me talk about **some related work.**

By related work, I mean the studies of **drawing in design process**. There are many, **many** researches about the role of drawing in design. However, for this proposal, I have **only** selected a few examples to serve as a background information for my research. Therefore, I would not talk about **ALL** the related work one can find.

(SLIDE 1,2,3 Related work)

Let me talk about 3 categories of related work. I will talk about 1) Design Studies, 2) Case Studies and 3) Protocol Studies.

(SLIDE Design studies)

DESIGN STUDIES

Let me talk about design studies first.

By Design Studies, I mean the books **on how to design**, and researchers about design process. For example, Paul Laseau has written a book called "**Graphic Thinking**" to teach **architects** how to design by **using drawings.** He describes drawing as **a means for design development.** He teaches designers to draw and use graphic language to put themselves in the right design context.

Let me tell you another example, Architect William Lockard wrote a book called "Design Drawing Experience."

He proposes that the designers DRAW to explore alternatives.

He argues that the **REASON WHY** architects need to draw **is to allow** our minds to **see, to comprehend and to respond** to more visual information than we can remember from verbal notes.

He also suggests that designers draw differently when focusing on different concerns such as building mass, landscape and interior design.

On the other hand, books on design research also emphasize the importance of drawing in **design thinking**.

For example, Peter Row has a book called "Design Thinking." He argues that architects use drawing to inquire about **shapes and spaces.**

Fraser's book, called "Envisioning Architecture" **describes** that architects **use diagrams and drawing** to **represent** and **abstract** design information.

Dan Herbert' in his book, called "Architectural Study Drawings" argues that drawings are more than **just a convenient strategy for solving design problems**.

He says that **DRAWING is** the designer's **principal** ways of thinking. He also argues that designers **MUST** interact with the drawing.

All these design studies talk about the use of freehand drawing in design. They argue that drawing is a graphic language, and represent design thinking. However, none of them identify the symbols for the "graphic language".

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Therefore, my study focus on finding **THE** graphic conventions that designers use in design.

CASE STUDIES:

Now, let me talk about some case studies. By case studies I mean the studies on **what architects say about** drawing and their own design process.

Many architects talk about the importance of drawing in their design process. For example, **architect** Michael Graves explains his **"referential sketch"** is a **"diary**" or a "**record**" of an architect's **discovery**.

He also says that the sketch is a "**shorthand**" notation of an architectural idea, recorded to be **remembered**, **elaborated** and **combined** with other sketches **in a later composition**.

Many other famous architects such as Peter Eisenman, **Renzo Piano** and Rem Koohas also talk about the importance of sketches and drawing.

In their architectural folio, they even included sketches from different stages to illustrate the design development.

In other words, architects and designers all talk about the importance of drawing in their design process. They use drawing to serve as a reference and to find information. Therefore, for my computer implementation part, I will use drawing as an interface to find design information.

PROTOCOL STUDIES

Now, let me talk about protocol studies. By protocol studies I mean the **psychology** studies on design process. Many researchers performed protocol analysis on design process to study the design problem solving activities.

For example, Chuck Eastman in his study "On the analysis of intuitive design" observed and recorded a design process. He concluded that different types of representation, such as words and drawings, are actually **corresponding** to the design problems that designers were working on.

Omer Akin has a book called "Psychology of Design." He observed designers sketches to find out about **design actions and attention shifts.** He concluded that walls and windows, furniture of similar size, or objects that are **closely positioned** are likely to form a chunk together.

In a recent research, Akin and Lin performed a study to separate verbal descriptions and design drawings. **They classified the design process** into different modes such as speaking, drawing and thinking. They found that designers can reproduce drawing from the verbal transcripts, or reproduce verbal transcripts from the drawing. They concluded that verbal transcripts and drawings **are echoes of each other.** And **THAT** they are both representations of the **design thinking**.

In another study, Masaki Suwa and Barbara Tversky video taped architects **sketching to design an art museum.** Later, when watching the tape, they asked participants to report what they **were thinking about when designing.**

They argue that architects **see** information from their sketches, and the seeing is the driving force for **refining design ideas.** They also classified the information they found from the protocols into different categories. These categories are **spaces, things, shapes, views, lights and circulation.** However, they did not identify the graphic symbols that associated with each category.

(break)

3. Empirical Studies (7 minutes)

All these protocol studies describe the association of thinking with design drawing. However, none of them identified the graphic symbols that designers use when designing.

Therefore, the main focus of my dissertation is to identify the association of drawing conventions with design thinking.

(SLIDE Hypo-method)

The HYPOTHESIS is that designers share drawing conventions when designing. And that they draw different symbols and diagrams when thinking about different design concerns. To address this issue, let me talk about the empirical studies that I have done, and a new experiment that I am planning to do.

a. my QP "What's in a diagram"

First, let me talk about the work I did for my qualifying paper.I performed an experiment to see if designers use drawing conventions indiagramming architectural problems

solutions

This experiment took place in an undergraduate design **theory and method** class at the University of Colorado at Boulder. 62 design students participated in the experiment. They were divided into four groups with different task sequence.

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and

The whole experiment has 4 tasks: 1) participants were asked to make diagrams from given stories, 2) they were asked to write stories from given diagrams, and 3) they were asked to pair diagrams and stories together, and 4) they were asked to comment on the existing diagram-story pairs that were taken from a case based design aid Archie.

(SLIDE FINDINGS)

I found several interesting results from the experiment. Let me talk about two major findings here that are directly related to this proposal.

1) **First**, designers only use a small set of symbols in their drawings. And they arrange them in conventional and consistent ways

As you can see here, a symbol of SUN is composed of a circle and light rays, a figure person has a circle to represent the head, and a shape to represent the body. walls and windows are usually represented by parallel lines.

2) **SECOND**, designers have different view preference for different concepts, for example, when thinking about **lighting** concerns or visual access with level change, they draw sectional views, when thinking about spatial arrangements, they draw plan views.

b. Proposed study

NOW, let me talk about the new experiment set up.

In the previous study I have already identified several drawing contexts and concerns. For example, attention to a lighting concern is usually indicated by

light rays and a symbol of sun, attention to spatial arrangement usually appears as bubble diagrams.

However, this previous experiment did not directly involve **design actions**. Therefore, I will conduct a new experiment **in which** participants will be asked to perform simple **design exercise**.

For the experiment, I will provide participants **paper and tracing paper** to draw on. I will give participants a design **program** to design. The whole experiment will have 4 tasks. Each task will focus on different issue,.

(SLIDE 4 tasks)

For example, The first (1) task will be about spatial arrangement. The second (2) task will ask participants to pay particular attention to lighting issues. And the third (3) task will focus on visual access. The final task will be to fit a big piece of furniture into a room, and making sure that a space will fulfill the spatial requirement.

The participants will be given 5 minutes to **complete each design tasks.** The whole experiment will take no more than **half an hour** for each participant.

Let me show you the design program.

(SLIDE, DESIGN BRIEF)

As you can see, I have chosen an architect's office to be the design program for the exercise. Because participating designers would either have been to an architect's office, or **know enough about how an office should function**.. SO the design task will not be too difficult to perform.

I have already performed 2 pilot studies. I found that the design program is easy enough to perform. The participants took **average about 5 minutes** to perform each task.

Based on the pilot studies, I have modified the descriptions of the design program to **make it clear**, and I have reduced the tasks from 5 to 4.

For future investigation, **a digital recording device** and a video camera might be useful to record more information. **However**, for this dissertation, I am only **focusing** on drawing symbols and their configurations. Therefore, I will only use paper to perform my empirical studies **and** leave **deeper** studies for future research.

c. expected results

As I mentioned before, From my previous experiment, I have already identified that designers **SHARE** drawing conventions.

I found that the symbol universe is small, and that designers use different symbols and diagrams for different design concerns, such as light rays for lighting, and bubble diagrams for spatial arrangements.

I have designed the new experiment to verify the previous studies. I expect this new experiment will show **several** sets of symbols in different design

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concerns. I will **also** interview the participants to verify the association of drawings and **design intentions.**

4. Implementation Right-Tool-Right-Time (7 minutes)

So, what's next?

What shall we do after we find out what are the drawing conventions that designers use? **Can you program a computer to understand these conventions?**

Therefore, the findings from the empirical studies naturally leads to computer implementation.

Now, let me tell you about design computing. I will first talk about my motivation for computer implementation, and then the reason why I choose the Electronic Cocktail Napkin as a platform to implement my Right-Tool-Right-Time manager. And then I will describe how this Right-tool-right-time manager will interact with other knowledge based design tools.

a. motivation for implementation

First, let me tell you why this design computing part is interesting. I am interested in how a computer can infer design intentions from design drawing. Because drawing are important. In **design schools or architectural firms**, designers usually draw to explore design ideas and solutions. Also, we would like computers to understand our drawings.

Why?

Because computers can **provide us knowledge bases to help us design.** Wouldn't it be nice if we can access design information by simply drawing a diagram?

For example, we have a system called Archie developed HERE at Georgia Tech.

(SLIDE) (Archie -- keyword search, design in background)

As some of you might know, Archie is a case base that **has** hundreds of stories about public buildings such as library and court houses.

We have asked designers to use Archie in their early design process. They all liked the system, they said "**yes**, the system is great, with all kinds of information **available**, but, I am not going to use it in my design."

Why not?

Because in order to find **useful** information, you have to go through the **boring keyword searching process.** You have to stop drawing, pull out the computer **keyboard**, and **fill up** a keyword search form.

Designers like to draw, they don't like to be stopped. Also, by the time you fill up all the keyword search forms and finally find something relevant, you could have drawn ten more interesting (design) diagrams already. **In other words, Archie provides useful information, but not in the context of design, so designers won't use them.**

Therefore, to make knowledge based systems like ARCHIE useful, we need to provide designers in the context of designing when they are **making design drawing.** Also, in order to be **really** useful, these knowledge based design tools need to be available **at the right time.**

For example, different design activities need **different kinds of supporting tools.** If a designer is thinking about visual access, a visual access **simulator** should come up, when thinking about spatial arrangement, maybe a case story **with similar configuration** should come up..

SO.....

How can we decide when is the right timing for the right tool?

The empirical studies of drawing conventions will give us some help. Because the drawing conventions that designers use when designing can be a good indication for the design concerns. Therefore, this can be useful to **activate the right design tools at the right time.** For the dissertation, I will build a prototype of the right-tool-at-the-right-time manager to explore how drawing conventions can be used to access knowledge based design **tools**.

The right-tool-right-time manager will 1) recognize different drawing symbols and diagrams to **infer** different design concerns, and 2) use these inference to **activate** appropriate design tools **for the task at hand.**

b. Cocktail Napkin platform (why? and what more)

Now, let me tell you the platform for my implementation,

The right tool right time manager will be built on top of a freehand sketching program called the Electronic Cocktail Napkin.

I am choosing the Cocktail Napkin program to be the platform for my implementation for 2 reasons:

1) by using the Napkin program, I will not be building a drawing program or a design environment from scratch, and I know the environment because I have been working on the program for the past two years

2). the Napkin drawing environment supports freehand sketching and user **programmable** recognition. This ability will enable me to easily input the results from the empirical studies into the system and try it out.

c. pieces of the RTRT implementation

Now, let me give you **SOME EXAMPLES** to demonstrate how ONE might use a right-tool-right-time **application**.

(SLIDE, ARCHIE-NAPKIN)

For example, imagine I am designing a public LIBRARY. I will start by drawing a bubble diagram to think about spatial arrangement. As you can see, I draw a bubble diagram to see how to arrange a reference section, and adult and children's sections.

The right-tool-right-time manager will infer my concerns **as spatial arrangement based on my drawing,** and use this to retrieve a case story **with a similar configuration** from the Archie case library.

(SLIDE -- NAPKIN-ISOVIST)

Let me show you another example, Later I might draw a floor plan to investigate visual access from different view points. The right-tool-righttime manager will use this to activate a view shed analysis program called Isovist.

As you can see, the right-tool-right-time manager will **translate** my current floor plan into the **Isovist program** and allow me see the simulation based on my drawing.

(SLIDE -- NAPKIN-GBC)

Another example,

Maybe I will make a simple diagram to **explore** how the building facade should look like. The right-tool-right-time manager will use this simple drawing to find some relevant information. In this case, the right-tool-righttime will found a picture and a quick time movie from a the Great Buildings Collection CD-ROM, that has 700 famous building.

The story can go on.

I am not proposing to build many different kinds of knowledge based systems for the right-tool-right-time **application**. **Instead**, I am proposing to **IMPLEMENT** the right-tool-at-the-right-time **application manager**.

IN SUMMARY, this right-tool-right-time manager will use freehand drawing as an interface to knowledge based systems.

The Right Tool at the Right Time **application** will support design activities such as exploring ideas, finding references, and retrieving images and information.

It will allow designers to **quickly sketch their ideas** with a digitizing tablet and pen just like **using a pencil and paper**. However, unlike a paper sketch, this **digital sketching environment** is interactive, it will identify designer's intention **by looking at their drawing**, and can be trained or personalized for different persons.

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5. Conclusions & Discussion, (3 minutes)

a. summary, the question, the experiment, the implementation

In conclusion, I am proposing that a computer program should provide right tools at the right times by **looking** at designers' drawing.

I am proposing to study design drawing conventions and use these conventions to activate the right design tools at the right time.

The dissertation will have **three** major parts, literature review, empirical studies, and software implementation.

The first goal of the dissertation is to find out **whether** it is possible to guess what designers are thinking by looking at what they draw

The second goal is to find out whether can we program a computer to recognize these drawing conventions.

And Finally, the last goal is to demonstrate how an intention recognizing computer program can help knowledge based systems become more useful.

AGAIN, I am proposing to investigate on drawing conventions to find out about design intentions, and **based on the finding** to implement a Right Tool at the Right Time application. In other words, Rather than asking designers to select a tool to use. I am exploring the possibility of **automatically** and **semi-automatically invoking** different design tools based on drawing.

For example, for the time being, to find a configuration from a case library, I need to say "**COMPUTER**, bring me a case library **NOW**."

But if we have a right-tool-right-time application, then the right-tool-right-time manager will bring up a case story of a similar configuration based on my drawing.

Of course, there can be an endless wishful list for what the right-tool-righttime manager should do. However, For the scope of this dissertation, I will limit myself **on only identifying graphic symbols and configurations** for the specific tasks I designed in the empirical studies, such as spatial arrangement, lighting and visual access, and leave deeper investigation for future works.

b. time line and outline of the dissertation document

Now let me describe time line for the project. I will work on Literature review, Empirical studies, and computer implementation for FALL & Winter quarters.. I will finish all the works in early Spring.

Then I will be writing the dissertation during the Spring and Summer quarters..

I will submit my draft for my committee to review in the Summer. And I will do my revision and editing based on the comments from the committee members.

And then I expect to defend my thesis in the Fall quarter Next year.

c. questions for discussion: