Stroke Sequence in Digital Sketching

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This paper explains how to use animated drawings created with a commercial portable pen to understand and teach design process. By recording and replaying pen strokes, the Logitech Io digital pen allows us to examine the drawing process. We have been using the pen to collect expert drawings, analyse the techniques and then teach drawing strategies.
The software's animation timeline engages viewers by giving narrative sequence to a drawing, revealing sub-steps of the design or drawing process for interactive examination and discussion. The timeline allows viewers to pull apart layers of information, revealing initial strokes of complicated drawings, separating overlaid corrections and facilitating stroke counting for protocol analysis.
In the classroom, students can see a variety of expert drawing techniques, use the pen in class and then immediately compare animated versions of their own efforts and expert examples. The ease of collecting new examples makes it possible to widen the range of examples to unconventional techniques.

Keywords: *drawing, design process and media, digital design tools, teaching*

I. Introduction

What happens when a designer approaches a blank sheet of paper? Usually we can only see the finished work without knowing how it came together. By using the Logitech Io digital pen and its IoReader 1.01 „instant replay" software (http://www.logitechio.com/), we can see how a picture was constructed and learn more about drawing techniques.

This paper describes how we have been working to discover what the pen can reveal about design drawing and refine how to use it in teaching. The project shows the potential of adapting a new interface to architectural design research & teaching. It shows how many individuals can be involved in creating useful examples and brainstorming about ways to use a new tool.

II. Background and Technology

From a survey of mobile tools for designers (Cheng 2003), we were intrigued by the pen-and-paper interface of the Logitech Io pen. Compared to Tablet PC's and handheld personal digital assistants, the pen is simple, inexpensive and unobtrusive. Its traditional pen-on-paper interface is accessible to even the most computer-phobic individuals. The pen has a camera that scans pen marks against paper with a special non-repeating pattern designed

by a Swedish group, Anoto (http://www.anotofunctionality.com/). The pen stores a sequence of these stroke path locations in a memory chip. The pen can then be docked to a computer to download the saved stroke information, and within accompanying software; the strokes can be sequentially replayed with an interactive timeline. While the pen is being currently being marketed for note-taking and database forms, it shows good potential for design teaching and research. (Other digital pens and software for Anoto paper developed by Sony Ericcson and Nokia were unavailable in the U.S.)

III. Project Approach: Teaching

Our project includes the following parts: collecting expert drawings, analysing and organizing the drawings, teaching with the drawings and studying design process.

In Spring 2003 we began to collect descriptive, analytic and creative design drawings by asking volunteer designers and artists to perform specific drawing tasks. In collecting drawings, we found that even quick sketches from experts are useful in demonstrating the skills that designers need on the job. After showing how the pen and software worked, we asked the volunteers to draw descriptively from a photo, to draw a room interior from life, to diagram a building from images and to execute a simple design problem.

After we collected a number of examples (including more than 50 sketches of Piazza San Marco), we selected the drawings that would illustrate a range of techniques most graphically.The descriptive drawings (from photos or from life) are easily organised into contrasting approaches such as linear vs. tonal, spatial vs. graphic, flat vs. layered, etc. Because of the way we framed the analytical diagramming and design problems, the initial samples were not easily compared or categorised. Instead, we could identify particular design operations (i.e. variation, addition, correction, restatement, etc.), discuss how drawing conventions were used and show how information was steadily added in the strongest examples. From analysing the drawings, we created Powerpoint presentations and began a website to document the examples: http://www.uoregon.edu/~arch/digsketch/

In Summer and Fall 2003, we used the digital pens to teach drawing to architecture students. We showed students both their own drawings and other people's drawing processes with the pen software. We began with a quick introduction to the pen functionality and by asking them to try it on a specific drawing task. After the students' initial efforts engaged them in the task, they were shown ways that experienced designers approached the same task. The students could then try out the shown drawing methods during a longer work period with some individual coaching. Following the work period,

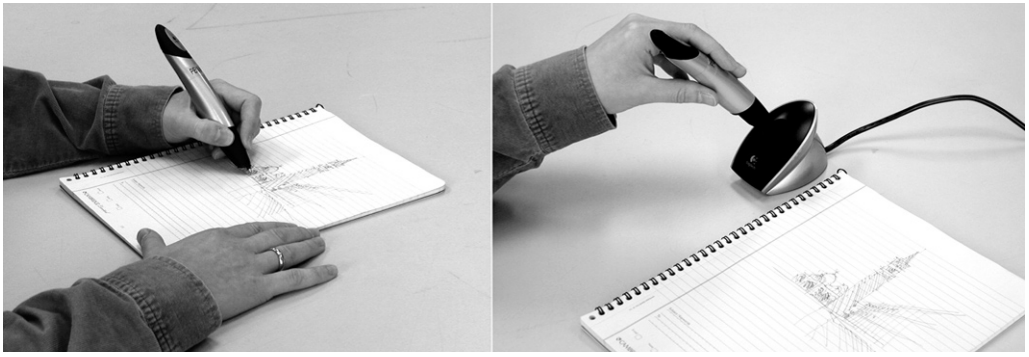


Figure 1
The Logitech Io pen is used with specially printed paper (left) and the pen is docked to a USB port for downloading.

Figure 2
The Io pen drawings can be exported as either .jpg raster images or .emf vector drawings. The Io pen drawing (left) was exported as .emf and manipulated in Adobe Illustrator (right).

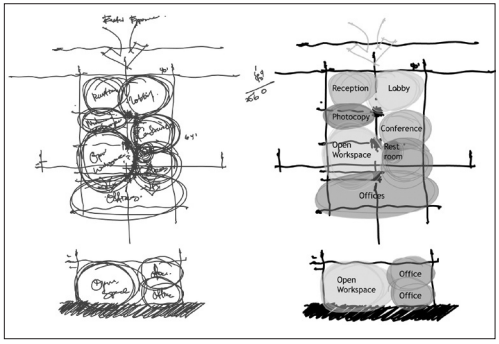
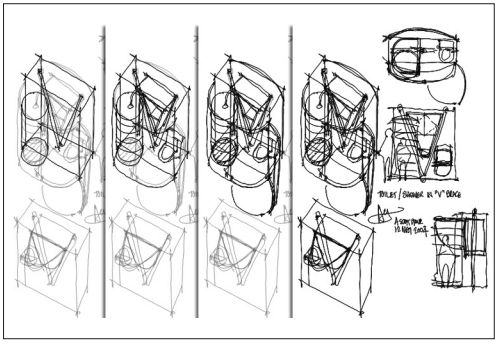


Figure 3
It's easy to compare how drawings are constructed, as in these 6 examples created from a photo of Piazza San Marco.



the class either reviewed anonymous student pen drawings as a large group or examined the stroke sequence of the drawings on an individual or small group basis.

IV. Analysis: Utility of the pen as a teaching tool

Students reacted favourably to being able to see the ways that drawings were constructed. The stroke replay is helpful in showing how to take the first steps towards a well-proportioned drawing, as in drawing an interior perspective. The software shows the sequence of construction lines that would ordinarily be buried in a final drawing, but it displays each line at one time, rather than gradually from the start of the stroke to the end.

Because the digital drawing process can be shared over the network and through projection, it can change the individual nature of drawing critique towards a more public process. (See Cheng 2004 for more about teaching with the pen)

In collecting example drawings, it helps to request very specific tasks to so that students can replicate the resulting methods. For descriptive drawing, constraining the visual input to a photo or a specific view of a room produces consistent results that accentuate differences in techniques. By making the subject identical, we could show how drawing techniques such as perspective construction lines, abstract contours, and shorthand marks contributed to the final results.

The pen has proved very useful for revealing drawing processes to the original draftsmen and to students. While drawing instructors are already deliberate and aware of steps followed with or without the software, others became more precise in describing the process of the drawing using the software replay.

V. Researching Design Communication and Process

What can the pen contribute to our understanding of design process? To complement our collection of animated drawings done from observation, we have been collecting design drawings from the imagination. We are examining the animated drawings to understand the structure of the design process and to compare how animated versus still drawings communicate. We plan to use what we find to create annotated teaching examples.

We have been collecting examples of focused, short design tasks because earlier open-ended questions yielded examples too diverse to analyze. For our first problems, designers worked in widely different ways, with some illustrating their questioning process, others documenting finished designs. To get more comparability, in recent trials we broke a larger problem of designing a small office within an existing shell into sub-tasks of space planning, interior lobby redesign, and façade design. We asked

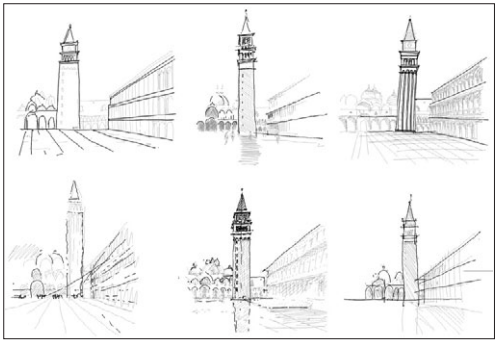


Figure 4
Construction of a Design Sketch can be captured with the timeline. (Example by A. Scott Howe).

designers to work their ideas out on paper rather than working on presentation images.

Reading Still vs. Animated Drawings

We wanted to know whether animated drawings would reveal the design process more clearly than still versions of the drawings and we were curious what additional information might be revealed. So, we asked designers first to do the task, then to examine others designer's solutions as still and animated drawings. By first doing the problem themselves, they became engaged with the task and contributed a solution to the pool.

To compare what they saw in still vs. animated design drawings, we queried the subjects after they examined a still image of another designer's solution, then queried them again after seeing the animated version of the same design solution. We asked them to identify the important design ideas and outline the major design steps as well as comparing the process to their own. We recorded the subject's responses in written questionnaires and verbal interviews caught on video clips with Camtasia Studio.

Observations on Reading animated drawings

We expected that the designers would be able to read the steps of the design process more accurately in animated versions but we found that the fuzzy definition of a step made it hard to assess whether they could read the steps. We found that six designers looking at the same animated design drawing parsed it into different chunks and described its design operations using different vocabulary. This implies that designers need to frame a design process according to their own previous training in order to understand it.

While answering the questions freely allowed the subjects to contribute unexpected observations about the design, selecting from set answers would yield more measurable results. In future trials, rather than allowing the subjects to name the design steps, we could provide a list of standard operations for them to select and order.

Conclusions on Reading Animated Drawings

Viewing the still drawings first, the subjects abstracted the design process into large chunks.

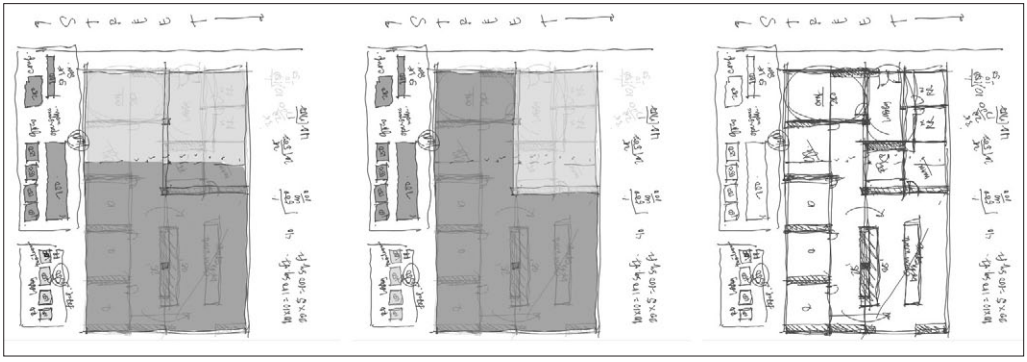


Figure 5
Revealing hidden process: The designer first placed the two major program areas by dividing the space proportionally with dashed line (left), then changed his mind and with the next strokes divided the space along the column lines. (example contributed by Ryan Smith).

Viewing the animated drawings next, the subjects usually verbalised a stream of sub-steps. The animated drawing's timeline removes pauses and makes the drawing act look continuous, blurring the idea of discrete chunks. While the animations only occasionally corrected the guesses about the major steps of the design, focused attention on each stroke of the drawing so that examination can be more complete. Interactively viewing animated drawings provides an opportunity to discover hidden subtleties of the design process.

The animations reveal more in drawings with only one or two vignettes, where the stages of the drawing are masked. Designers don't need an animation to understand the sequence of a drawing composed of many vignettes, they see each drawing vignette or type of mark making (calculations, notes, thumbnail sketches) as a separate step and then assign an order, often following the Western left to right, top to bottom convention. The animations can add value by making a confusing page of vignettes interesting. The animation gives a sequential hierarchy to a complex drawing, leading the viewer through a storyline of moving from one step to another.

Examining Design Process with the Timeline

Because the pen provides information on sequence, we looked at how the pen animations could be used to study sequence in design process. We used a space planning exercise in which designers were asked to place specific program areas into a building shell with given orientation, dimension and structure.

31 examples of a space-planning exercise were parsed into design operation steps, using the animation timeline to separate and identify tasks. To compare unlike examples, we assigned each task a % of the total strokes to completion rather than ordinal numbers (1st, 2nd, 3rd). So if there are 3 steps and the first, site planning is finished after 33 strokes of 100 strokes total, it is give a number of 33%. If the second task is completed after 50 of 100 strokes, it gets a number of 50%.

A summary of a comprehensive tally shows great

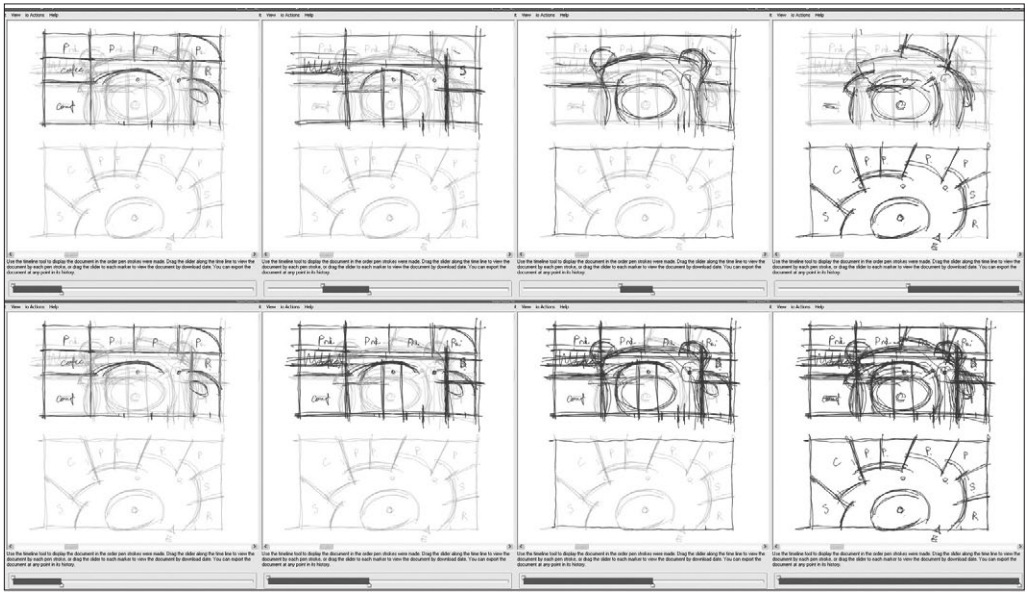


Figure 6
These views of a space-planning design show how the timeline can be manipulated to reveal overlaid steps of a designer's process. In the upper examples, earlier steps are obscured.

variability in design step order. In the table below, the 31 examples generally began by documenting the given site constraints. The designers used a variety of means to get to an initial scheme (calculating program areas, bubble diagrams, placing program areas, organizing the space with lines). The schemes are generally established about halfway through, with text added at the two-thirds point. Final steps are fleshing out the drawing with furnishings, articulation of the floor plan, ending with additional notes.

We can only get a rough approximation because stroke counting to get % completion can be deceiving. The IoReader software considers one stroke to be from pen-up to pen-down, so a word written in cursive could be only one stroke while the same word would require many strokes if printed.

So while the animated drawings are not ideal for quantitative studies, they allow us to closely examine the sub-steps that designers follow. The digital drawings are easily archived and efficiently reviewed in an interactive manner. As shown in the space-planning exercise, the animated drawings can reveal typical kinds of design operations within the great variety of approaches.

To create teaching examples, we are examining expert and beginning design solutions and to identify successful and weak design techniques. From our initial examples, we can observe how experienced designers

- move between different views, such as adding information alternately to related plan and section drawings or breaking away from a large plan to draw alternatives as thumbnails.
- fluidly use supporting tasks, such as dimensional

Space Planning Design Steps (summary of 31 examples)			
Order		# examples	% complete
1	**Site conditions**	**31**	**15%**
2	Calculations	6	31%
3	Dimensions	8	34%
4	Organizing lines, grid, modules	7	35%
5	Bubblediagram - program links	5	40%
6	Thumbnail plan(S)	8	47%
7	Additional site info	7	50%
8	Parti established	9	51%
9	Mezzanine plan	5	64%
10	**Text label or notes**	**21**	**68%**
11	Circulation	7	72%
12	Section drawings	6	74%
13	**Furnishings**	**13**	**75%**
14	**Floor plan**	**25**	**80%**
15	Clarification sketch	6	80%
16	Reinforce Graphics	7	90%
17	**Additional text**	**15**	**94%**

Table 1
Space Planning Design Steps Summary.

calculations or relationship diagrams or graphic refinement, to help in developing a plan.
- progressively add information with each view
- adjust conceptual diagrams to work with structural grids and accommodate programmed activities.

V. Conclusions & Directions for future work

The pen can help us understand and teach different approaches to sketching. It acts like a tape recorder, revealing unnoticed steps and triggering memories about the process of drawing. Its inconspicuous interface makes it useful for collecting design drawings in a seemingly private way.

The greatest benefit of the pens' stroke replay lies in clarifying many overlaid strokes. For descriptive drawings that often have many strokes, the tool works well to teach procedures and tricks of the trade. For design drawings of well-ordered vignettes, the animations are most helpful in revealing corrections. Because the software shows the digital drawing as a continuum of strokes, it shows the design process as many small steps. While this does not help beginners parse the process into larger chunks, it could help them see internalised techniques of tacit knowledge that experts unconsciously employ. If the Io software is developed to show not only complete strokes but also the time-stamped start and end of a stroke, it could reveal thinking pauses.

The pen has logistical advantages for teaching and studying drawing. The pen facilitates collection simultaneously from a large number of designers with immediate interactive review. Digital drawings can be easily archived and browsed. The interface makes it easy to look at many drawing animations quickly with pauses at areas of interest and compare multiple examples midstream.

Because the pen is good at capturing and interactively showing graphic procedures, it could be used to teach graphic statics or perspective drawing. Once precise examples are created, we can compare whether students seeing still versus animated examples follow the procedures more accurately. Additional studies could, compare the digital pen to videotaping and audio recording could show what characteristics are best captured by each medium. Eye-tracking equipment synchronised with Io pen drawings could be revealing about the relationship between looking and drawing.

In conclusion, the new interface of this simple, accessible tool provides many potential avenues for enriching a traditional discipline.

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