Research Statement

Richard C. DAVIS
School of Information Systems, Singapore Management University
Tel: (65) 6828-1967; Email: rcdavis@smu.edu.sg
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Introduction
My research seeks to help people think better as they design documents and other visual artifacts. Current creative tools like PowerPoint and Photoshop excel at making our designs look good, but looking good is only part of what helps a design achieve its purpose. Our designs may need to communicate ideas more clearly, summarize information more accurately, or provoke a desired emotional response. In my work, I build and deploy tools that promote better design thinking.

My current work is motivated by the fact that most creative tools discourage exploration of important design questions by distracting us with presentation details too early in the creative process. I want to reframe the design process so users can work primarily in rough form, adding presentation details only when needed. The best designers already work this way, but their tools are often a hindrance. Design tools should start in rough form, so users can take advantage of faster, continuous input methods like sketching that require less cognitive overhead. Tools should also support most revision in rough form so final presentation can be ignored. When high-level design is finished, there should be automated tools for adding presentation details quickly and easily.

To realize this vision, I have produced design tools for a variety of visual artifacts, including animations, illustrations, video games, and sand art. Most of my tools are intended for tablet computers, such as iPads and Tablet PCs, where users can draw and gesture directly on the surface. Some also allow users to snap photos of sketches or record their voice. Because users of my tools are less likely to be distracted with nitty-gritty details, they can prototype a greater variety of designs more quickly, leading to better designs. In many situations, their artifacts are just as effective even if presentation details are never added at all. With further research into automated addition of presentation details, the finishing process may become painless. When that happens, I believe that office and design applications will evolve to fit this reframed creative process, and we will all be thinking better about design.

Research Areas
Tools that illustrate a reframed design process are the centerpiece of my current research. These tools support fast, continuous input through sketching, gesturing, and voice, and they allow manipulation in rough form. Presentation details are largely ignored (as in K-Sketch and SandCanvas) or deferred until late in the process (as in Vignette and Playsketch). With Vignette, I am also exploring semi-automated addition of presentation details.
I use a variety of methods to evaluate my tools. Many creative tool researchers agree that multidimensional in-depth longitudinal case studies are the best evaluation methods. These require tools to be deployed and observed under normal working conditions, which is why I place such an emphasis on developing robust tools. When in-depth studies are not possible, I run short-term field studies and look for signs of improvement in design thinking. I also conduct laboratory evaluations to look for positive effects of this reframed design process, such as improved creative flow. Csikszentmihalyi mapped out key attributes of flow experiences, such as immediate feedback, personal control, high concentration, and intrinsic enjoyment. While these attributes are not directly measurable, I estimate my tools’ ability to promote them through metrics such as task time, cognitive load, artifact quality, and subjective measures.

**K-Sketch**

K-Sketch is a tool for “kinetic” (animated) sketches [1] that fits my vision for creative tools because all operations are done in rough form. I analyzed 72 rough 2D animation tasks and identified a set of 18 simple operations that could be used to perform the entire set of tasks. The first K-Sketch included 10 of these operations and supported 80% of the tasks.

In a comparison with PowerPoint, participants were three times faster with K-Sketch, because they felt compelled to beautify their animations when using PowerPoint. This added effort did not make participants any more comfortable showing their PowerPoint animations to others. Participants also reported significantly lower cognitive load with K-Sketch. Another study compared K-Sketch to a key-frame–based animation tool called The TAB Lite. K-Sketch users needed to do less preparation and less mathematical calculation to complete their tasks. These are signs that K-Sketch reduces distractions. In a field study, a UI designer was able to produce a wider variety of designs faster with K-Sketch. In another, 96 secondary school students used K-Sketch for three months in a science class. Their teacher reported that using K-Sketch improved students’ ability to recall what they had learned, and it made their misconceptions more apparent. These are signs that K-Sketch helps people use animation more effectively.

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The original K-Sketch was for novice animators and left objects and motions in rough form with limited editing support. K-Sketch 2 was developed through a grant from the Singapore-MIT GAMBIT Game Lab to explore the use of K-Sketch for video game design. To better support expert designers, K-Sketch 2 added small refinement features such as key frame interpolation, off-screen manipulation, and a new model for layering motions. Users can also grab images quickly from a web cam or import images and audio.

A K-Sketch 2 field study showed that animation sketching was helpful for prototyping action sequences in video games. Another study is underway to see how novices are affected by the addition of interpolation. I also plan to evaluate several unusual features of K-Sketch 2’s design, including its approach to managing groups and centers of rotation. In the long term, I will conduct a more thorough investigation into how K-Sketch 2 affects education and design settings.

**Vignette**

My proposed reframing of computer-mediated design processes can be seen in its entirety in the Vignette illustration system [5]. Illustrators can begin by sketching the entire scene to establish the global layout. This rough stage of the process ends with outlines of the major objects, but without detailed textures. The illustrator can then draw small patches of a desired texture in place and gesture to fill a region with that texture. Finally, the texture can be refined by changing density, curvature, or by adding a perspective tilt. Vignette puts presentation details in their proper place, after global layout has been established.

Vignette also shows how context and gestures can help to automate the addition of presentation details. Vignette’s texture synthesis engine models each pen stroke separately and preserves the density and arrangement of these elements as it fills a region. The resulting textures mimic the illustrator’s style, as shown in this illustration, created after only 15 minutes of training.
Users of Vignette said that the tool inspired them to explore more possibilities, a practice which usually leads to better results. Participants also praised the free-form gesture-based interaction for synthesizing textures, and they commented that Vignette made the illustration process more enjoyable. These comments indicate a greater sense of personal control and intrinsic enjoyment, which are signs of a heightened experience of creative flow.

**SandCanvas**

With SandCanvas, artists can create compelling visual performance art in the style of sand animation. (left) Artists use the entire region of contact between their hand and the surface. (right) Animations created with SandCanvas.

SandCanvas is a tabletop system for creating visual performance art in the style of sand animation [4]. In traditional sand animation, artists tell stories by creating animated images with sand, often before a live audience. SandCanvas simulates the feel of real sand and simplifies many tasks faced by sand animators, such as video mixing and frame-by-frame animation recording. But SandCanvas goes beyond the traditional form with new capabilities, such as real-time recording and playback of gestures during performances. Study participants used these novel features to make compelling visual performances, and they reported that SandCanvas was a pleasure to use. This project won the best video design award at the CHI 2011 conference and received an honorable mention for a best paper award.

This project illustrates the advantages of working in rough form. Sand is a naturally imprecise medium, so there is an expectation of roughness in both the artist and the audience. This frees the artist to focus their attention on higher-level concerns, such as the timing and layout of a piece. Presentation details are still important, but they depend primarily on the artist's skill, coming unconsciously from nuances of their hand movements. SandCanvas captures these nuances, because it uses the entire region of contact between the hand and the table surface (unlike many multi-touch devices, such as iPads, which reduce the hand to a series of points). The success of SandCanvas therefore shows how rich, continuous input can reduce cognitive overhead and free an artist to focus on their main goal: connecting with their audience.

**Playsketch**

Work has begun on Playsketch, a new application for prototyping animations, video games, and interactive applications. Playsketch’s interface is similar to K-Sketch’s, but the controls are being redesigned for multi-touch tablets, and a wider range of motions will be supported. To better support video game and UI designers, Playsketch will add a storyboard metaphor. Storyboard frames
will be linked in a tree-like structure instead of a linear structure, making it possible to prototype multiple versions of an action sequence in a video game or independent elements of a user interface. These additions will increase the ability of a designer to explore a design in rough form and should result in better designs.

With Playsketch, I also plan further exploration of semi-automated beautification and addition of presentation details. Sketches, motions, and user gestures can serve as hints for beautification and for generating the motion of other objects moving in similar ways. Playsketch will also provide a small set of objects with predefined behaviors (e.g., a walking figure, buttons) that can be easily converted to have a new look. These additions are likely to speed up the process of converting low-fidelity prototypes to high-fidelity prototypes, but they will be truly successful only if they can do so without distracting attention from more important design questions.

Other Tools and Techniques
Another creative tool that reframes the design process is SketchWizard [3]. SketchWizard gives designers of sketch user interfaces a new way to explore designs in rough form. Designers collect user feedback on a rough mock-up of a user interface that is manipulated by another designer “behind a curtain” through a graphical editing system. In studies, almost no one could tell when their user interface was controlled by a human being using SketchWizard.

I also investigate new interaction techniques when I need them for my creative tools. This led previously to an investigation of bimanual marking menus [6], and it recently caused me to begin investigating methods for preventing accidental touches when drawing on multi-touch surfaces. I will continue to pursue such research projects when the need arises.

Future Work: Revealing Connections between Artifacts
In my early research, I built tools that helped knowledge workers make sense of their personal notes by connecting their personal notes to documents, notes, and voice mail messages created by others in their social network [2, 7]. Revealing hidden connections can also help people think better during a design process. For example, when creating a diagram for a paper it may be important to keep in mind design notes, different versions of the paper, or other artifacts that may influence its content, such as documents, emails, and images. If many people are contributing to the paper, knowing who contributed a sentence or an illustration would make it possible to credit them or to contact them for clarification.

I draw inspiration for this research from source control systems, because they reveal the connections between different versions of software source code. However, this new system will be different in four ways. First, it will need to handle many media types in addition to text files. Second, the system will need to track many types of document connections, not just previous versions of the same document. Third, the system will need to track connections at a finer grain (i.e., at the block level rather than the document level). Finally, tracking should be done automatically, or at least semi-automatically.
I plan to pursue this new theme in three stages. The first stage will work with conventional office documents on a single device and for a single user. The second stage will work across devices and users. The third stage will combine this new theme with my current theme of reframing the design process. This will reveal connections between a rough draft of a document and other versions of it at different levels of refinement, a significant new challenge.

These two research themes, reframing the design process and revealing hidden connections, include enough unsolved problems to occupy me for the rest of my career. There is great need to pursue these themes, because our ability to create artifacts is growing faster than our ability to understand what we are creating. By improving our ability to think about what we design, we can communicate more effectively and focus our efforts more effectively on pressing problems.

Selected Publications and Outputs


