DENIM: Finding a Tighter Fit Between Tools and Practice for Web Site Design

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ABSTRACT

Through a study of web site design practice, we observed that web site designers design sites at different levels of refinement—site map, storyboard, and individual page—and that designers sketch at all levels during the early stages of design. However, existing web design tools do not support these tasks very well. Informed by these observations, we created DENIM, a system that helps web site designers in the early stages of design. DENIM supports sketching input, allows design at different refinement levels, and unifies the levels through zooming. We performed an informal evaluation with seven professional designers and found that they reacted positively to the concept and were interested in using such a system in their work.

Keywords

Web design, Zooming User Interface (ZUI), Sketching, Informal, Pen-based Computers, Rapid Prototyping

INTRODUCTION

Web site design has much in common with other types of design, such as graphic design and "traditional" graphical user interface design, but it is also emerging as its own discipline with its own practices and its own set of problems. We have taken a fresh look at web site design in order to determine what kinds of tools would be helpful to support designers. In this paper, we describe some of our observations of web site design practice and introduce a system named DENIM that is aimed at supporting the early phases of the web site design process.

We conducted an ethnographic study in which we observed and interviewed several professional web designers. This study showed that the process of designing a web site involves an iterative progression from less detailed to more detailed representations of the site. For example, designers often create *site maps* early in the process, which are high-level representations of a site in which each page or set of pages is depicted as a label. They then proceed to create *storyboards* of interaction sequences, which employ minimal page-level detail and focus instead on the navigational elements required to get from one page to another. Later still, designers create *schematics* and *mock-ups*, which are different representations of individual pages.

The design process often includes rapid exploration early on, with designers creating many low-fidelity sketches on paper. These sketches are considered crucial to the process. Designers can quickly sketch the overall look and feel of a web site without having to deal with unnecessary low-level details and without having to commit a large amount of time and effort to a single idea. Furthermore, sketches are important for communicating ideas with other team members and gaining valuable feedback from clients early in the design process. These uses of sketches are similar to what has been previously reported for GUI design [14, 28].

Yet, there is a gulf between the needs of web designers during early design phases and the tools available to them. Most web design tools focus on the creation of production web sites but do not support the early stages of design. The high-fidelity nature of these tools tends to force premature formalization of ideas and require undue attention to low-

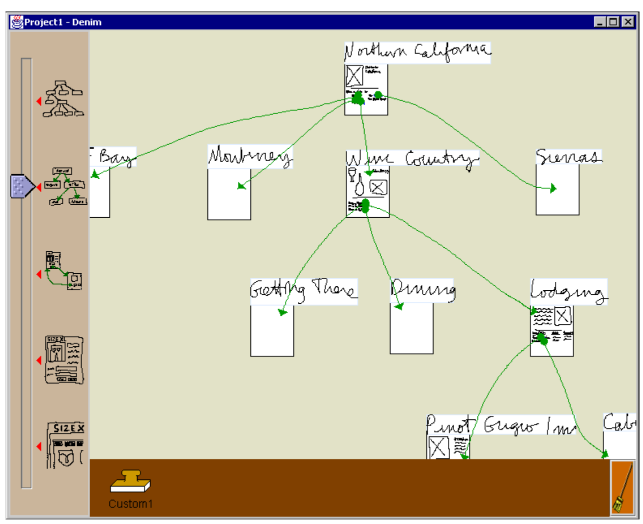

Figure 1. The DENIM Interface in s*ite map* view. This is the sample web site used in the evaluation.

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level details.

These were the primary observations that led to the design and implementation of DENIM, a system to assist web designers in the early stages of information, navigation, and interaction design. DENIM is an informal pen-based system [12] that allows designers to quickly sketch web pages, create links among them, and interact with them in a run mode (Figure 1). The different ways of viewing a web site, from site map to storyboard to individual pages, are integrated through the use of zooming. An informal evaluation of this system has yielded positive comments, subjectively rating high on usefulness and fair on usability.

AN INVESTIGATION INTO WEB SITE DESIGN

We conducted a series of ethnographic interviews with designers about how they work when designing web sites. In total, eleven designers from five different companies were interviewed, representing a range of backgrounds, experience levels, and roles with respect to web site design. During each interview, the designer was asked to choose a recent project that was completed or nearly completed, and walk the interviewer through the entire project, explaining what happened at each phase. The designer was asked to show examples of documents (including sketches) that he or she produced during each phase and explain the meaning of the document with respect to the process as a whole. At the end of the interviews, the designer was asked to give copies of the documents discussed during the interview to the interviewer for the interviewer's reference. In this way, many examples of design process artifacts were collected and subsequently analyzed. Examples of projects discussed include corporate identity and information sites, a state tourism site, a site for a municipal aquarium, an online clothing catalog, a university site, an online software tutorial, and sub-sites of a large Internet portal. A more complete description of the study can be found in [19].

Progressive Refinement

The designers we studied generally followed a process of progressive refinement of their designs from less detail to greater detail, and simultaneously from coarse granularity to fine granularity. By this we mean that there was a tendency to think about the larger picture, such as the overall site architecture, early on in the process, and then progressively focus on finer and finer details, such as the appearance of specific page elements, typefaces, and colors.

During the course of our interviews, we identified several types of documents that are commonly used by web designers to represent a site design at different granularities. *Site maps* generally represent an entire web site at a coarse granularity, where the smallest unit represented is a page or a related group of pages (Figure 2). At a finer level of granularity, some designers used *storyboards* to represent specific interaction sequences, such as how a user might execute a task using a part of the site (Figure 3). Finally, designers create representations of individual pages, which can range from *thumbnails*, which are miniature

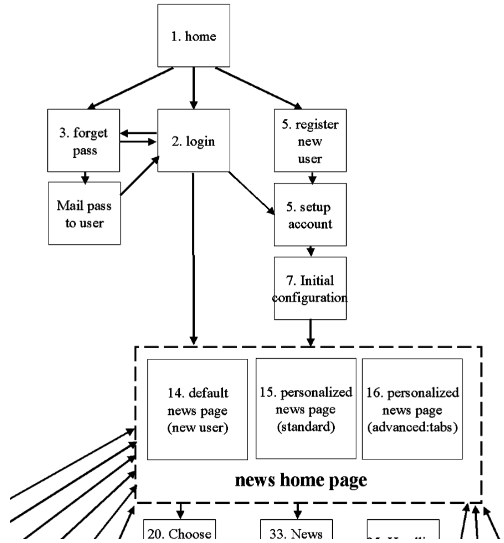


Figure 2. Part of a site map for a news web site

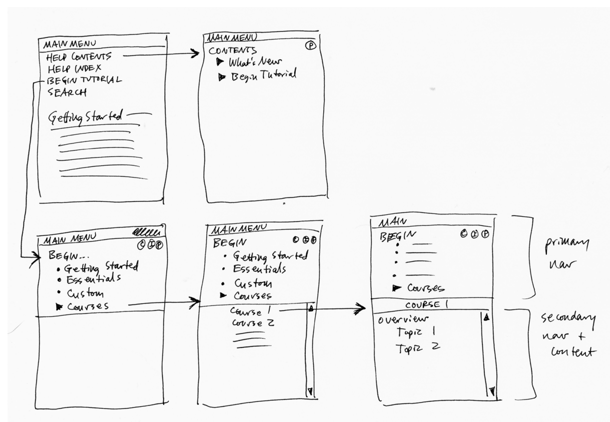


Figure 3. A hand-drawn storyboard showing how a user might interact with a tutorial system

representations of pages; to *roughs*, which are usually hand-drawn sketches of pages; to *schematics*, which are medium-fidelity representations of the information and navigation components on a page; to *mock-ups*, which are high-fidelity representations of the exact contents and appearance of a specific page.

The observation that designers create site visualizations at different levels of granularity and detail inspired us to offer a similar range of options in DENIM. We introduced zooming to allow multiple visualizations of a site while preserving a unified context in which to iteratively refine the site design.

Sketching

All of the designers we interviewed sketch with pen on paper as a regular part of their design process, even though eventually all of them end up using computerized tools. Some designers work for relatively long periods on paper before transferring to electronic media, while some merely make quick sketches on scrap paper before using computer-based tools to realize their ideas. It is worth noting that hand-sketched versions were observed for basically all of the document types described above, including site maps, storyboards, and individual pages.

Designers said that they sketch in order to “work through” their ideas before using tools like Illustrator or Photoshop to create more formal, precise versions of them. Several of them also said they use sketching to “try different things out,” i.e., they can explore the space of possibilities more effectively through sketching than through using computer-based tools, at least during the early parts of the process.

There are several reasons why designers switch from sketching to using computer-based tools. The following quote from one designer highlights one common reason:

> *The beginning of each step I’ll do on paper. As soon as I feel like I’m going to be doing any design revisions, I’ll move to [an electronic tool]… because it’s easier to make changes to these things.*

Besides the ability to incrementally modify electronic documents, other advantages of electronic media over pen and paper include the ease of replication and distribution of electronic documents. Electronic tools also offer the ability for designers to express themselves more precisely and to a greater level of detail than sketching on paper, and this precision is desirable later in the process when the basic ideas have been worked out. Another reason for switching to more formal representations is the need to share their design ideas with others outside the immediate design team, especially their clients.

In many cases designers expressed concern over the tendency of formal representations of early, unfinished ideas to cause viewers to focus on inappropriate details [28]. For example, a designer may wish to obtain feedback about the navigational flow of a particular user interaction. Many designers reported that clients and even other designers tend to focus on details like color and typography when presented with a set of high-fidelity mock-ups and have trouble focusing on the larger concepts. To strike a balance between the need to present “professional” representations and the desire to constrain feedback to relevant aspects of the current state of the design, several designers use *medium-fidelity* representations like schematics to represent web pages. Such representations can be made attractive without overspecifying graphical details that can confuse and mislead viewers.

The fact that all of the designers sketch as part of their design process supports our hypothesis that they would find a sketch-based tool familiar. Several of them indicated that they find themselves switching to electronic media earlier than they would like. This indicates that a sketch-based tool could meet a need that currently exists. A tool to support web site design should support the need of designers to design and view sites at multiple granularities and levels of detail. Furthermore, such a tool should support representations at multiple levels of formality. As we describe in the remainder of this paper, DENIM provides both an informal, sketch-based interface and the ability to view sites at several levels through zooming. Currently DENIM does not support the generation of representations of different levels of formality, though we plan to explore this area in the future.

RELATED WORK

Sketching and writing are natural activities used by many designers as part of the design process. DENIM captures this activity with an informal ink-based interface [12]. Using an informal interface is a key aspect of DENIM, as it allows designers to defer the details until later and focus on their task without having to worry about precision. Many research systems have taken this direction in recent years, either by not processing the ink [1, 5, 24, 25, 27] or by processing the ink internally while displaying the unprocessed ink [10, 14, 18, 23].

DENIM is most closely related to SILK [14], a sketch-based user interface prototyping tool. Using SILK, individual screens can be drawn, with certain sketches recognized as interface widgets. These screens can be linked to form storyboards [15], which can be tested in a run mode. DENIM takes many of these ideas and extends them to the domain of web site design. However, DENIM de-emphasizes the screen layout aspects of SILK, focusing instead on the creation of whole web sites. Furthermore, instead of the separate screen and storyboard views in SILK, all of the views are integrated through zooming. Also, SILK attempts to recognize the user’s sketches and display its interpretation as soon as possible. DENIM does very little recognition, and what little it does is done in the background, without getting in the user’s way.

DENIM’s use of storyboarding for behaviors is similar to SILK. Other systems that use storyboarding include Anecdote [11] and PatchWork [25].

WebStyler [12] is another sketch-based tool for prototyping individual web pages. However, DENIM addresses more aspects of web site design, including designing the site structure and being able to interact with the sketches.

There are many problems with using high-fidelity prototypes too early in the design process. By overspecifying the interface, designers are distracted from more fundamental issues such as deciding how the user interface should be structured [3]. They are also slowed down, which may hinder them from exploring as many ideas as they can [7], hampering their creativity. The tediousness of specifying a detailed interface may also discourage them from iterating on their ideas as many times as possible. Iterative design is widely considered to be a valuable technique for designing interfaces [8].

Because of these drawbacks, designers often sketch basic designs [26, 28]. Sketching has many advantages over traditional user-interface design tools. Sketches are inherently ambiguous, which allows the designer to focus on basic structural issues instead of unimportant details.

The ambiguity also allows multiple interpretations of the sketch, which can lead to more design ideas. Sketching is quick, so designers can rapidly explore different ideas and iterate on those ideas.

The importance of thinking of web site design as a process of refinement and representing the design at multiple levels of detail is discussed in [20] and [22]. These accounts of the web site design process are prescriptive in nature, whereas our study into web design was intended to be descriptive of current practices in the field. Our study was also focused on providing information directly related to building tools to support web site designers.

There is a lack of early-stage prototyping tools for the web. Our ethnographic study showed us that web designers use other tools to fill this gap. Macromedia Director is often used to assemble storyboards, while Visio is used for prototyping the high-level information architecture of a web site. However, Director is designed primarily as a multimedia authoring tool, and Visio is a general purpose diagramming tool. This makes using them for such high-level web site design awkward at best, since they are not designed for those tasks.

Currently, the most popular tools for creating web sites include Microsoft FrontPage, Adobe GoLive, Macromedia Dreamweaver, and NetObjects Fusion. However, these tools focus on designing page layout rather than the information architecture. Admittedly, each of them has a "navigation view" or a "site structure view" of a web site, which represents the site as a tree. However, this view often constrains any edits so that the tree structure remains intact. Furthermore, the site structure view and the page layout view are usually distinct and not unified. Lastly, these tools focus on producing high-fidelity representations, which is inappropriate in the early stages of design These are all important issues that we chose to address in DENIM.

THE DENIM SYSTEM

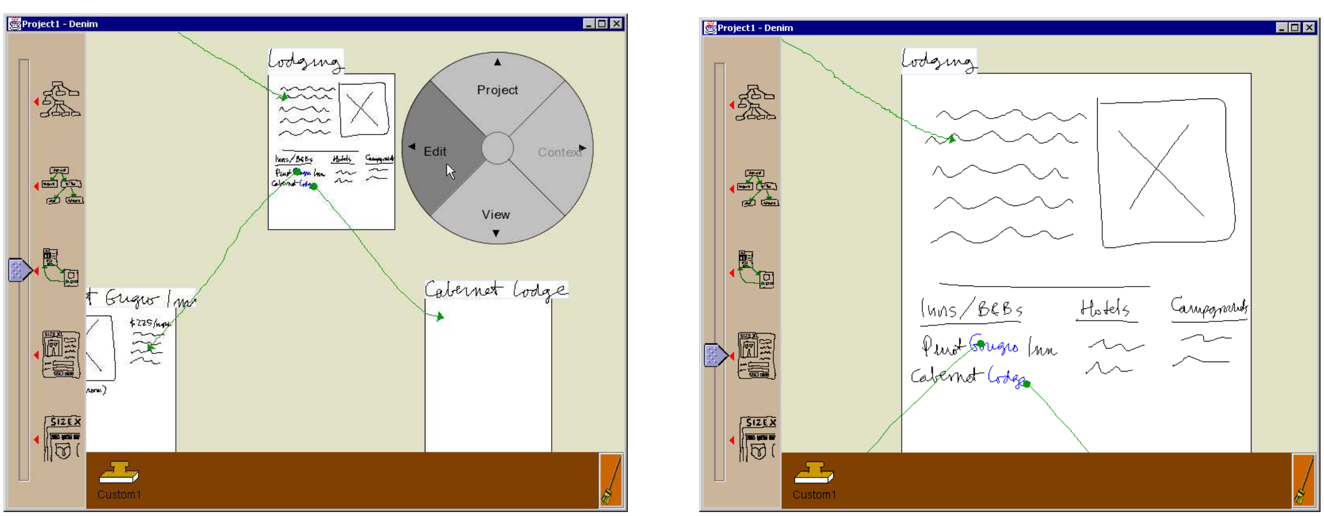
Informed by our study, we designed and implemented a prototyping tool to assist designers in the early stages of web site design. Intended to be more informal than SILK, we named our system DENIM, which also conveniently stands for *Design Environment for Navigation and Information Models*. Since we wanted to make our system available to as many designers as possible, we built DENIM in Java 2 using JDK 1.2.2, on top of SATIN, a toolkit for supporting informal pen-based interaction [13].

The DENIM interface is shown in Figures 1 and 4. The center area is a canvas where the user can create panels representing web pages, sketch the contents of those pages, and draw arrows between pages to represent their relationship to one another. On the left is a slider that reflects the current zoom level and allows the level to be set. The bottom area is a toolbox that will hold tools for inserting reusable components, such as templates. However, this part is not currently implemented.

Zooming

To change the zoom level, the user either drags the slider's elevator or clicks directly on one of the icons. Changing the zoom level initiates an animation showing the transition from the current zoom level to the desired zoom level. The center point for a zoom operation can be set by tapping on the background of the canvas. Such a tap causes crosshairs to be displayed at the point tapped, and any subsequent zoom operation will center on that point. Alternatively, if any objects are selected, the center of the object (or the center of the group of selected objects, if more than one is selected) is used as the zoom target.

There are five main zoom levels in DENIM, which are identified on the zoom slider with icons representing the type of view available at that level (see Figure 5). There is also an intermediate zoom level in between each main level. Three zoom levels—the site map, storyboard, and sketch levels—map directly to the most common representations of web site designs that we observed during our ethnographic study. The *site map* level (Figure 1) gives a view of the site as connected labels with attached thumbnails of individual pages. The *storyboard* level



(a) *(b)*

Figure 4. The *storyboard (a)* and *sketch (b)* zoom levels

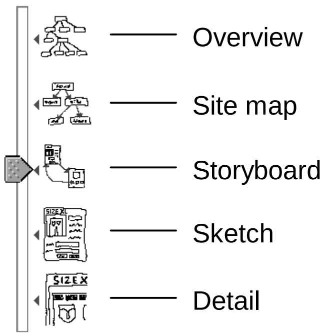


Figure 5. The zoom slider

(Figure 4a) allows the user to view several pages simultaneously and more clearly see the navigational relationships between the pages. The *sketch* level (Figure 4b) displays pages at "100%" scale, and is intended to allow users to sketch the page contents. In addition to these levels, there are two major levels at the extreme ends of the scale, with the *overview* level providing a more abstract, higher-level representation of the entire site, and the *detail* level providing a more fine-grained view of individual pages, for more precise sketching.

Creating Pages
In DENIM, web pages are represented by a label and a panel. The label represents the name or description of a page, while the panel represents the appearance of the page. The labels remain the same size throughout all the zoom levels, so that they can always be read.

There are two ways to create a new web page in DENIM. The first way is to simply write some words directly on the canvas while in site map view. These words are automatically converted into the label of a page, and a blank panel is created. The other way is to draw a rectangle, which is converted to a page of approximately the same size as the rectangle.

Links
Arrows are drawn between two pages to represent a link between those pages. We provide two kinds of links: *navigational* and *organizational*. Navigational links are links in the HTML sense: they represent the reference from an item on one page (e.g., a word or image) to another page. Organizational links are used to represent a conceptual link between two pages; that is, the designer eventually wants to make a navigational link from one page to another, but does not want to fill in the details at this time.

The system checks to see if new strokes are links. Organizational links start on one page and end in another. This creates a *gray* arrow from the source to the destination. Navigational links start on a specific object on one page and end in some other page. This creates a *green* arrow from the source to the destination. When creating a navigational link, any organizational links from the source page to the destination page are removed. As additional feedback, the source of the navigational link becomes blue.

Run Mode
After a number of pages have been sketched and navigational links drawn between them, it is possible to preview the interaction by entering Run mode. In Run mode, a separate "web browser" window comes up, and individual sketched web pages are displayed in it. If an element inside a page is the source of a navigational link, it is rendered in blue in the browser. Clicking on these elements causes the browser to display the target of the link, just as in a conventional browser. With Run mode, designers can test the interaction of sites that they are designing without having to create a full-fledged prototype.

Gestures and Pie Menus
Most commands in DENIM can be activated either through gestures[1] or through pie menus. The current implementation supports a relatively small set of gestures, as we are still experimenting with how to best map the functions of DENIM to a set of gestures. To activate a gesture, the user presses the button on the barrel of the pen and makes a stroke. Using a modified version of GDT [17] and Rubine's recognizer [21], we implemented gestures for panning, undo, redo, group select (select everything enclosed by a circular gesture), cut, copy, and paste. Tapping on an object without depressing the barrel button selects or deselects that object. Tapping on the canvas, outside of any web page, clears the selected objects and sets the zoom-center target, denoted by crosshairs. The selected object can also be dragged, moving it to a new location.

We use a form of semantic zooming [2] in which the interaction with objects changes with zoom. Several of the editing gestures work differently depending on the current zoom level. In the two broadest views, the overview and site map views, gestures work *shallowly*. That is, you can only select, move, or edit web pages, but not anything inside of a web page. In the two narrowest views, the sketch and detail views, gestures work *deeply*. That is, you can only select, move, or edit individual ink objects inside a web page, but not web pages themselves. The middle zoom view, the storyboard view, is a mixture of the two, depending on context. For example, the user taps the page's label or an empty area of the page to select the entire page but can tap any object inside a page to select that object.

Pie menus [4] are used to provide access to functions not easily mapped to gestures, as well as providing redundant access to certain commands, such as cut, copy, and paste. The user activates the pie menu by tapping the screen with the barrel button depressed. Keyboard shortcuts are available for several commands, including cut, copy, paste,

[1] By gesture, we mean a stroke created by the pen that activates a command.

delete, undo, and redo. The arrow keys can be used for panning, with page up and page down controlling zooming.

EVALUATION

We conducted an informal evaluation of DENIM in order to gain feedback about the usefulness of the basic functionality of the tool and the usability of the basic interactions, such as creating pages, creating links between pages, zooming, panning, and interacting with a design in run mode. Seven professional designers participated in the study, five of whom said that web site design projects constituted at least half of their current workload. The remaining two participants were a user interface designer working on non-web related projects and a manager of a usability group for a large software company.

The system that we used for the evaluation consisted of an IBM 560Z ThinkPad 300MHz Pentium II laptop running Windows NT 4.0, and an ITI VisionMaker Sketch 14 display tablet (see Figure 6). The participants interacted primarily with the display tablet, although they could also use the keyboard for shortcuts.

One evaluation session was conducted per participant, and each evaluation session consisted of three parts. First, the participant was asked to add a few elements to a drawing in Microsoft Paint to become familiar with using the display tablet and pen. The second task was to get the participant used to interacting with DENIM. We gave the user a pre-loaded web site design that we had previously created (see Figure 1) and asked them to use DENIM to create a new page, link the page to the site, and then run through the site (using Run mode) starting from the home page and ending at the page they just created.

The final part was a large design task, which was intended to be difficult to complete in the time allotted. We were interested in seeing how the participants approached a realistic design task and how they used DENIM to help them. To help motivate the participants to create the best design they could, we offered $250 (US) to the best design. In the task, the participant was to develop a web site for a fictitious start-up company. The web site was to help renters find places to rent and to help landlords find tenants. We provided a competitive analysis of a competitor's web site, market research on what renters and landlords say they wanted, and a description of what the client company required and desired. The participant had 45 to 60 minutes to come up with a preliminary site design, and then he or she presented the designs to us as if we were the rest of the design team.

Figure 6. The display tablet used in the evaluation

While the participants performed the tasks, we recorded what types of actions they did (e.g., panning, drawing, and creating new panels) and at what zoom levels they performed those actions. This was to give us a sense as to what features of DENIM they used and how well zooming supported the different design activities. We also recorded any critical incidents that occurred, and their general comments and reactions.

After the participants were finished with the tasks, they filled out a questionnaire. We asked what they thought of DENIM in terms of usefulness, ease of use, and how they thought using it would affect their design process. The questionnaire also covered background information, such as basic demographics, what their primary job responsibilities were, what tools they normally used, and how much web design experience they had.

Observations

Users made substantial use of different zoom levels, with usage concentrated primarily in the middle three levels (site map, storyboard, and sketch). Several users verbally expressed that they liked the concept of the different zoom levels and liked the ability to maintain a unified representation of the site, while interacting with it at different levels of detail. It appears that users felt that the integrated view would help them iterate more quickly through different design ideas. One user highlighted the advantages of the integrated view by observing:

> *It's not like 'OK, that's one idea,' then open a new file and work on a new [idea]. You don't need to do that. The iteration goes on within this [tool] and I can see the relationships.*

Another user described how she thought DENIM would improve her current process by remarking:

> *I usually [create site maps] in PowerPoint, then I go back to the navigational flow, then I go back to PowerPoint… And here it would be so easy to do that iterative kind of thing.*

However, the current integration of these views through zooming sometimes proved to be problematic. Several of the users became frustrated navigating around their site designs and found that they often had to zoom out to a higher level in order to find their desired target and then zoom back in on that target.

Likewise, users had trouble creating navigational links between pages that they had initially drawn far apart on the canvas. It was difficult to find a view of the site that would include both the source and the target, yet have enough detail to be able to find the specific object on the source page that they wished to represent the link source.

One possible way to ameliorate both of these problems would be to introduce a focus+context view [6] into DENIM. Being able to see more of the site in the periphery while zoomed in to a particular portion of the site could help reduce the difficulty of finding one's place in the site. Similarly, being able to compress the distance between a source and target page while maintaining a high level of detail in the source page would help relieve the problem of linking pages that were originally drawn far apart from each other in the site map.

Users appreciated the informal mode of interaction provided by DENIM. One user compared the interaction to other tools with the comment:

> *You draw a box in Illustrator or Freehand or Quark, and it's got attributes that have to be dealt with, and it interrupts the thought process.... It's nice to be able to get rid of all the business with the pictures and all the definite object attributes. That is such a hassle.*

At the same time, the free-form sketching interface provided some stumbling blocks. For example, handwriting on the screen was difficult, given the average performance of the application, the simple stroking algorithm used, and the lack of feedback from writing on a smooth screen. Two users experienced difficulty reading page labels. Another user wanted to type her page labels. Other users said that they like to handwrite while brainstorming, but would like the ability to replace handwritten labels with typed labels as their ideas become solidified. We plan to address these concerns by improving handwriting input, as well as supporting the progressive refinement of text objects by allowing their replacement with typed text.

Feedback

The responses to the post-test questionnaire, though informal, were instructive in several ways. Opinions about DENIM's perceived effect on the respondent's work practices were sharply divided based on the amount of the respondent's workload that consisted of web design projects. The two individuals not involved in web design ranked DENIM relatively low on factors such as "the perceived benefit using the tool would have on their ability to communicate with team members" and on "DENIM's overall usefulness" to them. The five web designers, on the other hand, had generally positive opinions of DENIM along these lines.

First, while the web designers ranked the ease-of-use just above average (6.4 out of 10), they ranked the usefulness fairly high (9.0 out of 10). This seems to indicate that, despite the shortcomings of the current implementation in terms of performance and fluid interaction, users felt that the basic concepts were on target.

Also, the web designers gave very high rankings when asked to rate DENIM according to its perceived ability to communicate with others involved in the design process. Those users rated DENIM better than 8.5 out of 10 in terms of ability to communicate with design team members (8.6), internal managers (8.8), and usability engineers and testers (8.8). They also gave similarly high marks to DENIM's improvement in their ability to express their ideas (9.0), iterate quickly through versions of a design (8.6), and overall efficiency (8.6). All users gave DENIM relatively low marks in terms of ability to communicate with clients (6.14 out of 10 overall), which we attribute largely to DENIM's inability to produce "cleaned-up" versions of sketches that would be acceptable to show to clients.

FUTURE DIRECTIONS

We are looking into focus+context techniques to help solve several visualization problems that we described in the previous section. We are also looking into other techniques to help keep a sense of context while zoomed in on individual pages, including radar views, as done in [9].

We are also looking into ways to support the generation of medium-fidelity prototypes from low-fidelity sketches. As noted before, such a feature could allow designers to give more "professional" presentations, while staying with sketching longer.

We would like DENIM to work with existing web design tools to fit more naturally into the entire web design cycle. This includes generating HTML and other artifacts that can be imported by other tools, and providing mechanisms for automatically generating medium-fidelity prototypes for presentation purposes. DENIM should also be able to import files from other tools, so that designers can smoothly move back and forth in the design process.

One requested feature is to have a robust history and versioning mechanism, so that a designer can easily search through the evolution of a particular design and compare different designs within a project.

We have devised extensions to the storyboarding mechanism to support the design of more sophisticated web interfaces as well as traditional GUIs [16], including methods to allow designers to specify their own reusable components. These components can be as simple as a new kind of widget or as complex as a template for a web page.

CONCLUSION

Our ethnographic study showed us that in the early stages of design, web designers go through an iterative process of progressive refinement, that each refinement focuses on finer levels of granularity and an increasing level of detail, and that sketching is used throughout the early part of this process. These observations informed the design of DENIM, an informal sketch-based system supporting web designers in the early stages of design. DENIM allows designers to quickly sketch out pages, create links among them, and interact with them in a run mode. The different ways of viewing a web site, from site map to storyboard to web page, are unified through the use of zooming. In an informal study with seven professional designers, we found that they were enthusiastic about DENIM's concepts and would like to use such a system in their work.

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