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Fluidly Revealing Information in Fluid Documents

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Abstract

Fluid documents alter their layout, typography, and other graphical characteristics in order to present supporting material in the context of the primary material that it annotates. The document surface acts as a canvas in which traditionally static elements may move and change smoothly to make room for additional information. This process is managed by a four-step negotiation architecture that yields complementary layout and presentation of all elements.

Introduction

Documents and other information spaces often include multiple layers of information: there is some primary information that is presented directly, and then supporting information that may optionally be included. Examples of supporting information are non-mainstream material that is presented in a footnote; attribution of prior work via a reference; derivations of a formula; definitions of technical terms; illustrations and diagrams; or simply more detail about a particular point that the entire audience may not be interested in.

We have been investigating user interface techniques for *fluid documents* for providing smooth, contextual access to additional information. Our approach is to alter the graphics or typography of a document in order to show the supporting information in the context of the primary information it annotates. This alteration is animated, so that the reader's attention is guided calmly to the revealed supporting material, and later guided back to the primary material.

Figures 1 and 2 show an excerpt from Shakespeare's *Romeo and Juliet*, with the existence of annotations indicated by underlines. In this instance, moving the cursor over an underlined phrase causes an annotation to grow from a tiny size to its full, readable size. At the same time, the primary text moves apart to make room for the annotation. Placing the annotation right at the annotated material not only allows the eye to quickly pick up the expanding annotation, but it also allows easy comparison to the primary material. When the reader is done with the annotation, she may simply move the mouse away and the annotation shrinks and the primary text closes back together.

But soft! What light through yonder window breaks?
It is the East, and Juliet is the sun!
Arise, fair sun, and kill the envious moon,
Who is already sick and pale with grief
That thou her maid art far more fair than she.
Be not her maid, since she is envious.
Her vestal livery is but sick and green,
And none but fools do wear it. Cast it off.

Figure 1. Underlines indicate the presence of an annotation.

But soft! What light through yonder window breaks?
It is the East, and Juliet is the sun!
Arise, fair sun, and kill the envious moon,
Who is already sick and pale with grief
That thou her maid art far more fair than she.
the moon is here thought of as Diana
Be not her maid, since she is envious.
Her vestal livery is but sick and green,
And none but fools do wear it. Cast it off.

Figure 2. Fluid interline.

Like Furnas' generalized fisheye views (Furnas 1986), a fluid document does not show all the information at once, instead allowing the user to guide the unveiling of more information as interest dictates. Focus+context systems (Leung and Apperley 1994; Robertson et al. 1993) similarly preserve context while providing more detail; however, fluid documents do not rely only on geometrically defined distortions. Instead, the techniques make use of the graphical properties of the information elements: position, color/saturation, size, shape, orientation, texture, and marks (Bertin 1983).

For example, the layout in Figure 2 uses the *fluid interline* technique for allocating space for annotations in textual documents (we call these annotations *glosses*), primarily modifying the position of the primary text to make space. This technique illustrates the central principle of fluid documents: when the user expresses interest in supporting information, the primary material must make (or find) space for that information, and the supporting information must present itself in a salient fashion. In

Figure 2, the gloss displays itself in a contrasting font and weight in order to set itself off from the surrounding text.

Fluid documents use a *negotiation architecture* to manage the selection of space and salience strategies by the primary and supporting material. The next section describes other fluid techniques that we have developed. Following that we describe the negotiation architecture that supports these techniques.

Fluid Document Techniques

We believe that techniques for altering the typography and layout of documents will be specific to the kinds of documents and the kinds of tasks the reader is engaged in. Therefore we set out to develop a variety of techniques, with different tradeoffs, for showing supporting information using the fluid document principles.

Text documents. Our initial implementations of fluid documents have been for textual documents. In particular, we have built a prototype for viewing textual annotations, as well as a *fluid links* hypertext browser. Fluid links use glosses to provide a summary about the destination of the link, in order to help the reader decide whether to follow the link (Zellweger et al. 1998, Zellweger et al. 1999). In both the annotation and fluid link applications, glosses can be shown using several different fluid techniques: interline, overlay, and margin callout.

The fluid interline technique presented in the previous section has several variations. The text can be moved as a block into the available space in the margins. Alternatively, the interline spacing can be compressed throughout the primary text, allowing space to be opened up below the anchor. Or more radically, the typefaces of the lines of primary text themselves can be "squashed" to make space.

Instead of altering the primary text's position, the *fluid overlay* technique alters the primary text's color so that supporting material can be placed on top of it (see Figure 3). The supporting material also must display itself in a contrasting color.

But soft! What light through yonder window breaks?
It is the East, and Juliet is the sun!
Arise, fair sun, and kill the envious moon,
Who is already sick and pale with grief
That thou her maid art far more fair than she.
Be not her maid, since she is envious.
the moon is here thought of as Diana
Her vestal livery is but sick and green,
And none but fools do wear it. Cast it off.

Figure 3. Fluid overlay.

As in all the fluid techniques, the transitions are animated; so the text fades to gray while the gloss is growing to full size. This technique keeps the layout of the primary text unchanged.

The *fluid margin callout* technique alters the primary text even less than fluid overlay: the only intrusion is a line that grows from the anchor text to the margin. In this case, the gloss is placed in existing white space (see Figure 4). This example also shows that glosses in our fluid links browser can include images.

But soft! What light through yonder window breaks?
It is the East, and Juliet is the sun!
Arise, fair sun, and kill the envious moon,
Who is already sick and pale with grief
That thou her maid art far more fair than she.
Be not her maid, since she is envious.
Her vestal livery is but sick and green,
And none but fools do wear it. Cast it off.

The moon is here thought of as Diana

Figure 4. Fluid margin callout.

Glosses can be "frozen" to allow them to stay in place while the reader continues elsewhere on the page. Frozen glosses introduce new terrain for the fluid techniques; for example, frozen glosses may introduce extra whitespace that is usable by subsequently opened glosses, or frozen glosses may need to be moved around to make space for a newly opened gloss. Examples of such use can be found in (Chang et al. 1998).

Control glosses. In addition to textual and graphical annotations, the Fluid Links browser also demonstrates "control glosses." A control gloss is like a small control panel attached to the objects it modifies. Like other glosses, they are usually indicated only by a mark. Mousing over the mark causes it to open full size, getting space from the primary material using some fluid technique. The user can then interact with the control panel to alter some property. In the Fluid Links browser, a control gloss allows switching between fluid techniques used by all glosses in the document. Of course, the range of control could be much narrower: control glosses in a word processing application could alter the formatting of words, for example.

Spreadsheets. To contrast with our explorations for textual documents, we next investigated a document type that has a great deal of graphical structure: spreadsheets. First, the *fluid spreadsheet* (Igarashi et al. 1998) supports glosses attached to any cell. For example, in Figure 5 the (pink) rectangular region beginning in cell F12 and containing "Skippy Tag 254…" is a gloss attached to cell E12. It opens up into an empty region of cells, without covering any cell that contains data.

More interestingly, the fluid spreadsheet is able to expose the supporting material behind the tabular data in the spreadsheet: the underlying constraints as specified by formula cells. By mousing over a cell (see cell C9 in Figure 5) the relationships to the other cells in the spreadsheet is revealed—in this case, the (green) shaded bars indicate that the cell is involved in a calculation in the column and row, yielding the results in the (yellow) cells C17 and H9. Clicking the darker (green) region in the cell fires an animation of the green bars shrinking into the yellow cells, thus dynamically illustrating the relationships. Furthermore, a global sequence of animations can be played to understand the entire structure of the spreadsheet.

	A	B	C	D	E	F	G	H	I
1				Dropped Dogs					
2									
3	**Mushers**	Koyuk	Elim	Golovin	Wt. Mt.	Safety	Nome	**Dogs**	**Total**
4	Barron							0.0	0.0
5	Boulding							0.0	0.0
6	Buser				2.0			2.0	2.0
7	Kyser							0.0	2.0
8	Jonrowe							0.0	2.0
9	Joy		1.0			1.0		2.0	4.0
10	Halter							0.0	4.0
11	King							0.0	4.0
12	Mackey				2.0	Skippy		2.0	6.0
13	Plettner		1.0			Tag 254		1.0	7.0
14	Redington					Happy		0.0	6.0
15	Swenson					Tag 067	1.0	1.0	8.0
16	Smyth	1.0						1.0	9.0
17	**Total**	1.0	2.0	0.0	4.0	1.0	1.0	9.0	9.0

Figure 5. Fluid visualization of spreadsheet constraints.
(A color version of this figure can be found at
http://www.parc.xerox.com/fluid/smartgraphics-figure5.html)

The fluid spreadsheet employs two dimensions for conveying information—coloration and temporal change—that are not addressed in the techniques explored for text documents. In these cases the supporting information is encoded in the alterations to the primary document, rather than as separable entities in themselves.

Negotiation Architecture

The fluid alterations to the document are managed by an architecture that is based on negotiation between the primary material and supporting material (Chang et al. 1998). The result of the negotiation is a layout for the primary material and a presentation of the supporting material that are complementary. The process is a negotiation because neither participant can dictate either the layout or the presentation, but may merely offer capabilities and preferences. For example, a textual gloss may have the ability to change its font size and color, while an image may be continuously scalable in size but not alterable in color. This design permits objects to encapsulate their capabilities, so that fluid objects can be developed in isolation and "dropped" into existing fluid documents.

In order to effectively communicate capabilities to each other, fluid objects conform to specific protocols in a graphical protocol hierarchy. The hierarchy allows participants in a negotiation to converge on a shared ancestor node as a basis for communication.

Our current negotiation architecture has served fluid documents that display supporting information as separate entities, as in textual annotations or fluid links glosses. The fluid spreadsheet's encoding of supporting information into the graphical and temporal behavior of the primary material is a model we have not yet supported in the architecture.

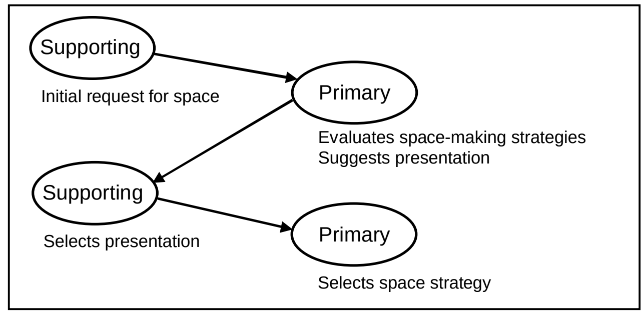

Figure 6. Negotiation sequence.

The negotiation is a four-step process (see Figure 6).

Step 1: Initial proposal (supporting object). The user indicates interest in the supporting information, causing the supporting object to initiate the negotiation. It communicates its preferred size and presentation to the primary object, along with information about the graphical protocol that it understands, and the range of graphical possibilities it is capable of.

Step 2: Guidelines (primary object). The primary object determines a graphical protocol that it can use to communicate with the supporting object. It then determines how closely it can satisfy the request by the supporting object. It does this by selecting among the various space-making strategies it can perform (for example, fluid interline or fluid overlay or even a composition of techniques). After it has selected a strategy, it puts together a set of graphical guidelines for the supporting object, including both a maximum size allowed as well as presentation requirements to ensure that the supporting object will be salient given the selected space-making strategy. For example, an interline strategy may require the supporting text be in a different font, size, or font style, to contrast with the surrounding text; or an overlay strategy may require the supporting text to be darker than the faded color.

Step 3: Presentation strategy choice (supporting object). The supporting object selects a presentation that conforms to the guidelines.

Step 4: Space-making strategy choice (primary object). The primary object finalizes its strategy choice based on the supporting object's choice. This may in some instances be different than the tentative choice made in Step 2, because the supporting object may have ended up taking up less space than expected, allowing the primary object to choose a more preferable, but less space-giving, strategy.

The design of the negotiation sequence was intended to allow enough exchange of information, while keeping the negotiation simple. One consequence is that the negotiation is not guaranteed to succeed. Thus, this simple architecture assumes that fluid document applications are designed such that their demands are lenient, so that negotiations are generally successful, and that there are reasonable alternatives in the rare event of a failed negotiation.

Evaluation

The various fluid documents techniques we have developed differ along several dimensions, including the degree of typographic adjustment and the distance glosses are placed from anchors. While placing glosses close to their anchors seems most beneficial, we were concerned that the radical adjustments of typography needed to accomplish this might disrupt reading activity. In addition, we wanted to find out how different techniques affect how glosses are used, and how readers react to the availability of glosses and the techniques used to display them.

To shed light on these questions, we carried out an observational study exploring the impact of fluid documents on reading and hypertext browsing (Zellweger et al. 2000). We compared three fluid techniques (interline, overlay, and margin) with two established techniques for incorporating details into a document (footnotes and pop-up ToolTips-style windows), as well as a conventional hypertext condition that displayed no glosses. Six subjects read and answered questions about two hypertext corpora while being monitored by an eyetracker. Results showed that gloss placement was significant: in conditions with glosses near the source anchor (fluid interline, fluid overlay, and pop-up), subjects kept glosses open on average for significantly shorter intervals than in conditions with distant glosses (fluid margin and footnote). In addition, eyetracking analysis showed no substantial differences in eye behavior between conditions, indicating that the animation present in the fluid conditions did not create visual disruptions. Subject comments conveyed a wide range of reactions to the different conditions: some subjects loved fluid techniques for reading and browsing, while others hated them. Moreover, subjects had varied preferences among the fluid techniques, with each technique receiving at least one best rating overall on the subjective questionnaires.

These results seem to indicate that the basic concepts underlying fluid documents can be effective: users can process moving text even in a serious reading situation, and providing information close to the anchor seems to be beneficial. The varied subjective preferences suggest that architectures like our negotiation architecture, which supports multiple fluid techniques, may be crucial to user acceptance.

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