User Centered Design Patterns for Visualization

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Abstract: Displays are increasingly being provided for use by non-IT experts, based on requests from (non-expert) clients of design. Designers of screen content and layout should be able to apply existing Visual Design knowledge. Most engineers and designers, however, are no specialist in Human-Computer Interaction. We aim at making this knowledge readily available for engineers who are responsible for designing screens. We provide an overview of knowledge available, and show our attempts to make this usable for engineers.

1 Screen Design is not Just About Pixels

Information Technology (IT) has been using displays for over 40 years. The variation in screen sizes is still growing. Screens are designed for clients of design (industries as well as buyers of products) who intend their products to be used by people. Screens are being used by people to see, understand, and experience things. Today's screen users are no longer IT specialists. Consequently, screen design should be based on insight in how visual presentations interact with human perception, understanding, decisions, and actions.

Engineers design (1) the screens, and most of the time engineers design (2) the way content data will be displayed. Both design efforts require attention to the prospective users of the screen. However, engineers who have to design the graphical user interface often lack sufficient education in Human-Computer Interaction (HCI) or Visual Design (VD) to optimally serve the user, especially in small and medium sized enterprises.

This paper is about knowledge of how information could / should be displayed. The paper shows our ongoing research in developing support for engineers. We aim at enabling them to make optimal use of design knowledge from HCI and VD. In fact this knowledge is available, (1) in the format of user interface design patterns (e.g., [We09], [Ti08]); (2) in publications from the design community (e.g., [LH03]); and (3) in (web-based) accounts of ongoing research (e.g., [OR09]).

Especially the first two types of sources are mostly collecting, combining, and structuring "second hand" knowledge, built from multiple instances of successful practice more than from theory, even if the sources we point to add theory based explanation "after the facts". All three types of sources are in constant development and expansion. The good news is that most of this knowledge is in fact available through the internet.

In section 2 we will point to HCI design pattern collections and provide an overview of the most relevant patterns for VD. Section 3 shows an example of VD knowledge from a state of the art Design book. Section 4 illustrates what VD knowledge can be derived from ongoing research that is public available. All three types of knowledge are in a continuing state of expansion and development. Consequently, these reviews are nothing more than a dated sample. Section 5 gives an account of a first attempt to provide this type of knowledge to engineers and to assess our approach. Section 6 concludes with our current ideas to improve the way engineers can use this knowledge.

2 HCI Design Patterns for Visual Design

Design patterns, originally developed for Architecture by Alexander [Ax77], but soon adopted by Software Engineering [GH95], are a common source of proven solutions for designers' problems, and, as such, are readily understandable and applicable. HCI design patterns, on the other hand, are a relatively new type of knowledge source, developed by HCI experts (e.g., [WV00], [TI08]), and intended to be readily applicable by engineers. The main difference with Software Engineering patterns is the focus: HCI patterns aim at solving the *users'* problems. Contrary to the goal of HCI design patterns, [SJ02] found that software developers "experience difficulty when attempting to understand, master and apply a specific pattern in their context". [SJ06]) indicated usability problems when pattern collections were used by engineers as well. Our research project has the flavor of discount usability, but the effect will be different from the approach of Nielsen [Ni94]. Where his approach takes care of saving costs of different usability evaluation steps, our approach is to improve the early stage of the design process, by supporting the design decisions of non-experts in usability design.

Our initial collection of VD knowledge (containing 29 patterns) is derived from two well known HCI design pattern collections [We09] and [Ti08]. Both collections base the knowledge they provide on design knowledge for which they could identify multiple independent successful applications. We provide a sample of patterns from both sources that we consider typical VD patterns, pointing to the source for details, examples of actual use, and theoretical explanation:

- **Center Stage** [We09] **User Problem:** where to find the important things in relation to all the things on the page; **Solution:** Create a large "center stage" that dominates on the page.

- **Color Coded Section** [We09] **User Problem:** need to recognize that they are in the right place; **Solution:** Color each major section with its own color.

- **Grid-based Layout** [We09] **User Problem:** need to be able to scan, read and understand a page quickly; **Solution:** Use grid system for placement and alignment of visual objects on the page.

- **Row Striping** [Ti08] **User Problem:** need to read or scan a table in search of particular information **Solution:** Use alternating row colors for making the table more readable.

- **Diagonal Balance** [Ti08] **User Problem:** Users who read from left to right have a natural eye movement from top left top bottom right; **Solution:** arrange page elements in an asymmetric fashion, balancing it by putting visual weight into both the upper left and the lower right corners.

- **Action Panel** [Ti08] **User Problem:** There are too many actions for making a button group, and a menu bar or pop-up menu is not obvious; **Solution:** Present a large group of related actions in a well organized UI panel that is always visible.

3 Visual Design Knowledge from Design Literature

Current literature on visual design (e.g., [LH03], [Tu97], [Sp06]) in many cases provides the authors' view on how to apply graphic techniques in order to make audience of the design understand, appreciate, experience, and act. The client of the design (the person or company who is paying the designer) in many cases has an explicit goal: to make the audience receive the message, to change its mind, to buy the product, etc. In this respect, different from the patterns discussed before, this design knowledge seems to aim, at least partly, to solve the client's problem. In the end, though, the client sometimes is the audience as well (the "client" goes to a bookshop to find a book that allows him to "use" it for exiting reading). Most sources in this domain are in fact collections of successful design, inspiring to expert readers, and structured along types of solutions, not user problems. [LH03] stands out in what the subtitle says *"100 Ways to Enhance Usability, Influence Perception, making Better Design Decisions, and Teach through Design"*. This type of knowledge can be transformed into patterns in a relatively straightforward way. We show examples of patterns developed from the clear-cut guidelines in [LH03] where examples from practice as well as theoretical background may be found.

- **Affordance** - **User Problem:** to know when and how to perform actions at a 2-D graphical interface; **Solution:** Represent a widget's function analogous to relevant objects from the user's physical world: draw 3-D buttons, sliders, thrash cans, as well as their changing image upon users' actions towards these, and allow the user to use the display as input location.

- **Chunking** – **User Problem:** to keep an overview in case of large collections of elements; **Solution:** Group collections of related elements / objects into a single element, *provided the user will not need to scan the elements in the chunk* – e.g., chunking will not work if the user has to choose one of the states in the USA.

- **Constraint** – **User Problem:** to understand what actions make sense, or are possible in the current state; **Solution:** Show action limits: sliders end-points; fading buttons when no meaningful actions are possible; input constraints for dates: "dd/mm/yy". If possible, consider to enforce relevant choices by providing pull-down menus for day, moth, year, country, etc.

- **Iconic representation** – **User Problem:** what does this icon mean; **Solution:** pictorial images improve recognition and recall of signs and controls. Similar icons use images that are visually analogous to actions, objects, or concepts; example icons exemplify these. Symbolic icons will work only as far as they resonate in the user's cultural background. Arbitrary icons have to be learned, so these will not work for incidental use.

4 Current research on visual design and perception of new media

Current available technologies like eye-tracking lead to a totally new way of analyzing the people's looking behavior while being confronted with, and interacting with, visual displays. We base our current examples on [OR09], where relevant results from well designed experiments are made available, that certainly are supportive for HCI experts, though for non experts a translation is needed. Here we only provide some attempts to transfer this type of knowledge into patterns that serve, mostly, the problems of the clients of design.

- **Meaningful scanning – Client Problem:** Make sure the user understands headline; **Solution:** Put message in first three words.

- **Restrict number of options – Client Problem:** How to make users consider all options; **Solution:** offer maximal 5 options at once.

- **Picture faces – Client Problem:** How to draw user's attention away from normal reading pattern; **Solution:** For PC screen only: use medium size (210 * 230 pixels) picture of (preferably 2) faces.

5 Fitting Patterns to Engineering Practice

First of all, we selected 29 patterns relevant to Visual Design: we changed the names to indicate the user's problem for which the pattern provided a possible solution. We edited the pattern to optimally fit the design knowledge that was supposed to be available with Engineers without expertise in HCI or VD. We provided a small group (8) of Computer Science students with this collection. All students were advanced Software Engineers, well aware of "traditional" patterns like [GH95]. As part of their curriculum they had to develop a visual design for a website and related paper documents. Half of them used a simple tool that just listed the patterns grouped in the category set used by [We09]. The other half were provided with a wizard that asked them questions in order to build s collection of most relevant patterns for their actual design case, see Figure 1. Both groups were able to identify and apply those patterns that were relevant for their design case.

Somewhat surprising, the wizard group still browsed all patterns, including those not suggested to them. We interpret this behavior as a strong need to be flexible, and play with alternative solutions. A wizard seems too much an authority, dictating in the end which solutions would make sense and which not. Users are feeling they lack control of, and insight in, the functioning of the wizard.

Figure 1: Pattern wizard (relevant current issues highlighted)

6 Envisioning a flexible Design Environment

We are currently developing a new VD pattern selection tool, where we provide the designer with possibilities to play around with the various aspects of the design space: characteristics of the actual design goal, aspects of the intended user group and their context (including the type of hardware expected to be user), as well as aspects of the intentions of the client of design.

Figures 2 - 6 show a mock-up, and the figure captions represent a use scenario. Designers may choose from drop down menus to select the most relevant category of screen objects (tables; long text; category names; icons) and user actions (print; navigate; input data; read). Depending on the designer's current choice, various sliders are provided to set characteristics of the user (goals), the object or system to be designed, and context of use. For some of these characteristics a point slider seems to be in place, in other cases it seems relevant to provide the possibility to play with a range.

Figure 2: Mock-up – At the start nothing has been selected, so the system warns that all patterns could apply. The designer opens the drop-down menu for “important screen objects” and chooses “long tables”

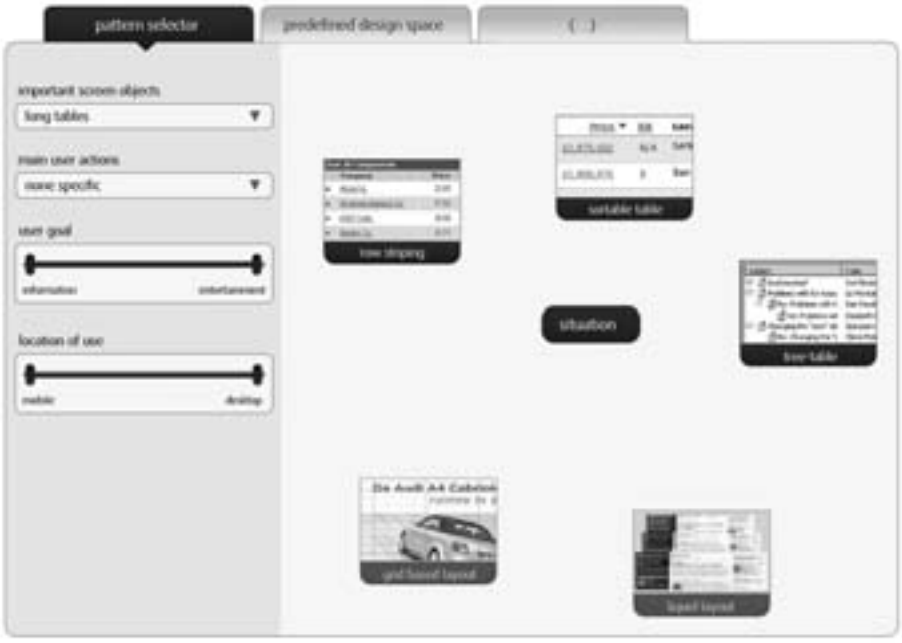

Figure 3: The system now presents 3 patterns that concern tables (row-stripping, tree-tables, and table-sorter) and, farther away from the current “situation” and more vaguely rendered, possibly relevant alternative patterns for liquid layout and grid layout

Figure 4: moving the “location of use” slider to restrict the range to “mobile”, causes a warning. All patterns disappear - tables are not a good idea for mobile phone or palm top screens. The designer starts anew, without identifying major screen objects. From the drop-down menu for “main user actions” he/she chooses “navigation”. All navigation patterns are now shown, plus (vaguely rendered) related patterns (color coded sections, breadcrumbs, and home links). In this “situation” extra sliders appear specific for navigation: “number of pages” and “site hierarchy”

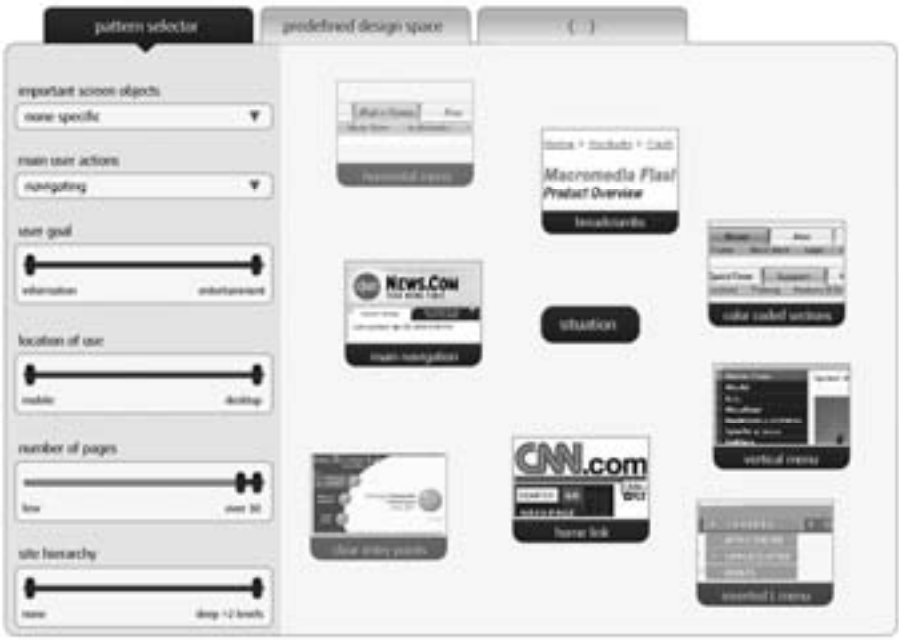

Figure 5: restricting the “number of pages” slider to “over 30” makes the patterns for “horizontal menu”, “clear entry points”, and “inverted L menu” to be rendered vaguely, since these mainly are effective for small-scale sites. Patterns for “breadcrumbs” and “color coded sections” have moved to the center of the “situation”

Figure 6: If, additionally, the site hierarchy range is “deep”, patterns that were vague and away from the “situation” are gone. If now the designer chooses a flat structure (“no hierarchy”) he will see only vaguely rendered patterns (not really fitting the “situation”), and a warning is issued.

In this way the designer can experiment with the weight he would like to put on various aspects and characteristics in this multidimensional design space. The relevance of the resulting patterns in the given configuration is represented by 'distance to the situation'.

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