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Design Space for Focus+Context Navigation in Web Forms

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ABSTRACT

Navigation in long forms commonly employs user interface design patterns such as scrolling, tabs, and wizard steps. Since these patterns hide contextual form fields outside the viewport or behind other tabs or pages, we propose to apply the focus+context principle from information visualization to form design. This work presents a design space analysis to support usability engineering of focus+context form navigation. We evaluated the design space's usefulness and applicability in a case study and found the design space has fostered creativity and helped to clearly document design decisions, indicating it can be a valuable support for engineering intelligent, form-based user interfaces.

Author Keywords

Navigation; Focus + Context; Web Form Design; HCI

ACM Classification Keywords

H.5.4. Hypertext/Hypermedia: Navigation

INTRODUCTION

Forms are widely employed as user interface metaphor for data entry and subsequent editing [21, 23]. Their proper design is considered crucial for smooth information exchange [3, 23, 36]. This work primarily understands 'long' forms in a spatial sense (e.g., number of fields), as opposed to form filling time or cognitive complexity. Long forms are considered a bad design practice – e.g., an empirical study [36, p.294] and guidelines [3] recommend against long forms and unnecessary questions – but they cannot always be avoided. Long forms can result from application requirements for editing large sets of data in domains such as business administration, social networking, e-health and e-government, see Table 1. Furthermore, vertically spatious forms result from design recommendations [3] [23, p.164] to avoid multiple columns and to only ask one question per row.

Hence, given the length of many forms, users need effective means for navigation. Existing navigation solutions are problematic because either the whole form is shown on one page and requires a lot of scrolling, or else the form is split into tabs or pages. Both options hide the majority of contextual form fields (either outside the viewport or in other tabs), leading to a loss of context for the user. The underlying 'loss of context' problem has been addressed in other domains using the focus+context technique in information visualization [7, 18].

Domain and Form	Number of Fields
Business Adm.: Editing a person in JFire	35
Social Networking: Profile page in Xing	66
E-Health: OpenClinica Docetaxel sample study	143
E-Government: US 1040 tax return form	246
Software Eng.: Eclipse preferences dialog	> 300

Table 1. Examples of long forms in different domains. Number of fields counted as input fields and options, without headings, labels and buttons.

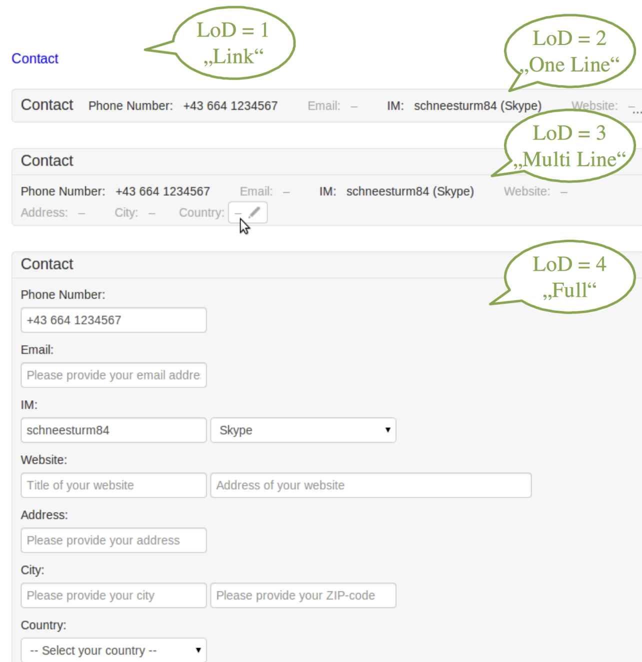

Figure 1. Focus+context navigation in long forms, as designed in the case study. The level of detail (LOD) depends on the user's degree of interest.

Methodologically, this paper analyzes the design space for how the focus+context principle from information visualization (infovis) can be applied to web form design in order to improve navigation in long forms. The primary contribution of the paper consists of the design space and its evaluation regarding usefulness and practical applicability in a case study where form navigation was redesigned in a social network profile page scenario (see Figure 1).

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Form Design

Best practices for form design are captured in guidelines [3] and books [23, 36]. Related research has been classified [3] into five areas: form content, layout, input types, error handling, and submission. Directions for future research are provided in [21], seeking to make the form user interface metaphor more interactive and application-like. Navigation in long forms is treated in [13] with a focus on button placement in web survey design. Linear form filling scenarios with a predictable number of steps can be supported with progress indicators [23, 36] that should communicate scope (overview of the overall steps), position (the current page), and status (of the form submission) [36]. Designers may force linear navigation by using the 'wizard steps' design pattern, allowing them to adapt the form based on previous input. In contrast, non-linear form filling is typical in the domains shown in Table 1: to fill, revise, and complete these forms, users navigate freely around the various form sections.

Navigation

Navigation is a widely used concept in HCI research that metaphorically likens information seeking in electronic environments to navigation in the physical world [14, 16]. An overview of research in mobile, wearable, embedded, 3D, and desktop systems is provided in [34]. The cognitive processes involved in human navigation are detailed in [32]. One branch of navigation research has examined navigation *between* documents, e.g., in hypertext environments [10, 14, 29] and websites [30], or when trying to find the right form to fill in an enterprise resource planning system [33]. In contrast, research on *within*-document navigation investigates topics such as reading long documents [1, 9, 20], navigation in lists [18] and tree-like structures [8], and navigation in long web forms [13], as examined in this paper.

A formal, graph-based model where nodes represent views and edges represent possible transitions allows to formulate two requirements for efficient navigation [19]. Firstly, the out-degree of each node must be relatively small because given limited display size, each view can only show a small number of outgoing navigation links. Consequently, navigation is likely to include multiple steps, which leads to the second requirement: the maximum length of all navigation paths should be short to make navigation efficient. Focus+context techniques fulfill the first requirement by only showing contextually relevant information that users can navigate to, and the second requirement if the contextual information provides shortcuts that abbreviate navigation paths.

Adaptive UIs

As a defining characteristic, adaptive systems modify their behavior based on models of user attributes and actions in order to improve the interaction with the user [22, 26]. To implement such adaptation, software architectures of adaptive systems employ runtime models of the UI to reflect and manipulate the current state of the interactive system [5]. In focus+context approaches, the runtime model computes the users' degree of interest (DOI) and calculates the level of detail (LOD) for UI elements [8], compare Figure 2. A taxonomy of adaptive UIs is provided in [26], allowing to classify

Classification criteria	**Classification of this work**
Initiating agents	User, system.
Type of adaption	Manner of presentation.
UI-Level of adaptation	Visible
Scope of adaptation	User behavior, etc. [1]
Goals of adaptation	Make complex systems usable
Methods of adaptation	Switching.
Strategy of adaptation[2]	During use.

[1] More options are considered in the design space section of this paper.
[2] Strategy refers to the timing of adaptation: pre / post / during use.

Table 2. Classification of the focus+context form navigation proposed in this work as an adaptive user interface, using the taxonomy from [26].

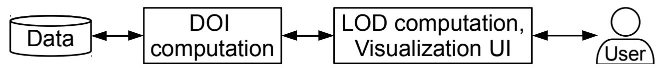

Figure 2. Architecture of focus+context systems, as in [8], Figure 1.

the present work as shown in Table 2: the overall goal of focus+context form navigation is to make complex systems usable; to achieve this goal, the manner of presentation of specific form sections is switched upon user initiative, and upon system initiative when the UI is initially displayed.

Related work has used adaptive systems to improve performance in navigation [22] and menu selection [17] tasks and to reduce visual clutter in form design [25]. Forecasts of future user behavior have been used to improve navigation [2]. Evaluations of adaptive systems have mostly focused on performance, but the users' emotional response and how much they learn from using the system is also important [22]. Adaptive systems have been criticized for introducing additional complexity [35]. It is therefore important to design simple interactions to avoid drawbacks in efficiency and satisfaction.

The Focus + Context Principle

The focus+context principle, as formulated in the infovis discipline by Card et al. [7], states that users simultaneously need detailed information (at the user's focus of interest) and overview (context). It suggests these two kinds of information to be combined into a single, dynamic display that balances global overview and local detail [18]: specific areas of interest are shown in great detail to make interaction feasible while other areas give a compact overview of the global context the user is operating in. A taxonomy of infovis techniques used for navigation design [11] includes zooming (temporally separated views), overview+detail (spatially separated views), focus+context (interwoven focal and contextual views), and cue-based techniques (highlighting of focal elements). The focus+context principle is relevant to existing form navigation patterns where most of the context is hidden either outside the scrolling viewport or behind other tabs or pages. A link between focus+context techniques and navigation is also established in [18]: "Context is not only needed to interpret a static view of an item, providing meaning. It is also critical for moving around effectively". Related work has likewise proposed applying the focus+context principle to navigation in long forms [21] but did not provide a specific solution.

Design Space: Design questions and corresponding options
DOI: Degree of Interest Computation
A-priori importance of form elements:
– Manually assigned by form author
– Automatically derived from form schema
Modelling the user's interest:
– Single focal point (with spatial / structural / semantic distance calculation)
– Multiple foci of interest
– Discrete or continuous distributions of interest
Granularity of DOI computation:
– Per control, field, fieldset, section or page
Timing of DOI computation:
– During use, pre-use, post-use
Influencing factors:
– User characteristics, user behavior, context of use, domain
LOD: Level of Detail Computation and Visualization
Influencing factors:
– DOI values and (optionally) total available display space
The number of LODs:
– Multiple, discrete LODs vs. an infinite number of continuous LODs
Techniques for 'making space':
– Semantic approaches: Filtering, aggregation
– Visual approaches: Scaling, distortion, highlighting
– Layout: Block movement, deformation, overlay, outside allocation
Designing LODs by applying the above techniques to:
– Labels, values, form controls
– Hints, validation errors
– Selection fields and corresponding options
– Composite fields, fieldsets, form layout

Table 3. The proposed design space for focus+context form navigation.

A DESIGN SPACE FOR F+C FORM NAVIGATION

Based on the above findings, we suggest applying the focus+context principle to navigation in long forms. The user's focus of interest determines which part of the form is fully shown; the rest of the form is shown in a more compact, aggregated, read-only way. Since this can be designed in various ways, the concept of design spaces is apt to systematically describe design options and their implications. Design spaces have been proposed as a semi-formal notation of design questions (i.e., key issues to be addressed in a design project), design options (possible answers to design questions), and evaluation criteria (implications of design options, used for choosing between design options) [24]. In order to make our proposed design space reusable across multiple projects and domains, we present questions and options in a generic way, see Table 3. Project-specific evaluation criteria and decisions made in one specific scenario are presented in the case study.

The overall structure of the proposed design space can be seen in Table 3, consisting of design options for the two essential components of focus+context visualization as described in [8, 18] and depicted in Figure 2. The degree of interest (DOI) computation component determines the most relevant subset of information. The visualization component computes the levels of detail (LOD) for elements of the UI based on DOI computation and considering the limited display space.

DOI: Degree of Interest Computation

Degree of interest is used to model the instantaneous interest a user is likely to have in various parts of the UI. Furnas [18] describes a generalized fisheye formalism to estimate a user's DOI in various features of large information structures based on current user activity, defined as

DOI of feature = A-priori importance - Distance from focal point,

where a-priori importance describes the static, intrinsic importance of the features of an information structure, and the focal point describes one specific point of heightened activity.

In form design, *a-priori importance* can be manually assigned by the form author based on the domain-specific importance of form fields. Additionally, a-priori importance can be derived automatically from a given form schema, e.g., an algorithm may assign higher initial DOI values for fields that were marked as 'required' by the form author. Furthermore, the importance of specific fields may be adapted based on the characteristics of individual users or user groups, such as physical and cognitive abilities, preferences, expectations, and experience, compare [26]. E.g., user characteristics based on market segmentation in e-commerce could be used by an algorithm to adapt shopping forms.

Modeling a user's interest in various UI elements as a single *focal point* has been proposed [8, 18] as a highly simplified but practical abstraction. In form design, distance from the focal point may be calculated spatially using a metric on the visualization space (e.g., pixel distance in the UI), structurally using a metric on the form schema (e.g., distance measured in number of fields or fieldsets), or semantically based on the domain-specific similarity or co-relevance of specific form sections. Related work has also considered multiple, discrete focal points [4]. In an even more general form, DOI can be modeled as distribution of interest values over elements of a UI (or elements of the underlying data structure). In form design, DOI can be distributed with different granularity across form elements: per control, field (whereas one field may contain multiple controls), fieldset, section, tab or page.

Different *timings* have been proposed for adapting system behavior [26]. During-use adaptation is the most dynamic option, able to adapt the system while in use. This is required for DOI computation in focus+context visualizations to adapt the system to the user's fluctuating focus of interest. Pre-use adaptation corresponds to the a-priori importance of features in the above formula for DOI computation. Post-use adaptation relates to adapting the system between usage sessions.

Many *factors* can be exploited to influence DOI computation. Related work in infovis has mostly included user behavior such as mouse position and movement, mouse click and hover events, and keyboard input. Other input modalities include taps and gestures on touch devices and other means of interaction such as gestures or eye gaze. Form-specific factors that can be exploited for DOI computation include previously entered data, focus and blur events of input fields and fieldsets, validation errors, and unfilled but required fields. Advanced approaches have considered the social behavior of multiple users [15] or tried to predict future behavior [2]. Context of use has also been proposed as an influencing factor [26]. E.g., in form design, DOI values may depend on mobile vs. stationary usage in private versus public environments.

Figure 3. Form controls may be hidden to reduce visual clutter. Screenshot from youtube.com, where the control is revealed on mouse over.

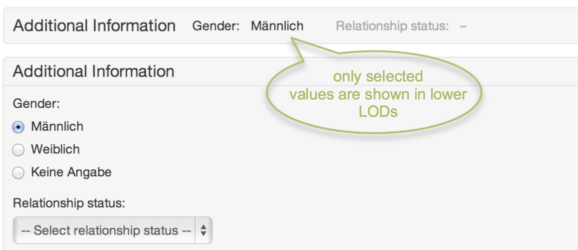

Figure 4. Deselected values may be hidden in lower LODs.

LOD: Level of Detail Computation and Visualization

The visualization component of focus+context user interfaces must be able to display UI elements with different levels of detail (LOD) [11]. The computation of LOD values is a function of DOI values and available display space. Since DOI values change over time, the visualization component must continually recalculate the below formula, compare [8, 9] and Figure 2 for corresponding software architectures.

LOD of feature = ƒ (DOI of feature, total display space).

The above formula for LOD calculation shows that in addition to DOI values, the available display space can be used to influence the LOD computation. E.g., the visualization component may be designed to "squeeze" the entire UI into one screen as in [9]. Another possible aim is to fit a printable form on one sheet of paper as in [23, p.102].

Designing lower LODs immediately raises the question what to omit in order to make space [18]. Previous research in infovis has explored a large variety of techniques for selective reduction of information based on the DOI formalism. Semantic approaches address *what* parts of a structure to display, visual approaches address *how* to display them [18]. "What" corresponds to techniques for filtering and aggregating information, "how" corresponds to techniques for scaling, distorting and highlighting of visual representations [7, 18]. More specific techniques for 'making space' within textual documents are described in [9]. Block movement moves neighboring elements apart to make space. Deformation scales or deforms elements. Overlay allows elements to be rendered on top of others. Outside allocation creates an empty space outside the current view, such as a page margin, and uses it to display additional information.

A varying *number of LODs* may be used in focus+context designs. Multiple, discrete LODs can be designed using filtering, aggregation and highlighting techniques. An infinite number of continuous levels of detail can be designed using distortion and scaling techniques. Note that in traditional form design, the whole form is rendered with just one LOD, but interactive form features such as tooltips and selection-dependent expanding of form sections [36, ch.12] can be likened to additional levels of detail.

The design of form elements should result in a semantically meaningful *progression of levels of detail*. Many design options exist because all of the before-mentioned visualization techniques (filtering, scaling, highlighting...) can be applied to the various form elements. E.g., *Labels* may be omitted for non-empty fields, if the field's content is self-explanatory. *Values* may be truncated to save space, especially for text-areas with potentially long contents (compare LoD 2 and 3, Figure 1). The *type of form control* may be hidden to reduce visual clutter, as shown in Figure 3. *Hints and help* may be hidden in lower LODs. *Validation errors* may be compacted in lower LODs, e.g., by only showing a warning icon. *Deselected options* in selection fields (such as unchosen radio buttons and check boxes) can be hidden, see Figure 4. *Composite fields and fieldsets* may be compacted by filtering the most important information (compare LoD 3 and 4, Figure 1). The *form layout* may be adjusted to use less space, e.g., by decreasing whitespace, by removing line breaks, and by changing the labels' placement (compare LoD 2, 3 and 4, Figure 1).

The *transition between different LODs* should be smooth to avoid confusion. Scaling, distortion, and block movement techniques can be improved using spatial animations to avoid abrupt changes. Filtering and aggregation techniques can be improved by highlighting the focused element so the user does not lose sight of it during a transition. Highlighting may use graphic styles such as color and font weight to differentiate important from less important elements. Alternatively and additionally, highlighting may use the temporal dimension by showing important elements at once, but fading in less important elements with a delay; a method termed "ephemeral adaptation" which has performed better than graphic highlighting in menu selection tasks [17].

Intended Use of the Design Space

The above design space can be employed as design tool for supporting usability engineering and UI design of navigation in form-based UIs. Methodologically, the design space is best used in early to medium phases of usability engineering. Within Mayhew's Usability Engineering Lifecycle [27], the design space can be used in levels 1 and 2 for prototyping and UI design activities. Within Jarret and Gaffney's form design process [23], it can be used in the conversation layer of form design, seeking to "make the form flow easily" [23].

To use the design space, designers should first define users, tasks, and the intended form schema, as described in the relationship layer in [23]. Based on this knowledge, they can draft a concept for DOI computation using options from the DOI section of our design space as inspiration. Design decisions will depend on the specific project, e.g., different information may be available to influence DOI computation. Designers can then proceed to the more visual design of the different levels of detail, inspired by options in the LOD section of our design space. These activities can and should be iterated using prototyping and formative usability evaluations.

CASE STUDY

To evaluate the design space's practical usefulness and applicability, it was employed in a case study, choosing social network profile pages as scenario. The scenario comprises both initial filling and subsequent revising in a stationary usage context – similar to forms in productivity applications and different from, e.g., registration forms and questionnaires.

Application of the Design Space within the Case Study

One senior designer (> 5 years in UI design) and one junior designer (student in HCI) were tasked with employing the design space (presented to them in textual and tabular representations, as in this paper) for redesigning navigation in a social network profile page prototype. The prototype was neutrally styled and consisted of 75 form controls arranged in 27 fields and 6 fieldsets. Prior to using the design space, the designers analyzed the scenario, describing form filling to be non-linear, sparse (irrelevant fields are left empty), to some degree explorative, and not strictly goal-directed, compare [20] for more on goal directedness. The designers performed three iterations joined by two formative usability tests. Their design decisions are documented in the following paragraphs. The resulting visual design is shown in Figure 1.

When designing *DOI (degree of interest) computation*, a constant a-priori importance was applied to all form elements. User interest was modeled using per-fieldset granularity and a single focal point, with linearly decreasing DOI values for neighboring fieldsets. DOI values are computed during use, based on focussing of form fields by clicking or tabbing.

LOD (level of detail) computation is performed whenever a DOI value changes. The corresponding algorithm is similar to [9] in that it takes the available screen space into account: the algorithm first assigns the maximum LOD to the focussed fieldset. It then tries to fit the remaining fieldsets into the available screen space and otherwise resorts to scrolling. Four levels of detail were designed as shown in Figure 1, using the visualization techniques of filtering, aggregation, highlighting, block movement, and overlay. Specifically, lower LODs use a more compact form layout, omit empty fields, truncate long textual values, omit non-chosen radio buttons and check boxes, and reduce visual clutter by hiding the type of form control (but reveal it on mouse over). The lowest LODs go even further, truncating an entire fieldset's representation to one line or even a single word. Switching between LODs is eased using animations and graphical highlighting.

Lessons Learned, Evaluation Results

Applicability and Usefulness: Designers reported a mostly positive experience with the design space, stating they had successfully applied the design space and benefited from using it. They criticized they had not been able to choose some design options because of the generic nature of the prototype given to them (e.g., specific user profiles would have opened additional options) – we conclude that the prototype's purposely generic nature was a trade-off in study design between realism and generalizability. The designers had very positive opinions on the general applicability of the focus+context principle to form design, based on their experiences in the case study.

Creativity: The designers reported their biggest benefit while using the design space was that it fostered creativity by providing a list of design options, thus enabling them to discuss options they would otherwise not have considered. The amount of options was initially overwhelming, but later appreciated for inspiration. Additional options suggested by the designers were later added to the design space.

Decision making: The designers found the design space supported their making of design decisions. Its textual description particularly provided helpful details and explanations.

Documenting design decisions: The designers found the design space's structure (particularly its tabular representation) has helped documenting design decisions in a structured way.

Usability Evaluation: To evaluate the resulting focus+context design, we performed a preliminary usability test with 30 novice users, using tabbed and scrolled designs as control conditions. There was no significant effect of navigation design on either navigation performance (measured as task completion time) or subjective satisfaction. All users could easily work with the prototype without needing help or assistance.

CONCLUSION AND FUTURE WORK

This paper introduces a generic design space for focus+context navigation in long forms, based on two critical issues elicited from literature: computation of the user's degree of interest and subsequent visualization of form elements in varying levels of detail. An initial evaluation of the design space within a case study supports its applicability and usefulness for usability engineering and user interface design. Firstly, the design space's applicability and the general feasibility of focus+context form designs can clearly be seen from the prototype resulting from the case study (see Figure 1). Even novice users could easily work with the prototype with similar performance as in tabbed and scrolled designs, as evaluated in a preliminary usability test. Secondly, the designers' experience within the case study strongly supports both the applicability and usefulness of the design space: they found it fostered creativity and helped making and documenting design decisions. Future work should quantify the effect of focus+context form design on performance and user satisfaction in different scenarios and should further evaluate the design space by using it in other projects.

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