Automatically Generating Custom User Interfaces for Users With Physical Disabilities

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1. INTRODUCTION

Graphical user interfaces (GUIs) for desktop applications are usually optimized for typical users who interact with computers via keyboard, mouse and a small range of display sizes. Part of the reason why some users with vision or motor impairments find it hard to use computers is not their inherent inability to use computers effectively but the mismatch between those users' individual needs and the designers' assumptions. In some cases no external assistive technology may be required if an interface is rendered in a way that takes into account a user's unique capabilities. For example, to make an interface accessible to a user with a moderate vision impairment, it may be sufficient to make all the fonts and important visual cues larger, while appropriately rearranging the interface to make it fit in the available screen area. It is not necessary to elongate the slider tracks, for example, as long as the slider elements are made larger and the tracks are drawn with a thicker line. Similarly, users lacking fine motor control may find it easier to interact with interfaces where only widgets with large targets and no need for dragging are used. In cases when the use of assistive technologies cannot be avoided, those technologies also work better with a dedicated GUI design: for example, users who explore a screen serially (with a magnifying lense or a screen reader) may find it easier to navigate a hierarchically structured interface, where each panel contains only a limited number of elements.

Most users have unique needs (due to their tasks, preferences or capabilities) that would make them benefit from custom user interfaces. It is particularly true of users with physical impairments because different types, degrees or combinations of impairments imply very different preferences for how the user may want to interact with computers. It is

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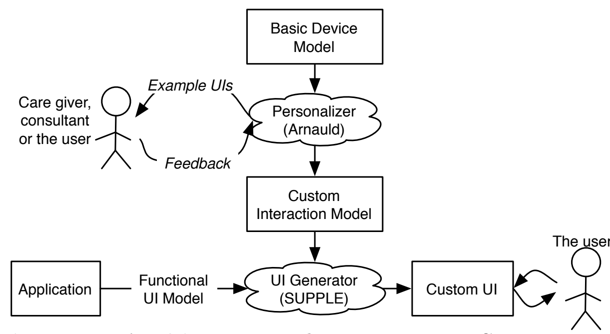

Figure 1: Architecture of our system: SUPPLE combines a functional specification of a UI with an interaction model to automatically generate a custom interface; with ARNAULD, the user can personalize the system to his or her individual needs.

unreasonable to expect GUI designers to provide personalized solutions for each of the possible users of their products. We thus propose automatic interface generation as a compelling and scalable solution. Of course, model-based user-interface generation has been studied for many years, but our approach (detailed in the next section) eschews the typical approach of heuristic rulesm which are often brittle. Instead, we use decision-theoretic optimization over a personalized utility function that is induced using max-margin, machine-learning techniques.

2. CUSTOM INTERFACES FOR ALL

Because every user's needs are different, our system starts by engaging the user herself, her care giver or a consultant in a personalization process. Out of the box, the system's device model includes information about what widgets (or UI building blocks) are available on a given computing platform but it does not include the knowledge of how to combine them to create interfaces that best fit the needs of a particular user. Because the parameters used by the automatic UI generator are not intuitive and are hard to choose by hand, we have developed ARNAULD system [2] that allows one to come up with the right parameters solely by providing feedback about concrete user interfaces (e.g., by comparing pairs of UIs). Our preliminary studies show that novice users can complete this one-time personalization process in less than 20 minutes. The result of this process is a custom interaction model. From now on the user can use any application that provides a description of its user interface in an abstract manner (using what we call a *functional* UI model).

(a) (b) (c)

Figure 2: Three different GUIs generated automatically by SUPPLE for three different desktop users: (a) a typical user; (b) a user with a slight motor impairment: no widgets with small targets (spinners, check boxes, radio buttons) or that require dragging (sliders) are used; (c) a user with slight vision impairment: all fonts and important visual cues are larger (we will use a color scheme with higher contrast in the final version of the sytem). SUPPLE rendered interfaces (b) and (c) using tab panes to accommodate larger widgets in the same amount of screen space as the original interface.

Our SUPPLE system [1] combines the functional UI model with the custom interaction model to automatically produce a user interface specifically designed for the particular individual. The interface generation process takes less than 2 seconds even for complex applications.

Figure 2 shows three different interfaces for a stereo system automatically generated by SUPPLE given the same screen size constraints but different interaction models. Figure 2a shows the baseline UI designed for the typical user interacting with the computer with a keyboard and mouse. UI in Figure 2b is designed for a user with a slight motor impairment that makes it awkward for him to click on small targets or perform dragging – all widgets used in this interface have large click targets but because of their slightly larger size, the interface had to be organized into several tab panes. The last interface in Figure 2 was generated for a user with a moderate vision impairment: all fonts and other visual cues are larger though none of the widgets are enlarged more than necessary to increase their visibility.

2.1 Optimization For UI Generation

In SUPPLE, we cast UI rendering as a constrained optimization problem, where the metric to be optimized is the estimated ease of use of the rendered interface, and the constraints are based on the available widgets and screen size. This approach is a radical departure from the dominant paradigm of using knowledge-based techniques for user interface generation. Unlike the previous approaches, SUPPLE trivially adapts to devices with vastly different screen sizes and using SUPPLE on a novel device only requires specifying a new device model listing what widgets are available on that device. Finally, by modifying the parameters of the objective function (which is a part of the interaction model), SUPPLE can be made to produce very different styles of user interfaces.

Although there has been some previous work that used optimization methods for laying out widgets within a dialog window, our rendering algorithm does much more: it chooses the widgets, the layout, and the navigation structure of the UI (i.e., puts things into tab panes or pop-up windows if everything cannot fit on one screen).

Despite computational complexity of the problem, our algorithm is very efficient and renders even complex interfaces in less than two seconds on a standard desktop computer.

2.2 Personalizing The Process

SUPPLE, like many other optimization-based systems, can produce very different outcomes given different parameter values in the interaction model. Manually finding the parameters that yield the desired outcome is a tedious, error-prone process. Thus, we developed ARNAULD [2], a set of basic interactions and machine learning techniques, that allows accurate parameter estimation by soliciting user's feedback on concrete outcomes. In the case of SUPPLE, about two dozen interactions (taking less than 15 minutes) suffice to find the parameters. ARNAULD uses a small number of sample application UIs during the training process, but the learned parameters allow SUPPLE to generate interfaces for applications that weren't included in the training set.

3. CONCLUSIONS

We demonstrate that flexible, automatic UI generation can help provide users with custom-tailored interfaces that optimally take advantage of these users' abilities. This tailoring task isn't feasible for human designers, because of a large number of users with differing individual needs and preferences. When completed, our system will be scalable — allowing users with physical impairments, their consultants or care givers, to easily reparametrize the UI generator for the needs of individual users. In addition to developing these personalization interactions, we are also expanding the set of interactions and widgets from which SUPPLE can choose, when creating an interface; this will increase the range of individual needs to which SUPPLE can adapt.

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4. REFERENCES

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