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Genetic algorithms supporting generative design of user interfaces: Examples

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ABSTRACT

Designing User Interfaces (UIs) is considered a creative and human-intensive task, and this prevents from adopting computer-aided tools to explore alternative solutions. A number of decisions are to be taken, such as optimizing the displacement of UI items on the available screen space or selecting an adequate palette of colors. Therefore, the UI design process is iterative in nature, time consuming, and costly.

Generative design, while keeping the centrality of human creativity, introduces a novel approach to assist humans in finding effective and esthetically convincing solutions. Meta-heuristics are a means to apply generative design in practice. We advocate the use of meta-heuristics to supporting different aspects of the UI design process. In this paper we discuss the application of genetic algorithms to solve two different problems: building hierarchical menu layouts and selecting color palettes based on a set of constraints. The paper discusses the results of two experimental applications developed in Poste Italiane, namely the money ordering by Automated Teller Machine (ATM) interfaces and the provision of financial information by kiosks.

1. Introduction

Usability is one of the main factors affecting the quality of software systems [9,1,26] and user interfaces are a key to successful software applications and services. From a user perspective, usability is important because it can make the difference between performing a task easily, and enjoying the process, or being frustrated. A usable user interface depends upon a number of factors, including how well interaction fits user needs and expectations and how easy and intuitive it is to access functionality and recover the needed information. In the past, a great effort has been spent to make interfaces easy to learn, use, and remember, accessible to impaired users, error tolerant, and esthetically pleasing [27].

The information society made the need for usable and accessible interfaces central to the quality of services delivered over the web [28]. Making information and services accessible to the broadest audience represents an important social challenge and requires to address new issues in designing user interfaces. Indeed, although attractive user interfaces are highly desirable (attractiveness is one of the attributes defining usability in the ISO/IEC 9126-1 quality model), they should be made accessible to the largest audience in order to build barrier free services and applications. For this purpose, W3C established guidelines [37] for designing accessible user interfaces.

The design of usable and accessible interfaces is generally pursued though an iterative process that involves people who actually use the system [14], as depicted in Fig. 1.

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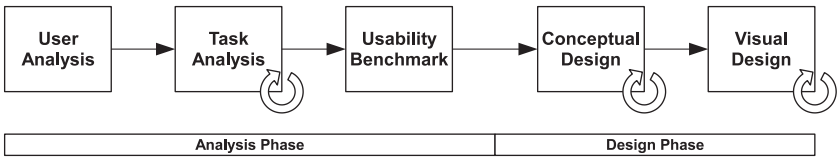

Fig. 1. The usability process [14].

User Analysis concerns gathering information about the potential users and their needs, through site visits, focus groups, surveys, and quantitative data. This is used as an input to Task Analysis, aimed at identifying how people will perform activities. Usability Benchmark delivers a set of metrics that will assess interface quality before the design phase begins. The design phase comprises two activities: (i) Conceptual design defines the basic user-system interaction, the objects in the UI, and the contexts in which interaction takes place, whilst (ii) Visual design refines the UI appearance.

Such a process is demanding to implement, but its return of investment (ROI) can be realized in [7]:

Internal ROI
- Increased user productivity.
- Decreased user errors.
- Decreased training costs.
- Savings gained from making changes earlier in design life cycle.
- Decreased user support.

External ROI
- Increased sales.
- Decreased customer support costs.
- Savings gained from making changes earlier in the design life cycle.
- Reduced cost of providing training.

Graphical User Interfaces (GUIs) represent the most common means for delivering user interfaces. As case studies, in this paper we will consider two different problems concerning the design of menu systems, and the selection of colors for Color Vision Deficiency (CVD) users.

Case 1: *Menu System*. At the time of their introduction, menu systems represented a major shift from command-line interfaces. The early systems were very simple and did not support hierarchical structures. Since then, menus have evolved in structure, functionality, and purpose. Today, the menu system is a key component to makes GUIs attractive and usable, and special care is paid to their design and implementation. This is not only related to traditional desktop applications. In modern web applications, the menu systems play a key role in helping the user to navigate functionalities, especially after the advent of AJAX and Rich Internet Applications (RIAs). The menu system layout is a basic ingredient to increase productivity.In designing a menu layout, engineers have to consider many aspects including how effectively functionalities are retrieved and activated, what are the preferences of users, and what standard guidelines suggest. These aspects are translated into several design requirements, which often are conflicting. For instance, although having flat hierarchical structures improves accessibility, a limitation to the number of items is needed in order not to have long lists. At the same time, users could have preferences for the item order. A trade-off between these different requirements must be found in order to maximize the menu system quality.

Case 2: *Color selection for CVD users*. Color vision impaired users perceive colors differently from other users. This means, that although original colors could meet the required luminance contrast ratios this could not be the case for CVD users making difficult to access information and services. This requires to choose color palettes that do not cause discomfort to users with color vision deficiencies. At the same time, it is desirable not to renounce to the original chromatic idea, avoiding interfaces that are not attractive. It is possible to look for a trade-off between chromatic choices and accessibility for impaired users. This requires finding, among the possible color combinations, the palette providing high luminance contrast ratio, but still preserving the original chromatic choice.

The problems above, while they address usability from different perspectives, have several aspects in common:

- Human creativity is central.
- Solutions are iteratively built by refinements.
- Goals can be quantitatively defined.
- They are combinatorial in nature.

Generative design [5] offers new opportunities for creativity in engineering problems, by including meta-heuristics into searching the space of solutions and producing new, and often unexpected, artifacts. By contrast to traditional design, where