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Generative UI design in SAPI Project

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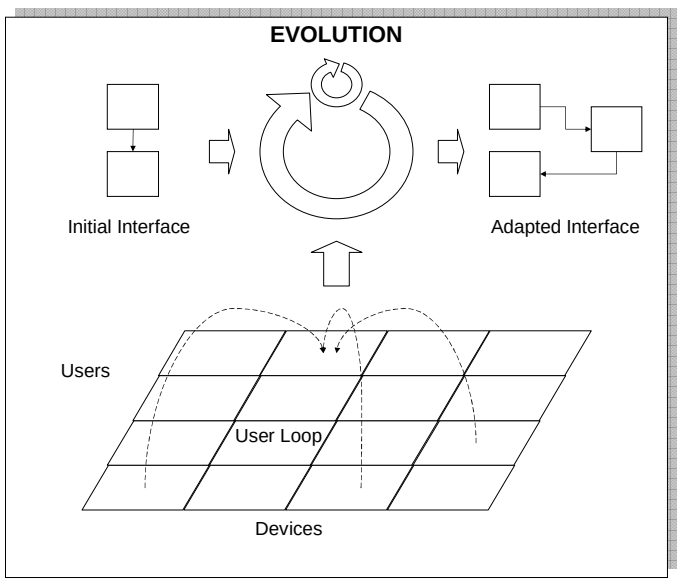
Introduction

Usability and Accessibility engineering is generally addressed by providing documented recommendations and guidelines to content creators or interface designers, leaving the choice and the reaching of quality solutions entirely up to human ability. Existing guidelines, such as Apple's Human Interface Guidelines and Sun's Java Look and Feel Guidelines are either too specific or too vague, and do not therefore always apply to the problem at hand.
UI designers tend to be guided both by objective measures gleaned from UI style guidelines and design principles, and by subjective measures such as the "look" and "feel" of an interface. However, reaching a trade-off between aesthetic considerations and other requirements, recommendations and guidelines is not an easy task to accomplish.



Interactive Algorithms

In interactive search algorithms, a major issue regards how to best use data obtained by the user interaction.
Users differs for age, education, skills, gender, and vision disorders. Therefore data cannot be used directly for evolving the interface, if we are interested to adapt the interface to specific needs and preferences.
It is necessary to identify a way for transposing data from one user class to another, as the richer the dataset is, the more effective the evolution can be. There exist no model to perform this task, and a wrong transposition can heavily affect the evolution result. We aim to investigate the application of both statistical and inferential models

Aim

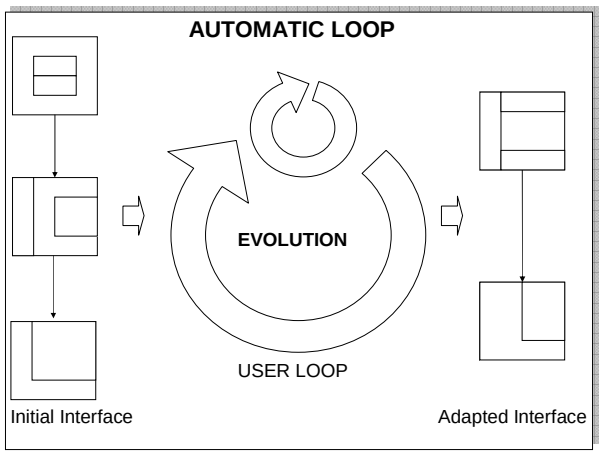
The objective of the SAPI (Automatic System for the Visually Impaired) project is the development of a software platform aimed at delivering services and at experimenting with novel generative techniques for the automatic provision of user interfaces to different classes of users with vision disorders by means of different devices.
The approach adopted by SAPI is inspired by the principles of "Universal Design" which changes the concept of "Average User" with respect to the various user skill levels, needs and preferences. Traditional methodologies of user interface development, such as those based on incremental developments centered on focus groups, soon proved to be inappropriate, as they are very time consuming and expensive. In order to produce a larger set of interfaces, better tailored to user needs and device features, SAPI is focusing research activities on experimenting with generative techniques (in particular those based on evolutionary algorithms) as a promising and viable solution.

Generative Design

Generative design offers new opportunities for experiencing creativity in engineering problems, by including meta-heuristics in the research into the solution space and producing new, and often unexpected, artifacts.
In contrast to traditional design, where the role of the designer is to explore a solution space in order that a direct relationship between designers' intentions and artifacts be established, generative design involves the use of assisting techniques and systems for refining and completing the design task.
The designer is no longer responsible for meeting a set of recommendations, guidelines and requirements in order to evolve the original idea. This task is left to supporting systems that are better able to address this specific task, leaving the human designer free to drive the designing process, keeping him/her focused on creative thought. Thus, human abilities are being emphasized by the generative approach, making the designers responsible for shaping the constraints on the dynamic process and its behavior. In addition, generative approaches are able to generate novel, surprising solutions, able to stimulate designers' creativity and imagination.

Meta-heuristics used in generative design include :

- Self-organization
- Evolutionary Techniques (GA, GP)
- Interactive Evolution
- Swarm Systems
- Ant Colonies
- Generative Grammars



Interactive Interface Evolution

Innovative Aspects

- A larger number of alternative can be explored thus pro-actively supporting human creativity and decision-making
- Different quality attributes and guidelines can be considered one at a time thus facilitating the trade-off between conflicting criteria
- Designers are free to focus on more value-adding tasks, leaving algorithms to fine-tune their choices
- Interfaces can be automatically adapted to a larger set of devices, and a more specific set of user preferences

This approach has begun to be researched only relatively recently in regards to some aspects. For instance, Quiroz et al. encode user interfaces as individuals in Interactive Genetic Algorithms (IGAs), and run through a number of generations to help explore the space of UI designs. Ichikawa et al. describe the re-working of Web page color for color-deficient viewers. The authors of this have designed fitness function in order to preserve detail and to minimize the distance between an input color and its corresponding remapped color.

Although they look at usability from different points of view, both the problems have some aspects in common:

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

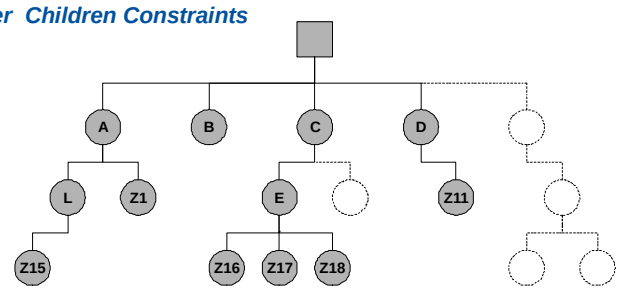
Example of Generative solutions for UI Design

Menu System

- Menu layout is a hierarchical structure by which the user gains access to application functionalities
  - A menu layout is made of menus
  - Each menu contains a list of items referring to submenus or to actions
- Designers have to consider many aspects including:
  - How effectively functionalities are retrieved and activated
  - What standard guidelines suggest *(Apple's Human Interface Guidelines, Sun's Java Look and Feel Guidelines*)
  - What are the preferences of users
- These aspects are often conflicting and make menu system design a combinatorial optimization problem as it depends on the arrangement of each item in different positions onto the menu structure

A Genetic Algorithm is implemented to identify best menu layuots and to select the menu organization which meets a set of preferences or constraints such as:

- ***Level Contraints***
- ***Repetition Constraints***
- ***Ordering Constraints (Path Ordering, Item Under Menu, Menu Ordering)***
- ***Number Children Constraints***

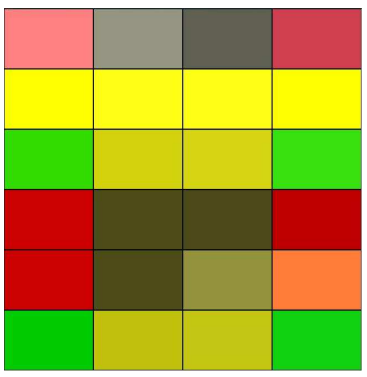


Color Palettes

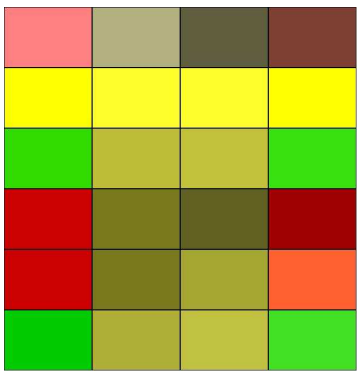
- **Color blindness, or Color Vision Deficiency (CVD), is known to be a signicant barrier to effective computer use**
- **According to UK Disability Rights Commission: Color accessibility is the second most recurrent accessibility barrier to the Web for disabled users**

Color vision impaired users perceive colors differently from normal users. This means, that although original colors could meet the required luminance contrast ratios for a normal user, the same colors, as perceived by visually impaired users, could not meet at all these requirements: perceived colors can show up with a lower contrast ratio, making difficult for same audience to access information and services. This requires to adopt color palettes that do not cause significant discomfort to users with CVD. This does not mean to renounce to the original chromatic idea and to make interfaces that are not attractive or boring. It is possible to look for a trade-off between chromatic choices and accessibility for impaired users. This requires to find among the possible color combinations, the palette providing high luminance contrast ratio, but still preserving the original chromatic choice.

As user-system interaction is the key focus, designing user interface attains to human creativity, perception and aesthetics. For color selection this aspect stands out. Choosing colors is part of the artistic process that leads to outline a user interface.
In SAPI this problem has been addressed by developing a Genetic Algorithm to identify the palette providing better contrast among different correlated colors and minimizing chromatic differences.



Optimization of the original palette for protanopes and deuteranopes. 1st column is the original palette, 2nd column is the perceived palette, 3rd and 4th columns are the optimized result seen by deuteranopes and by normal color viewers respectively



SAPI

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