Examples Galleries Generated by Interactive Genetic Algorithms

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ABSTRACT
Examples browsing is a common designer practice in user interface design. Several design galleries can be found on Internet. However, those galleries are hand crafted and thus limited and cumbersome to build. In this paper, we claim for tools for supporting both the production and exploration of examples.. We describe a running prototype based on Interactive Genetic Algorithms (IGA), and relate an early evaluation.

Keywords:
Creativity, User Interface design,examples galleries, generation, Interactive Genetic Algorithms.

INTRODUCTION

According to [6], a design activity can be defined as a *specific* problem-solving situation. *Specific* in the sense that design problems are by nature *ill-defined* and *open-ended*. They are *ill-defined* since the design goals and constraints are incomplete, imprecise and evolve along the design process. This ill-definition leads designers to construct their own representation of the problem. Thereby each designer solves his/her own specific problem. Design problems are *open-ended* as they present no single correct solution but rather a set of potential solutions. Generally speaking, design can be seen as a purposeful, constrained decision making activity. It implies a set of variables which values have to be set to determine a particular design. This set is referred to as the *design space* [17]. A design space is often large and likely to evolve along the design process as new constraints emerge, resulting in the introduction of new variables.

Designing a User Interface (UI) can be seen as an exploration of the design space to find one correct solution. Tohidi *et al.* [40] argue that designers should first explore in breadth before in depth *i.e.*, get the right design before achieving the design right. Indeed, producing numerous designs enhances the probability to get creative ones. However this task is difficult: mental fixations on first ideas, also called premature commitment, may curb the exploration [32]. Prior experiences may also hinder the exploration as designers may perceive false analogy between the evident attributes of the problem.

In this paper, we focus on the early design phases. We aim at providing inspiration to designers to help them to produce numerous designs. We explore how UI models can be used to build a tool to help designers to achieve this goal. We start by a study about the notion of creative processes and present how examples galleries can serve as a source of inspiration. As hand crafted examples galleries are cumbersome to set up, we propose to automatically generate examples galleries. This leads us to the exploration of automatic generation of UIs through model based approaches using Interactive Genetic Algorithms (IGA). We then present Magellan an IGA that relies on model based approaches to produce creative UIs. The third part of the paper is dedicated to the description of an experiment we made for exploring how automatically generated examples can be integrated into the early phases of a creative UI design process. We present the experiment and analyze the results. They give rise to numerous perspectives.

CREATIVITY AND CREATIVITY SUPPORT: RELATED WORK

First we present different views on creative process, succeeded by requirements for tools that aim to support creative designs. Then, we focus on the inspiration aspect of creativity through examples and design galleries. Finally we present relevant works in automatic generation of UIs with model-based approaches and interactive genetic algorithms.

Creativity

Creativity relates to three aspects: creative person, creative product, and creative process. This paper is about creative process.

An iterative and Evolutionary process

Campbell [10] and Simonton [36] argue that creativity could be seen as a Darwinian process. In a first step, ideas are submitted to blind variations and recombinations, resulting in the generation of a multitude of variants. These variants are then subjected to a selection mechanism. Last, a retention process is applied to the selected variations: selected ideas are preserved in the creator knowledge and propagated through communication with other creators.

Generating new ideas

The variations that generate new ideas are said to be blind in the sense that there is no way to decide *a priori* which variations will produce good results in the long term.

However this notion of blind variation is not to be reduced to purely random variations. One can restrict the set of variations over the exploration of the variations. For instance, one can try first to apply ergonomically valid variations, or starting with variations on the layout before trying new colors.

As previously stated, design might be seen as a decision-making activity on a set of design variables. Hence, the generation of new ideas might result from the variations of such variables. Gero [17] defines two types of design process based on these variables: *Routine design* process deals with variables taking values in well-known range while *innovative design* deals with variables taking unexpected values. Finally Gero [17] proposes that creative design processes have the potential to aid in the design of creative artifacts based on the addition and deletion of design variables. For instance, the design of a frame can be based on two variables: its width and height. The addition of the radius variable enables the design of rounded frames that might be seen as creative. However, if the radius variable is set to 0, the resulted frame exhibits no difference from the previous frame. Hence, there is no guarantee that the results of such processes would be considered as creative.

Selecting Ideas

This point of view is close to the one defended by Buxton [8] for whom creativity could take place in 1) the meaningful distinct options from which to choose to solve the problem and 2) the definition of the criteria, or heuristics, according to which options are selected or rejected.

Sketches

This iterative and evolutionary process is also reflected in the sketching activity. It can be seen as a "conversation", or dialectic process [19] between the designer and his/her sketches. First, sketches are created with respect to the current knowledge of the designer. Then, by reading these first sketches, the designers may interpret them in a way that (hopefully) may generate new ideas. This extraction of new knowledge (respectively creation) results from what Goldschmidt calls "seeing as" (respectively "seeing that"). It means that the new knowledge is translated into sketch, which in turn leads to new interpretations, etc.

Buxton [8] and Tohidi [40] elicit sketching and prototyping as key for creative designs whatever the domain is. Buxton stresses that the value of sketches does not lie in the produced artifact itself (the drawing) but in its ability to trigger the desired and appropriate behaviors, conversations and interactions. Indeed, sketches are the vehicle and not the target. Designers do not draw sketches to depict ideas that are well consolidated in their mind. Rather, they draw sketches to try out vague and uncertain ideas. When seeing the sketches, designers can spot problems they may not have anticipated. Even more, they can see new features and relations among elements that they have drawn. Some of them were not intended in the original sketches. These unintended discoveries promote new ideas and refine current ones.

The simplest way to experience sketching is to use sheets of paper, scissor, pencil and glue. However, paper based sketches are not really appropriate to describe interaction. In some cases, this shortcoming can simply be overcome by using animated GIF. In a more general way, electronic tools such as SILK [22] or DENIM [24] have been developed to enable designers to quickly specify the interaction directly from sketches. Other tools such as SketchiXML [12] enable designers to sketch a UI that is then interpreted as a set of UsiXML widgets. However, the set of widgets is not extensible (*i.e.*, a brand new widget can not be added), which is a strong limitation for creativity.

Examples as a source of inspiration

In creative process, one uses retrieval, analogical transfer, and mental transformation of prior experience to build new representations and design solutions. Prior experience and examples may provide expertise to fully explore the design space [38].

According to Herring [21], examples are crucial to any design activities. They support both the generation of new ideas and the selection of interesting ones. Examples enable to identify limitation of previous designs and reinterpretation and recombination of ideas. This is particularly true in web design where there is a set of ingredients to compose with. They also help in understanding tendencies and identifying originality.

However they may induce a bias in the production of creative ideas. In their experiments, Smith *et al.* [38] asked subjects to produce drawing of creatures. Subjects of the experimental group were presented with examples of creatures that share *critical* features such as antennae, four legs and a tail. They showed that examples exposure induces *conformity:* features are transferred from the example. The conformity effect seems to be unintentional: even people who were specifically instructed not to reproduce the examples borrowed elements from them.

Although examples induce conformity, they might not hinder creativity. Marsh *et al.* argue that "*in designing a novel solution to some problem, incorporation of the features provided in examples is neither a wholly sufficient nor a satisfying demonstration that creativity has been constrained*" [26]. Marsh *et al.* drifted three experiments from Smith *et al.:* effect of a larger number of examples, incorporation of non-natural features, and delay between exposure and design. Although there is an increase in the conformity when a larger number of examples is shown, the number of non-common features also increases while the number of fairly common features decreases. Together, these results suggest that the provision of examples may not constraint creativity but rather influence which of many more common attributes people choose to include or exclude.

When exposed to examples with non natural features, subjects tend to produce more creative designs than people without examples or with natural examples. Marsh *et al.* concluded that in creative activities, providing examples may ultimately alter the nature of creative products but may not limit or constraint the creativity in any pejorative way.

One major drawback of this experiment is that examples shared common features. Whilst presenting standard examples induces standard productions, diversification increases creativity. Bonnardel [6] compared exposition of designers to intra-domain and inter-domain examples. The facilitating effect of examples was more important with inter-domain examples than with intra-domain examples. One other result was that {the impact of examples is important at the beginning and tends to decrease along the design process.

In the next section, we discuss requirements for tools to efficiently support creative design processes and present tools for supporting creativity with examples.

Creative Support Tools

Requirements

Shneidermann [35] devises four design principles for Creative Support Tools (CST). Three of these principles deal with the management and the sharing of knowledge. CST *provide a rich history-keeping* of any previous works of the designer. They also provide a rich search mechanism to browse them and to *support exploratory search* of previous and related works. The tools should provide means for the designer to share his/her work and *enable collaboration* with peers and every stakeholder. The last principle, *"low thresholds, high ceilings, and wide walls",* deals with common desirable attributes for software tools. Such tools should be easy for novices to begin, yet provide ambitious functionality that experts need. At last, they should also have a wide range of functionalities.

Losch *et al.* [25] define five types of functionalities for Creative support tools. As motivation is a key aspect of creativity [1], CST should *support the designers' motivation* and enable them to reach the flow experience. In this particular state of mind, the designer is fully immersed in his/her activity and has a feeling of success in the design process. In line with Shneidermann's principles, CST should provide *domain knowledge support*. Those functionalities should not be restraint to passive storage and search. They should be extended to active requirements infringement and detection of possible application of design rules (*e.g.,* a drawing tool could suggest standard height/width ratio while drawing a rectangle). Closely related are the functionalities to *support requirements handling*. CST should also enable *externalization support* for designers to freely express their ideas along the design process. At last, CST should *provide inspiration and analogy support*.

Examples galleries

Herring [21] highlights that in design, in particular in web UI design, examples browsing largely supports inspiration. Browsing includes many sources such as the Internet, magazines, books, as well as physical products.

Whilst there are numerous examples galleries on the Internet, there is to our best knowledge no formal study of them. We briefly report the authors experience about them. Numerous design specialized websites propose showcase updates regularly. They enable designers to share their design and to look up for the current trend. We identify four types of galleries: 1) some websites propose regular batch of examples related to one topic (for instance one page-design, portfolio, or 404 not found pages)[1]. 2) Some others just add content regularly to a set of categories, such as the business of the webpages (restaurants, music, art etc.) or the style (drawing, 3D, minimal etc.). 3) Some galleries focus on presenting elementary components of web design (hyperlinks, navigation bars, background patterns, etc.) rather than the whole site. 4) Some galleries present a gallery of styles for a unique website[2].

One limitation of these galleries is their lack of support for exploration. Whilst most galleries provide a structuration in categories, there is no easy means for browsing examples. At best, some galleries mark designs with tags (e.g., dominant color) that allow the search of similarly tagged designs.

Lee *et al.* [23] explore how interactive examples galleries can help to design a personal webpage. In addition to classical webpage editing tools, designers were enabled to navigate among the examples and to copy/paste parts of the examples to build their own design. An experiment shows that independent raters preferred webpages designed with the aid of examples. The main limitation of this work is that example webpages have to be manually harvested and tagged in order to be usable in the gallery. One other limitation is that authors only provided examples closely related to the problem (*i.e.*, personal webpages). As a consequence, it is impossible to provide an examples gallery of a brand new interactive system, for which no example does exist.

The issue could be addressed by an automatic examples generation. In the Computer-Generated Imagery field, Marks *et al.* [27] propose a design gallery to help designers deciding about parameters values (*e.g.,* light positioning) for a given scene. Examples are automatically generated such as they present a large variety. Hence the designer can quickly explore the design space.

In the next section we present two approaches to automatic generation of User Interfaces, Model-Based approaches, and Interactive Genetic Algorithm based approaches.

Automatic Generation of User Interfaces

A lot of works has been done in HCI to support automatic UI generation from models of a high level of abstraction

[1] http://sixrevisions.com

[2] http://www.csszengarden.com/

[4,16]. Concepts and user tasks (C&T) models (*e.g.,* CTT [31]) are often used to provide such a high level description. From the C&T model, transformations are applied to produce a more concrete model (*e.g.,* an HTML page). These transformations may use several sources of knowledge. For instance, transformations used in SUPPLE [16] consider information about the platform (in terms of screen size and available widgets) and the users (in terms of motor capabilities and typical user tasks sequences). In any case, transformations need knowledge on how a user task can be concretized into a widget. We study hereafter how this knowledge can be capitalized.

The first capitalization of knowledge on how user tasks can be concretized is probably widgets toolkits. These widgets are well-established solutions to recurring problems. With the standardization of the context of use in the 1980's (a PC with a screen, a keyboard and a mouse) and its stability over a quiet long period of time (15-20 years), UI toolkits tended to implement the WIMP (Windows Icon Menu Pointing device) paradigm. The WIMP paradigm was the capitalization of best practices for this context of use. For instance, designers having to implement a "select items" can use widgets such as checkboxes or accumulators.

UI patterns are another form of capitalization of the know-how in UI design. They describe solutions and their rationale to recurrent design problems in a given context of use. Usually, solutions detailed in UI patterns are more complex than simple widgets. They imply the use of several widgets, layout consideration, look and feel, etc. UI patterns can be used at design time only. They do not provide codes directly usable to build a UI.

Demeure et al. [13] explore the use of semantic networks to capitalize UI design know-how. The underlying idea is to combine the know-how of toolkits and patterns in a unified structure. Nodes of the graph embed UI models while arcs of the graph express relationships between these UI models. UI models are compliant with the level of abstraction of the CAMELEON framework [9]: some nodes embed concept and tasks models (*e.g.,* an instant messenger interactive system described using the CTT language), others embed Abstract UIs (AUI), Concrete UIs (CUI) or Final UIs (FUI). Models embedded in the nodes may be very simple (*e.g.,* a widget for a FUI node) or more complex (*e.g.,* a task tree for a concept and tasks node). Arcs of the graph express relationships of the CAMELEON framework: two nodes can be related by a concretization relationship, an abstraction relationship, a translation etc. In addition, "composition" arcs express how some nodes are composed of several UI models coming from different nodes. Arcs actually embed a context of use description and the rationale that underlies the relationship between nodes. For instance, a concretization arc linking a concept and task node (*e.g.,* the task *"Choose an element in a set"*) to a CUI node (*e.g.,* a list of radio-buttons) would describe that this concretization is valuable for a graphical UI if the number of elements is lower or equal than 7 with regards to ergonomic consideration. This semantic graph can be used both at design time and runtime. Indeed, nodes of the graph embed models or code that can directly be used to build a UI. As a consequence, this form of capitalization is a good candidate for sustaining the generation of examples.

Model based approaches to UI generation have proved effective on routine design for which a set of transformation is known to produce interesting result. For instance form-based and data-driven application are well addressed by Model based approaches. Unfortunately those approaches tend to have predictable result and lake expressivity to produce a large range of example for a design gallery.

Interactive Genetic Algorithms

In this section, we consider tools that are able to generate multiple possible solutions for the problem under design. The underlying idea is to guide designers in the design space. The tools that we present here are based on interactive genetic algorithms. We first briefly describe the principles before detailing some tools that use it.

Interactive Genetic Algorithms (IGA) are search techniques that enable the designer to evolve solutions (also called individuals), through mutations and recombinations of existing solutions. IGA are a good option when the solution space is large, and no optimal solution can be found directly but where one can assess the potential of a particular solution. The process of an IGA is roughly the following. Designer are presented with several solutions for a given design problem. From their selection of the most promising or interesting solutions a new set of solutions is generated. The new set of solutions is presented to the designer and the cycle continues until the designer decides he/she has found an interesting solution.

IGA have been widely used in design problems to ease the search of solutions [40]. For instance, successful applications have been released in the domain of graphical art [37, 34].

In the HCI domain, Montmarché *et al.* proposed Imagine, a tool to generate HTML web pages using IGA. In his/her approach, individuals represent either Cascading Style Sheets (CSS) [29] or CSS plus webpage layout [30]. In his/her tools, the population is composed of 12 individuals; each of them is used to generate a web page. Individual can be partially edited (colors customization) by designers for saving time.

Although these works provide interesting results, they also suffer from three main limitations. First, only a subset of CSS attributes is taken into account. Second, the CSS applies on a predefined set of elements. This limitation is probably due to the lack of semantic encoded in a web page. Indeed, the HTML document only provides a syntactic structure. There is no standard to represent semantic information in it. Hence, there is no guarantee that a layout evolution is not going to separate semantically close HTML elements or, on the contrary, to visually group semantically distant HTML elements. Since both the set of selectors and the set of style attributes are fixed along the evolution process, there is no enrichment of the solutions (for example additional elements cannot appear, like a label in front of a text entry). The lack of semantics also leads to the third limitation of Monmarché's approach: the impossibility to substitute an HTML element by another one (for instance the substitution of a text entry representing a date by a calendar).

Quiroz [33] and then Banerjee *et al.* [2] explore IGA to generate XUL UIs. They use wider populations (hundreds of individuals) but present only a subset of the population to designers. The designers have to select the best and the worst individuals. Then, an interpolation/extrapolation algorithm is applied to the rest of the population to automatically evaluate individuals. The evaluation of the individuals is partially done by the users inputs (referred to as "subjective evaluation") and partially done by automatic evaluation (referred to as "objective evaluation"). In [33], the objective evaluation concern the 1) contrast between background and foreground colors and 2) the alignment of widgets, done by construction as widgets were placed on a two columns grid.

Although at a first glance this approach seems to be promising with regard to the user fatigue, it is based on the assumption that it is possible to automatically evaluate a UI given "bad" and "good" samples. In addition, the layout is simplistic and it is not possible to replace widgets with semantically equivalent ones. At last, there is no enrichment of the solutions along the IGA process.

Du Plessis [15] proposes to enhance the work done by [33] by focusing on the layout. Instead of aligning widgets in a grid, [15] uses a tree representation of the widgets where parent nodes are layouts (*e.g.,* grid, flow). The tree structure and the type of layout nodes are then mutated along the IGA process to produce new UIs. Results are visually more aesthetic than the ones obtained by [33] but suffer from similar drawbacks: there is no semantic description of the UI that could enable widget substitutions and there is no enrichment along the IGA process. However, the evaluation set up in [15] is particularly interesting: unlike Monmarché (who provides only informal evaluation by showing obtained results) and Quiroz (who is mainly interested in reducing user fatigue and evaluating produced UIs), Du Plessis asked evaluators of his system (three HCI experts) to fill in a short questionnaire to gather qualitative data. The answers pointed out the problem of the semantics (they expected related fields, such as "name" and "surname", to be grouped), the lack of control over the evolution process ("you cannot control the mutations") and in particular the impossibility to fix some elements while making others evolve.

As a conclusion of this section, IGA are good candidates to produce a multitude of design examples that can inspire designers. We propose to couple them with user interface model based approaches to keep trace of the semantic and increase the quality of the UI produced. This has been done in our tool Magellan and we describe how in the next section.

EXAMPLES GALLERIES GENERATED BY MAGELLAN

In order to illustrate this section, we use an instant messenger as a running case study. We designed this application at the CAMELEON concept and task level (**Fig. 2**): Users can manage their profile (photo, Status, Name), their contact list (add, edit or delete a contact) and open chats with a contact. The application is by default initiated under Gaëlle's account with a list of five contacts (Tux, Alex, Dimitri, Nadine and Amélie). At last, two conversations are opened by Gaëlle with Alex and Dimitri. A basic concrete UI corresponding to this concepts and tasks model is presented in **Fig. 1**.

We choose the Instant Messenger as a case study because it is more appealing than form based UI such as the controller used by Quiroz[33]. It is also more interactive than web pages used by Lee [23] and Monmarché [29], hence more suitable to the evolution of widgets and creative design. Lastly, we believe that previous encounters with instant messenger software are likely to hinder designer creativity thus making the generation of examples more valuable.

Magellan

We enhanced Magellan, an IGA tool done by Masson *et al.* [28]. Magellan is based on both an Interactive Genetic Algorithm and manipulates Model-Based UI.

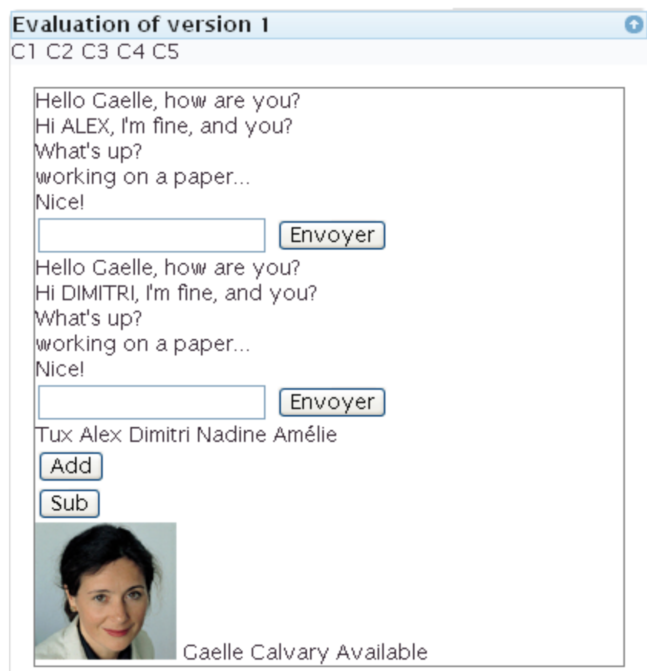

Fig. 1: Default HTML rendering of the case study

Magellan takes as input a C&T model of the application under design (rather than a first design example). This C&T

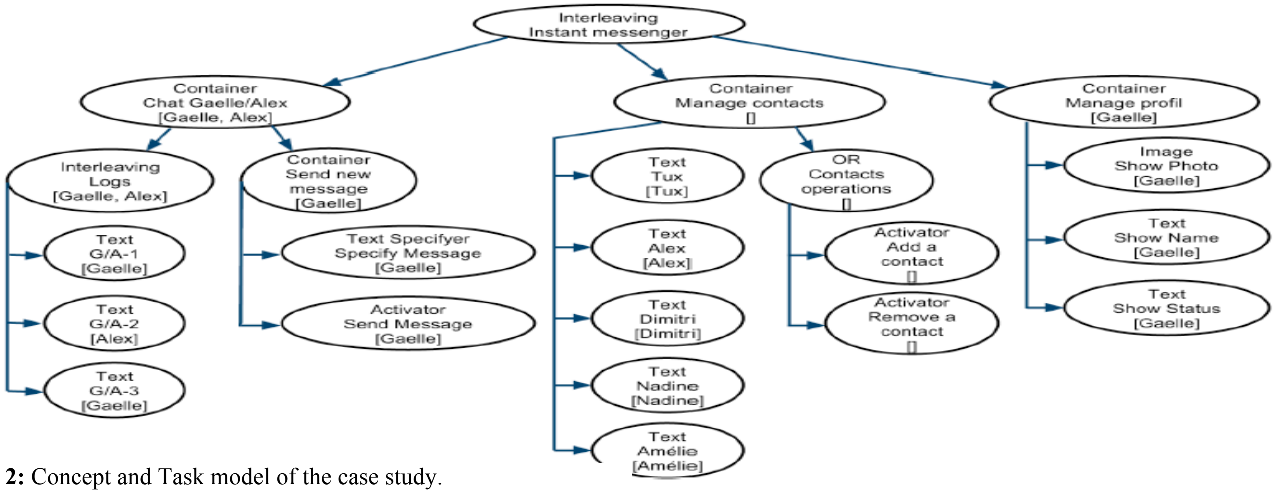

Fig. 2: Concept and Task model of the case study.

model enables designers to encode the semantic of the application.

Magellan evolves sets of transformations that apply on this C&T input model. Each set of transformations when applied to the C&T model results in a different UI. Those resulting UI are presented to the designer to be evaluated. One major advantage of this approach is that the input model can be changed (*e.g.,* adding new tasks) while conserving the individuals (i.e the transformations). Thus, designers are able to update the input model to reflect their design decisions while conserving previously evolved transformations. More generally speaking, interesting sets of transformations can be reuse on brand new project (*e.g.,* for maintaining coherence or reusing interesting ideas).

Those transformations partially rely on a semantic network that capitalizes the design knowledge of how user tasks and tasks operators can be transformed into widgets and laid out. For each widget and layout, the semantic network capitalizes their respective customizations parameters (*e.g.,* size, colors, etc.). We use an extended version of the database presented in [13]. This version includes several HTML JQuery based widgets and the management of evolvable parameters. The size of the design space that Magellan targets is largely determined by the information stored in this semantic network.

The evolution of individuals relies on three cornerstones: *parameters tweaking, widgets substitutions* and *UI enrichments*. These mechanisms are detailed hereafter.

Parameters tweaking

Parameters tweaking is similar to the evolution introduced in [29] or [33]. Each widget come with its own set of parameters. For instance, the multicolumns interleaving widget has a parameter to control the number of column. Each parameter comes with a set of evolution rules, which enables blind variations. These rules might be basic ranged random function for numerical parameter, such as element width or height. More complex rules can also exists such as choosing colors (background and Foreground) based on a 5-color theme model to ensure visual coherence between widgets and sufficient contrast for readability.

Widgets substitution

As proposed by Campbell [10], task-widget association follows a blind mutation process constrained by the semantic network that ensures that selected widgets are compliant to the original task. Our semantic network contains 40 different html widgets. In particular: 3 containers (simple html div, frame, collapsible frame), 4 interleavings (linear, accordions, tabbed panels, and multicolumns), etc…

UI enrichment

UI enrichment consists in producing transformations that add widget elements not directly related to the part of the C&T model they are applied on. This addition might serve different purposes: increase guidance, improve aesthetic, etc. For instance, in the case study, Gaëlle's messages can be prefixed by her photo (**Fig.**), which result in a graphically richer and more aesthetic UI than the corresponding part in Fig 1. Currently, UI enrichment relies on the concepts associated to each task (on Fig 3, the photo and the messages share the concept of "Gaelle").

Fig. 3: Example of UI enrichment; Gaelle's picture prefixes her sentences

In Gero's [18] vision of creative process, parameters tweaking belongs to the routine design or the innovative design class. Montmarché Quiro and Du plessis addressed routine design.

Magellan on the other hand through can address

While widgets substitution and UI enrichment introduce new variables to be evolved and thus belong to the creative design class. These aspects enable Magellan to explore a wider design space than the ones covered by Montmarché [29], Quiroz [33] and Du Plessis [15].

EVALUATION OF MAGELLAN

We conducted an early study of Magellan to test if and how it can be used to produce example galleries.

Experimental protocol

We follow a semi-structured interviews protocol. The underlying objective of semi-directed interviews is not a quantitative evaluation of behaviors or needs, but aims at the emergence of a numerous ideas, opinions or habits, even if they are infrequent in the population under study. Semi-directed interviews are done in face-to-face with an interview grid as a support. The grid includes the set of themes that must be discussed during the interview. The first theme is relatively large to slowly induce the participant into the interview. For instance first questions are related to his/her habits about informatics, advantages and shortcomings of software he/she uses and so on. Following themes focus on the object of the study.

To obtain a large panel of ideas and increase the variability, participant recruitment focuses on potentially motivated people whom socio-demographic characteristics differ from each other. We target people interested either in HCI or in design. To increase variability HCI people ranges from students to teachers, while designers come from various domains (*e.g.,* a product designer and a graphic designer).

Participants to the experiment include 8 males and 3 females. They can be classified into four groups regarding their HCI background: *HCI experts* include 1 HCI assistant professor (E2) and 3 Ph.D students (E0, E3, E4). E4 has the particularity to have more than 20 years of experience in industry. *Programmers* are expert code developers. They include 1 webmaster (E8) and 1 senior programmer (E5). *Designers* include 1 product designer (E1) and 1 graphic designer (E10). Lastly *Beginners* have little knowledge about programming and HCI. They include 3 undergraduate Students with at least one HCI course (E6, E7, E9). Table 1 sums up participants profiles.

ID	HCI background	Description
E0	Programmer	Ph.D student, web design
E1	Designer	Product Designer
E2	HCI expert	Assistant professor
E3	HCI expert	Ph.d student
E4	HCI expert	Ph.D student, 20 years of experience in industry
E5	Programmer	Senior Programmer
E6	Beginner	HCI student
E7	Beginner	HCI student
E8	Programmer	Webmaster
E9	Beginner	HCI student
E10	Designer	Graphic Designer

Table 1. Participants to the experiment.

For this experiment the gallery displays a population of 16 designs. Initially the population is submitted to a mildly mutation pressure to induce enough variety between elements.

Each new population presented in the gallery is the result of a mix between designer choices and new designs. Designer selected designs are matched together to reflect designer choices while shuffling features between designs to produce new possibly interesting combination. The introduction of new design ensures that the galleries always display a large variety of features to inspire designer.

Each interview consists of three parts. First, the participants fill in a form about their HCI design practice and their knowledge about creativity. Then they are faced with a description of our case study and asked to produce several sketches of UI design. The participants are provided with papers and color pens and have about 45 minutes to come up with their design. After a small debriefing, Magellan is presented to the participants. They are asked to think aloud while browsing the examples. Finally, we debrief with the participants about the examples; in particular we focus the advantages, shortcomings and possible improvements of the approach and tool. At the end of the session, we present Picbreeder [34] as another creative support tool to feed in the discussion.

At the first step we collect information about participants' design practices, in particular about the way they explore design spaces through sketching and examples browsing. We gather which elements of the design they first explored in the early phase (layout, colors, pictures etc.). It aims to introduce the participant in the experiment, and for us to confirm our knowledge on design practice. The second step enables the participants to actually start a design process, and us to observe them *in situ.* The last step provided feedback on the examples produced by Magellan. By doing so we collected designers' thoughts and needs regarding examples generated by IGA. They are related in the next section.

Evaluation results

First Step

The questionnaire, followed by a short discussion, confirmed our knowledge on design practice and processes. Most of the participants stated to follow an iterative and incremental design process. Only *designers* reported to use tools such as Photoshop to refine their ideas before going to production. Other participants reported that they would directly implement their ideas.

Furthermore, participants confirmed that they usually explore existing designs before or while designing. We gather three types of exploration. A first exploration type is about reviewing similar websites or applications (E1, E7, E8, E9) or specialized websites in design (E0, E6, E8). The objectives of this exploration are to collect knowledge, tendencies, and to identify problems and solutions.

Tendencies researches are not futile, but result from the following consideration: if the design is too unusual, the user will possibly reject it, whilst if too usual the design could be considered boring. A second exploration type could be called random exploration. It usually occurs in the form of non targeted searches (*e.g.,* during the everyday life, for another project) (E1, E3 E4). Such searches are not restricted to domain specific UIs (*e.g.,* medical website in the case of a medical project) nor specially related to UI designs. For instance, inspiration can be drawn from analogy with other designs: E1 said to have been inspired by an old phone dial in his design. Finally, the third type of exploration was mentioned by professional designers (E1, E10): they use to picture libraries they build over the years.

According to the participants, when they seek for inspiration from other designs they seem to be principally focus on aesthetic elements like images, background, logo, color themes, etc. However, it is not limited to the look and feel. E4 and E2 stated that they sometimes copy the code of webpages and modify the look and feel to suit their project. Finally, merely half of the participants (5 on 11) reported to consider the layout as an innovative element that they would look for in examples.

Second step

Participants first start by an analysis of the problem, and pick out one or two main flaws of existing instant messengers. They then start sketching a proposition. Most participants identified the problem of the number of chats window However, only (E1) proposed several tracks of ideas, and was willing to take more time to propose more ideas.

As stated by Buxton [8], participants' sketches used a simple drawing style. Contrary to what was stated in the first step, sketches were poor in graphic elements. Participants mostly focused on the layout of the interface rather than on background, images, etc. In particular, most of the sketches were monochromatic. Only one participant (E4) proposed sketches using several colors. Some others used colors to distinguish their comments or to highlight some parts of their sketches. As discovered in the first step, most participants focused on only one track, and only produced one design.

Third step

In general, participants found Magellan “not perfect but interesting” (E1). The main flaws exhibited in Magellan come from the following points:

- Participants were confused by the injection of new design at each iteration of the IGA. They wondered why some of the propositions did not correspond to their previous selections. However, the injection of new individuals was not considered intrinsically bad. Rather, the lack of visual identification of the new elements was the cause of participant’s trouble.
- Participants were sometimes reluctant to select a UI design because a part of it displeased them. Conversely, they expressed that they would like to evolve only parts of a design instead of the whole.
- Participants were frustrated not to be able to edit directly some parts of the UI. For instance they would have liked to resize or move elements, change the color theme, or a specific widget.

The third step confirmed what has been seen in the second one: participants focused mainly on the layout of generated design. They all started selecting or commenting the UIs presented by Magellanwith respect to their layout. Critics were made about layouts that produced UI design with insufficient distinction between the tasks or UI design that were difficult to read. These designs were largely rejected while the ones with clear separation and guidance were preferred. However, rejected designs helped some participants to envision shortcomings about their own designs made in the second phase of the experiment. This behavior is common with real-life example as stated in [21]

Although Magellan does not include many graphical elements such as images, it produces rich colored UIs (*e.g.,* gradients background). From the first step, one may have expected that participants would select some designs based on a pleasant color theme. However it appears that UIs were rarely chosen based on their color theme. Rather, UI were rejected if the color displeased to the participant (for example pink themed UIs were largely disliked). Furthermore, while participants have proposed monochromatic design, black and white UIs were systemically rejected.

Lastly, widget substitution has been considered as very interesting by participants. They reported that seeing widgets in context was more interesting than seeing them in a widget gallery. As a result, they stated to be more inclined to use new widgets discovered via Magellan.

3.3 Discussion

Through this experiment, we intended to test the potential of IGA to generate examples galleries. Whilst participants have positive reactions toward Magellan and exhibit expectable behavior to a normal example browsing sessions there is still much to do.

In the early phases of the design process, designers externalize ideas with a visual language proper to early sketching [8]. The visual language used by Magellan is closer to high-fidelity prototypes than sketches. Hence, this could explain the fact that produced sketches in the second step of the experiment used no color, whilst black and white UIs proposed in Magellan looked as unfinished regarding colored UIs. In the third step, participants were still looking for early designs. They were more interested in the general organization of the UI than in “details” such as the background color. However if A good color theme is not sufficient to make a good design, a bad color theme is sufficient to make a bad one. Smilarly high fidelity prototypes were not utterly useless. In some cases, they enabled designers to understand that a design they envisioned was actually not so good.

The first conclusion we draw from this experiment is that IGA gallery should be able to produce designs at different levels of fidelity. Sketch like design could inspire general ideas. For instance, it seems that individuals of the first populations could “forget” details and focus on layout. It is only when participants were satisfied with the layout that they really started to look at interactors or color theme. As a consequence, we think that the evolved designs should become more and more precise over the generation, starting from sketches and progressively turning into final designs.

The second conclusion we draw from this experiment is that designers should be able to directly edit the designs proposed by IGA galleries. Our first assumption was that designers would consider presented designs as those found in web galleries and start sketching again. In reality they try to evolve designs to get something close to what they had in mind. The impossibility for designers to import UI sketches into Magellan and to print designs produced by Magellan can probably explain why designers did not use pens and papers. Participants explicitly stated their need to edit designs proposed by Magellan. They wanted to be able to tune layout or colors but also to insert UI elements they had sketched in the second step of the experiment. They also stated that Magellan should take care of propagating the modification to the next generation of UI designs. Last, they expressed the need to be able to manually combine parts of designs in a similar way that what is done by Lee [23].

The last conclusion we draw is that there is a need for limiting the evolution of a UI to a part of it instead of considering the whole UI. In addition, participants mentioned that they would like to score selected parts not only as “good” but also as “bad” so that to remove them from the next generation of UI designs.

In summary, we elicit three main requirements for a tool like Magellan: it should support manual edition, an enhanced selection of individuals and the production of designs at several levels of precision.

RESEARCH ROADMAP AS A CONCLUSION

Interactive Genetic Algorithms have proven their ability to produce interesting design solutions in several fields. However UI designers do not use these approaches. Indeed, IGA do not provide all features and functionalities required by Creative Support Tools [35]. In this paper, we study whether and how IGA can fit in a creative UI design process relying on sketching. The results highlight that IGA tools should use visual languages proper to UI sketches.

Design spaces targeted by IGA depend on the information stored in the databases that capitalize the possible tasks, tasks operators, CUIs, etc. Currently, these databases are graphs of models limited to the CAMELEON levels of abstraction. As our experiment shows that there is a need for combining these “classical” models with sketches, we elicit improvements to be done for this research area:

· Consistently integrating sketches within “classical” UI models. In particular, in addition to the level of abstraction, the level of precision has to be considered. A first step has been done in [14] were UI models are classified with respect to the CAMELEON levels of abstraction and levels of precision ranging from sketch to code.

· Making it possible for IGA to generate sketch level UI designs (not only final UIs). IGA should start by producing a population of UI designs at the sketch level and make it evolve into final UI populations over generations.

· Supporting manual edition of presented designs. This is a crucial point as participants of our experiment strongly requested to be actors of the process. It is especially challenging since UIs are sketches.

· Supporting partial selection of individuals.

· Consistently integrating the design process into the UIs database itself so that to keep trace of the design rationale. This would also be a means to seamlessly enrich the database with the experience of UI design teams.

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