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Emerging issues in visual interfaces*

TIZIANA CATARCI[1], GIUSEPPE SANTUCCI[1] and LAURA TARANTINO[2]

[1]*Dipartimento di Informatica e Sistemistica, Università di Roma 'La Sapienza', Roma, Italy (email: {catarci,santucci}@dis.uniroma1.it)*
[2]*Dipartimento di Ingegneria Elettrica, Università dell'Aquila, L'Aquila, Italy (email: laura@ing.univaq.it)*

Abstract

The continual growth of the Global Information Infrastructure (GII) prompts dramatic changes in both the types of information involved, and the kind of people who access it. In this paper, we briefly survey the most recent results with respect to the User Interface area, as emerged from the work presented at the fourth edition of the Conference on Advanced Visual Interfaces (AVI'98), focusing on interaction with large information spaces, multimodality, and usability issues.

1 Introduction

That the user interface has become a crucial component able to determine the success or unsuccess of any modern (information intensive) application is surely witnessed by the extraordinary growth of the Global Information Infrastructure (GII) (Gershon & Brown, 1996). It is interface technology more than anything else that triggered such an explosive expansion: a click on the mouse is all users need to traverse links across the world. Dramatic changes are hence taking place in both the nature of information spaces (larger and with multiple media involved), and the kind of people who access the available information (Myers et al., 1996). In this paper, we briefly survey some recent contributions coming from the Visual Interface field, presented at the fourth edition of the Conference on Advanced Visual Interfaces (AVI'98) (Catarci et al., 1998).

In particular, we touch representation and locomotion aspects for large information spaces, we survey results from usability tests, and we see that, although the term "information visualization" is our starting point, the goal is really "information perceptualization", which implies the use of many senses to increase the rate at which people can assimilate and understand information (Card, 1996).

2 Information flow or information flood?

Indeed, information digestion and assimilation are the user's definite goals, difficult to achieve if one lets unstructured floods of data collect in perceptually-rich and information-overabundant displays. The GII flood can turn out to be useful only if it can be converted in a somehow structured information flow that users can *consume*.

The term *consume* may be indeed taken literally, if we follow the approach proposed by Pirolli and Card (Catarci et al., 1998, pp. 83–93): to evaluate the valuable knowledge gainable from a system in relation to the cost of the necessary interaction, they have been developing the Information Foraging Theory by merging optimal foraging theory in biology with theories of

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human cognition (e.g., Information Patch Models are borrowed from patch models used to analyse the food-foraging strategies of animals).

It goes without saying that a good design is the very first step to achieve applications that effectively serve users and their needs, and that the design must be based on ergonomic criteria that cover both *representational* and *locomotion* aspects.

Insights on ergonomic criteria are given by Nigay and Vernier (Catarci et al., 1998, pp. 37–47), based on studies of how the user perceives and manipulates a large information space. In their taxonomy, representational issues are addressed by *interaction flexibility* criteria (representation multiplicity, adaptability, and I/O re-use), while locomotion aspects are addressed by *interaction robustness* criteria (observability, honesty and predictability). The paper also provides design rules identified from ergonomic criteria and illustrates the design approach and results through the VITESSE system. VITESSE provides six representational systems to visualize the results of a query submitted to a WWW search engine. According to *adaptability* requirements, the representation choice responsibility is on the user, that, acting on a palette of icons, switches from one representational system to the other.

A complementary approach is found in systems characterized by *adaptivity* (automatic adaptability), where the user's role is more implicit and the representation choice responsibility is put on the system. Such a behavior is, e.g., typical of interactive systems where multiresolution models provide multiple Level of Details (LODs) for each object of the scene. At runtime the visualization software has to decide which LOD is appropriate, e.g., depending on the distance between the camera and the object when the locomotion metaphor is based on the navigation in a 3D-space. Beside supporting the communication goal of the graphics by reducing the probability of distracting the viewer's attention by unimportant details, LOD techniques allow for saving computational resources, and therefore reenables interaction real-time conditions.

Since the basic idea is to use abstraction mechanisms in order to reduce the total weight of the presentation, the LOD approach finds applicability for displaying large sets of data, as discussed by Woodruff et al. (Catarci et al., 1998, pp. 57–66), as well as for displaying complex graphics (e.g., 3D illustrations), as discussed by Kruger (Catarci et al., 1998, pp. 47–57). Both systems are directed towards the designer, on whom is put the burden of defining appropriate amounts of detail. Kruger (Catarci et al., 1998, pp. 47–57), in the context of intent-based 3D illustrations, proposes a functional model of graphical abstraction taking into account both computational and cognitive resources; by means of an evaluation component detecting artifacts the results can be improved stepwise through a generate-and-test cycle. Woodruff et al., in the context of database visualization environments, propose VIDA (Visual Information Density Adjuster), which interactively guides the design of multiresolution applications fulfilling the principle of *Constant Information Density*. The basic idea is that the amount of the displayed information should remain constant as the user pans and zooms, by either (1) showing objects at a greater detail when the user is closer to them, or (2) making more objects appear as the user zooms in, or (3) both.

Though stemming from considerations on user's attentiveness, the above discussed proposals also address a problem deriving from screen restraints: because of the limited size of the screen, observability of the set of elements is impossible in its entire scope and detail. *Observability* allows the user to evaluate the internal state of the system from the perceivable representation of the state, and has to be related to both representation and locomotion aspects. *Predictability* is therefore to be enforced: the user knowledge of the interaction history should suffice for determining the result of future interaction. In other words, the navigational technique should enable the user to fully determine the consequence of the next input action.

As extensively discussed by Furnas (1997), structure "traversability" (i.e., the ability to form a path through an information structure) is only a minimal requirement. Even efficient traversability is not enough: it does little good if a short path to a destination exists if the path is unfindable. According to Furnas, "strong navigability" should ideally be enforced, to allow the navigator to find the shortest path to the target without error and in a history-less fashion. The latter property requires that some residue or scent of the target must be observable by the user at every node.

In the PolyNav system proposed by Wittenburg et al. (Catarci et al., 1998, pp. 76–82) images extracted from Web pages are the primary vehicle for conveying residue. PolyNav is directed towards providers of Web information who are able to select, structure and cache images, and focusses on using images for supporting rapid previewing and scanning in a previously structured space. The main novelty of the approach lies in the adoption of the mental model of locomotion used by Micronesia and Polynesia navigators, where the traveler remains stationary while the terrain moves relative to the traveler. Hence, in the PolyNav system the initiative of movement is shifted away from the user and onto the system: the presentation is modeled as a flow of information streaming to the user.

3 Dealing with multiple media

As pointed out before, flexibility is a desirable property of any interactive application to support effective and robust communication. In the last years we have witnessed an impressive progress in the way human beings interact with computers. Textual interfaces have been totally replaced by graphical ones, based on pointing devices and windows displaying multiple data types, such as text, sound, image, and video. This successful approach can be considered only the first step: multimodal interaction and augmented reality are just behind the corner.

Multimodal interaction is based on the idea of involving as much human sense as possible: it results in user interfaces combining visual display and natural language. Results from simulation studies reported in the paper by De Angeli et al. (Catarci et al., 1998, pp. 164–173) confirm the power of multimodal interaction, and suggest guidelines for designing effective multimodal interfaces integrating visual display, pointing and natural languages.

Moreover, attempts have been made to increase the effectiveness of natural language simulating facial expression, intonation, and gestures. Proposals in this direction come from Pelachaud and Poggi (Catarci et al., 1998, pp. 156–163), who present a system that, in the context of dialogues between synthetic agents, is able to automatically select the appropriate performative and its corresponding facial behaviors. Considering the context and the type of Hearer to compute the Speaker's behavior enhances the credibility of the latter.

We note that not only are multimodal interfaces able to shorten the distance between people and computers but they can also be conveniently used in dangerous contexts; as an example, think of a computer road map working with a Global Position System installed on a car: it is definitely safer to follow aural instructions than neglecting the street to look at a blinking point on a little computer screen.

Augmented Reality is one more step forward. As discussed by Mackay in her invited paper (Catarci et al., 1998, pp. 13–22), augmented reality is more intriguing but requires, nowadays, more complex and expensive hardware. The challenging idea underlying such an approach is to leave the user free to continue her/his work with her/his standard tools (e.g., engineering drawings and flight strips) augmenting them with a wealth of digital information and communication capabilities. Even for a computer scientist it is quite amazing to watch engineers working with the Ariel system (Catarci et al., 1998, pp. 13–22), adding a voice annotation directly on the paper drawing to share his/her idea with a remote colleague. Of course this requires a special environment, like cameras and projectors, able to monitor user actions, recognize the paper position and project on the paper computer images. If someone thinks that this approach is totally unfeasible because of the complexity and the cost of the needed hardware we can object that this may be the same opinion a designer of a full textual operative system used a couple of years ago (e.g., DOS 3.1) may have had about using Windows '98.

4 Usability issues

As an effect of the GII expansion, the potential user community of information systems is becoming large and rather nontechnical, with most users bound to remain permanent novices with respect to many of the diverse information sources they access (Myers et al., 1996). Therefore, *usability* is a key issue that cannot be left out of consideration.

As a matter of fact, the key role of the user in the development process of interactive systems has been widely recognized (the term user-centered has been coined to denote recent design modalities which are oriented in such a direction (Norman and Draper, 1986). Note that user-centered design is particularly significant not only when building new systems, but also in re-engineering legacy systems, as shown in the industrial experience reported in the paper by Dassovich and Giannetti (Catarci et al., 1998, pp. 94–101). To be user-centered, the development of any interactive system, should be carried out by emphasizing the following three points (Badre, 1993):

1. the identification of the users and their needs;
2. the usage of this information to develop a system which, through a suitable interface, meets the users' needs;
3. the usability evaluation and validation tests of the system.

During the last few years, a particular emphasis has been given to the last point. Several different definitions of usability exist in the literature. In Bevan and Macleod (1993) a very comprehensive definition of usability is given as "the extent to which a product can be used with efficiency, effectiveness and satisfaction by specific users to achieve specific goals in specific environments". More precisely, the effectiveness refers to the extent to which the intended goals of the system can be achieved; the efficiency is the time, the money, and the mental effort spent to achieve these goals; the satisfaction depends on how comfortable the users feel using the system. From this point of view, the usability is a major component of the quality of interaction between the user and the overall system.

Usually at least one measure for each factor determining the quality of interaction must be provided. The effectiveness can be evaluated by relating the goals or subgoals of using the system to the accuracy and completeness that these goals can be achieved with. Measures of efficiency relate the level of effectiveness achieved at the expense of various resources, such as mental and physical effort, time, financial cost, etc. Measures of satisfaction describe the comfort and acceptability of the overall system used. The learnability of a product may be measured by comparing the usability of a product handled by one user along a time scale.

Some of these measures (e.g., accuracy and response time) can be evaluated quite precisely. Frequently, this is done by either recording real users performing predefined tasks with the system and then analyzing the recorded data, or directly observing the users. Although the observation (or recording) of real users performing real tasks gives extremely significant results, it has some drawbacks. For instance, since experiments usually take place in usability labs, they do not yield detailed data associated with real working situations, and do not allow critical incident identification. In order to overcome this problem, in the invited AVI paper by Hartson and Castillo (Catarci et al., 1998, pp. 22–29) it has been proposed to enrich the direct evaluation by adding a *remote evaluation*, a method based on real users self-reporting critical incidents encountered in real tasks performed in their normal working environment. Results show that users with only brief training can identify, report and rate the severity level of their own critical incidents. The ability of the users to discover and analyze their own errors seems to be in contrast with the difficulties encountered by usability experts when analyzing the users' errors during the usability tests, as reported in the paper by Mark Springett (Catarci et al., 1998, pp. 102–113). Indeed, this paper describes a study designed to measure the distance between symptoms of usability problems, as detected during the usability studies, and root causes of these errors.

Further difficulties in performing real usability experiments come from both the high costs and complex organization, due to the need of involving a significant number of real users. As a consequence, techniques have been studied that permit the evaluation of system usability without running user studies, relying instead on experts' evaluation. A particular technique oriented towards hypermedia systems has been proposed by Garzotto et al. (Catarci et al., 1998, pp. 135–145). The basic idea is in the definition of a set of hypermedia-specific usability attributes and of general "*patterns of evaluation activities*", that can be performed by usability experts to check such attributes systematically.

5 Conclusions

Just looking at the recent literature, it is easy to see that HCI is among the computer science fields which are mostly "running" towards the future. As a consequence, we expect to enjoy very exciting advanced visual interfaces at AVI2000. In the meantime, information about how to purchase the AVI'98 Proceedings can be found at `http://www.ing.univaq.it/avi98/`.

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