Impediments to designing and developing for accessibility, accommodation and high quality interaction

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1. INTRODUCTION

Universal design entails the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design. In the context of Human-Computer Interaction (HCI), design for all entails the design of interactive artefacts accessible and highly usable by the broadest possible end user population, including disabled and elderly people. The distinctive characteristics of such a notion is the emphasis upon accessibility and high quality interaction. These two usability requirements provide the driving forces towards a new paradigm of User Interface Software and Technology (UIST) intended to deliver products widely usable by users with diverse requirements in a variety of contexts. The current generation of UIST, though making solid contributions towards more natural and intuitive interaction mechanisms, has traditionally failed to account for the notion of accessibility, as considered in the present context. As a result, the capability to effectively and efficiently produce user interfaces for all is seriously prohibited.

Given the current practice regarding interactive computer-based software development and the requirements for accessibility, accommodation and high quality interaction, it follows that a new HCI research and practice agenda is needed based on human needs and social responsibility. At the core of such an agenda lie two basic questions, which have surfaced throughout the short history of HCI and continue to pose challenges, despite recent progress. These are the underlying theory of design and the notion of user interface software architecture. In the following, we provide a brief account of each one and reflect upon the challenges underpinning the study of HCI in the emerging information age.

2. IN SEARCH FOR A THEORY OF DESIGN FOR ACCESSIBILITY AND HIGH QUALITY INTERACTIONS

In recent years, there have been several attempts to defining and providing frameworks for the design of human-machine interactions. Their distinctive characteristic has been the emphasis upon either experimentation or theory-based contributions [Carroll 91]. This distinction has given rise to two alternative perspectives or methodological stands for the design of human-computer interactions, namely the *human factors* perspective and the corresponding *cognitive science* approach, based on information-processing psychology. It turns out that neither school of thought has delivered the HCI results originally anticipated, despite the substantial work and the contributions made to the study of interactive computer-based systems. This is not only evident from the recent literature and the on-going debates in the mainstream HCI field, but also from the evident lack of sound supporting methodology to account for diverse user groups, including people with disabilities, or radically different interaction style requirements. In the following sections, we attempt to outline the main points of contention and to highlight their relevance to the study of design of HCI in a broader context accounting for accessibility, accommodation and quality.

2.1 The Human Factors perspective

The Human Factors evaluation paradigm of the 1970s introduced a reactive approach to HCI design. It is largely based upon laboratory-based experimentation, utilising a cluster of techniques for assessing usability and quality of use of information artefacts. According to this reactive paradigm, designers plan and develop prototypes of new or improved systems and then human factors specialists assess usability. Such an approach, originally built upon well-found user testing methodology and principles of software ergonomics. More recently, new techniques (i.e. inspection methods, heuristics, standards recommendations, participatory approaches, etc) have evolved to account for the relatively high cost of experimentation and the requirement for timely, user-centred and effective human factors input to the design of interactive-computer based artefacts.

The major criticism of the traditional human factors perspective to the design of HCI has been based on two lines of thinking, namely its limited focus and its insufficiency to translate empirical findings to improved / new designs. The first line of critique, related to the limited focus of the human factors contributions, is grounded on the emphasis that this approach places upon evaluation. It is argued that human factors have traditionally concentrated upon methods and tools with an explicit evaluation flavour and have failed to provide a consolidated wisdom (other than general guidelines, heuristics and intuition), and integrative support for the whole life cycle. In line with this point of view, the second line of critique raises the issue of translating results and empirical findings to improvements and new (more effective) designs. Additionally, specific techniques adopted by human factors specialists, such as task analysis, have recently been under fire resulting in doubts regarding their theoretical underpinnings as design tools, their practical use and deliverables to the design activity. Finally, the emphasis on laboratory-based experiments as opposed to real work-place inquiries has been criticised as an inadequate approach to delivering actually meaningful and useful results.

With regards to human factors studies covering the domain of disability and the corresponding contributions to user interface software and technology, the situation is even worse. In particular, the recent literature does not deliver anything more than guidelines which, although useful, suffer from well-known shortcomings, related both to the actual human factors design input delivered, as well as to their practical use by designers [Stephanidis 97]. These introduce several challenges for the human factors tradition which need to be progressively addressed before experimental approaches claim to deliver the much needed tools and methods for a more effective and efficient design practice.

2.2 Cognitive science perspective

The cognitive science tradition [Norman 91] is a more recent attempt, led primarily by research in information-processing psychology and Artificial Intelligence, to establish a distinct multidisciplinary research program to study the cognitive properties of human beings and information artefacts. The central idea of cognitive science is that both human beings and the computer can be regarded as information processing entities that could be studied using similar methodology and criteria. It follows therefore that cognition is largely regarded as a type of computation. Since its origin, there have been several calls for either better utilisation, broadening the range or extending the scope of information processing psychology, as originally embedded in the work of Card, Moran and Newell [Card 83] in order to provide a more effective science-base for the study of HCI. This is mainly attributed to certain identified limitations or shortcomings underpinning the cognitive science inquiry into HCI. The recent critique raises several issues on the appropriateness and suitability of cognitive science, as expressed through information-processing psychology, to the HCI field. In the following, we provide a brief and non-exhaustive account of the principal considerations underpinning such critiques.

The first line of contention stems from the scepticism that has risen from the evident lack of demonstrable impact of the cognitive approach to the field of HCI and the lack of substantial reference examples addressing real world problems. Advocates of this line of thinking argue that, with the exception of very few cases of limited substance, the use of cognitive models have not delivered results demonstrating real benefits of this approach to designing new or improved computer-based interactive systems. Additionally, it is also argued that if cognitive science is to improve the current situation of theory-based design input to HCI, it will need to provide reference examples covering substantial real world design cases, something that is currently missing from the available pool of knowledge and the consolidated wisdom. This line of thinking is further supported when one considers that some of the major innovations in the field of HCI were not advanced as a result of cognitive (information-processing) psychology contribution.

A second point of contention relates to the suitability of cognitive science and the resulting theories, as foundation for design, due to their focus on what the users should do as opposed to what users actually do in various work contexts, as well as its underlying laboratory-based versus contextual inquiry into real work situations. More specifically, the early work in the GOMS family of cognitive models assumed error-free behaviour. Though, subsequent efforts attempt to remedy this shortcoming, the current results suffer from a more serious impediment which is grounded on the fact that cognitive models are biased towards what the users should do as opposed to what they actually do in real practice. More recent approaches, such as Programmable User Models or Runnable User Models assume that user behaviour may be programmed by a designer in the laboratory with no need to investigate the actual work context within which users operate. Critics consider this as a serious shortcoming and question the validity of a science-base providing laboratory-oriented predictive theories. Instead, it is argued that what is needed is a unified, rich and expressive framework for descriptive and prescriptive theory for HCI design.

A third item of contention relates to the basic unit of analysis assumed by cognitive models. It is argued that concentrating the study of interactions at the level of the user action without considering the context in which such actions occur, cannot provide a meaningful and adequate framework of analysis and/or synthesis. This is evident from the resulting descriptions generated by a cognitive model which offer limited contextual information which frequently cannot even be understood by the users whose actions are being modelled.

In the context of disability, cognitive models, such as GOMS, have had minor impact. One study, by Horstman and Levene, [Horstman 90] concentrated upon a word prediction task in an augmentative communication system. Their work, however, has come under fire by Newell and colleagues [Newell 92a] which has resulted in a lively exchange regarding the suitability of cognitive user modelling in augmentative and alternative communication [Hortsman 92], [Newell 92b].

2.3 Emerging perspectives

In recent years, there have been several proposals for remedying the shortcomings identified above, either through suggestions for better utilisation of the existing knowledge and science base, or broadening the range or even extending the scope of information processing psychology with concepts from developmental approaches [Nardi 96], such *activity theory, action theory*, *communications theory*, *situated action model* and *distributed cognition*. The normative perspective adopted in these efforts is that interactions between humans and information artefacts should be studied in specific contexts. Despite their common ground, the above alternatives for the study of context differ with regards to at least three dimensions, namely the unit of analysis, the categories offered to support a description of context and the extend to which each treats actions as structured prior or during activity. Although a detailed account of each of these proposals is beyond the scope of this abstract, we will be content to acknowledge their promising contribution to the study of HCI in a broader context which accounts for accessibility, accommodation and high quality of interaction.

3. USER INTERFACE ARCHITECTURES

Another challenging issue relates to a suitable reference model for user interface architectures facilitating design for all. In the past there have been several attempts to extract a reference model from concrete user interface architectures in order to classify existing prototypes and to guide the construction of user interface software. The best known architectural abstractions of user interface software include the Seeheim, PAC [Coutaz 90], ALV, MVC and Arch/Slinky models [UIMS 92]. However, these models fall short to address the requirements for design for all. This is due to several properties underpinning these models which constitute serious impediments to universal accessibility.

First of all, currently prevalent user interface architectures pre-suppose a narrow view of interaction constrained to the visual channel of communication and bound, in the majority of cases, to the visual embodiment of the desktop metaphor. Secondly, the type of interfaces that can be developed are suited for the able-bodied user possessing immediate and direct access to the computer. This precludes access to interactive applications and services by a large proportion of the end user population, either lacking the human resources required to engage and sustain interaction (i.e. disabled and elderly people), or being instantly at a disadvantage. Thirdly, the current paradigm of user interface development is characterised primarily as being programming-intensive rather than design oriented. As a result, granding access to an interface for a disabled user requires re-implementation of the interactive component of the software, rather than instantiation of an alternative design.

Finally, the situation is further complicated by several additional problems related to the currently prevailing design philosophy and methodologies. These are briefly summarised as follows. Prevailing design philosophy and supporting methodologies are single-artefact oriented, dismissing the context within which these artefacts are to be encountered or used. Broadening the scope of design to study context necessitates a shift of perspective towards a more suitable unit of analysis, such as that of *activity*, as opposed to contextually isolated *user actions*, as well as multiple artefacts differentiated by the varieties of context in which they are to be encountered. These requirements raise serious implications on the approach used to study context, the richness of the method adopted to identity and document artefacts, the reasoning behind their occurrences, and the architectural model according to which such artefacts become embedded into user interface implementations.

It follows therefore that if the objective of user interfaces for all is to materialise, what is required is a departure from the current state of affairs towards a new interaction design philosophy and a new paradigm for developing interactive computer-based applications. Such a departure should be driven by two critical requirements, namely:

- the focus on design space analysis versus single design artefacts - rather than constraining the outcome of design to a single artefact, design for all advocates an explicit focus towards a range of enumerated plausible design alternatives suitable for different target user groups, and a basic rationale for selecting the most appropriate artefact, given the intended context of use;

- the generation of implemented versions of design artefacts from specifications as opposed to programming-intensive efforts - a fusion mechanism whereby concrete design alternatives are unified into specifications of abstract and reusable design patterns, from which implemented interactive components are generated.

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