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Human Machine Interaction

Research Results of the MMI Program

Springer

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Preface

The interaction between humans and machines is a central concern of computer science. How can machines become convivial? How can machines present results of computations in a comprehensive way? What modes of communication between man and machine exist and how can they be best exploited according to the needs of a particular application? These are only a few of the important questions that neede to be addressed in order to enhance the usability of these universal machines that participate more and more in our daily life.

The design of human–computer interfaces calls for different abilities. Therefore, the Hasler Foundation launched a research program on "Man–Machine Interaction" (MMI) in 2005. At this time in Switzerland, the technical Universities of Applied Science emerged from the old engineering schools as new structures with new tasks. Among their responsibilities, applied research was explicitly stated as a new challenge. The goal is to transfer results of fundamental scientific research into applications. In order to foster this transfer, the Hasler Foundation decided to shape the program in such a way as to encourage close collaboration between universities and the newly formed Universities of Applied Science. One of the explicit objectives of the MMI program was to aid the Universities of Applied Science to build up their research activities, by benefiting from the research experience and the research results of universities. This should enhance technology and science transfer between the two complementary kinds of schools.

In the call for projects, collaboration between at least one partner from a University and one from a University of Applied Science was required. More than 80 project proposals were submitted, from which 20 were selected for a hearing and discussion. A limited number of projects were then invited to submit detailed applications. Finally eight of these projects were selected for funding by the Hasler Foundation. All these projects were also partially supported by the associated universities and other third parties such as the Swiss National Science Foundation. The members of all the project teams met in a workshop organized by the Hasler Foundation for two days in March 2007 in Appenberg. More than 40 scientists engaged in the program, along with international invited speakers who participated in the workshop. This volume documents the results of the MMI program. The Hasler Foundation's existing endowments derive from the former Hasler AG (1852-1986), a pioneer of the Swiss telecommunications industry. The foundation is committed to promoting high-level research and education in the field of information and telecommunication systems. MMI is one of several programs launched and supported by the foundation. We refer readers to the website www.haslerfoundation.ch for further information.

The Hasler Foundation thanks the main editor Denis Lalanne and the authors of the contributed papers. We also thank Springer for accepting this volume in

the prestigious *Lecture Notes in Computer Science* series. It is our hope that we thereby contribute to advancing and encouraging further research in the field of man–machine interaction.

January 2009 Jürg Kohlas

Acknowledgments

The reviewing process of this book involved mostly internal reviewers (taking part in the authoring of some chapters of this book), and also external international experts to insure the scientific quality of the chapters. We thank both internal and external reviewers for their hard work.

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Introduction

Human–machine interaction (HMI), or more commonly human–computer interaction (HCI), is the study of interaction between people and computers. It is an interdisciplinary subject, relating computer science with many other fields of research such as psychology, sociology, and the arts.

This book presents results from the eight projects supported by the Research Program in Man–Machine Interaction (MMI) funded by the Hasler Foundation between 2005 and 2008. The research program focused on specific sub-domains of HMI including multimodal interaction, tangible user interfaces, information and scientific visualization, sonification, augmented reality, and haptic interfaces. The projects developed innovative interaction and enabling technologies (image and video analysis, speech recognition, object identification, etc.) to support humans in important application domains such as health, sport, and the inclusion of blind people in society.

I decided to also incorporate three survey chapters at the beginning of this book in order to situate the work with respect to the international state of the art. These chapters (Part I) introduce the three fundamental research areas addressed by the projects supported by the MMI Research Program. The projects themselves are presented in detail in the three parts that follow: multimodal user interfaces (Part II), interactive visualization (Part III), and mixed reality (Part IV). Each part is described in more detail below.

The first part (Part I: Chaps. 1–3) surveys the principal HMI research axes covered by the projects in the MMI research program, along with a recent international state of the art and a selection of projects that have been partly or fully undertaken at Swiss universities. The domain of multimodal user interfaces is surveyed in the first chapter: "Multimodal Interfaces: A Survey of Principles, Models and Frameworks." Multimodal interfaces coordinate natural input modalities such as speech, touch, gestures, and body movements with multimedia system outputs such as synthesized speech, sounds, and visualizations. The creation of a multimodal interface reveals a number of associated issues covered in this chapter, such as the fusion of heterogeneous data types, language modeling and dialog management, and time-sensitive software architectures. This chapter summarizes the major challenges in the field and concludes with an outline of the current state of multimodal interaction research in Switzerland. The domains of scientific visualization and information visualization are introduced in the second chapter: "Interactive Visualization - A Survey." Scientific visualization and information visualization are both concerned with presenting data to users. Scientific visualization is different from information visualization in that it involves the presentation of data that have some physical or geometric correspondence, while information visualization focuses on abstract data without such correspondences such as symbolic, tabular, networked, hierarchical,

or textual information sources. The survey describes typical applications and research directions and reviews current Swiss research activities related to interactive visualization. The field of mixed reality is discussed in the third chapter: "Mixed Reality—A Survey." Mixed reality deals with the combination of real-world and computer generated data. Here, real and virtual worlds are merged to produce new environments where physical and digital objects co-exist and interact in real time. It is the convergence of domains such as augmented reality, augmented virtuality, and virtual reality. Research challenges addressed in this field include the tracking of real-world objects and the creation of hand-held displays or projection systems that augment the real world with computer generated graphics. This chapter gives an overview of the field by presenting example applications, technical solutions, and current research challenges. The chapter concludes with a review of mixed reality projects that include participants from Swiss universities.

The second part (Part II: Chaps. 4–6) presents projects from the MMI research program related to multimodal user interfaces. Three focus areas are addressed: speech-based user interfaces in hostile environments, tangible user interaction, and emotion-based man–machine interaction. Chapter 4, "Intelligent Multi-Modal Interfaces for Mobile Applications in Hostile Environments," describes how speech-based user-system interaction can be used to support human–computer interaction in tasks with high cognitive load, such as sailing in racing conditions. Chapter 5, "MEMODULES as Tangible Shortcuts to Multimedia Information," uses the manipulation of physical objects, combined with classical modalities such as speech and gesture, as a way to interact with digital information and create tangible reminders in real life. Finally, chap. 6, "Why Androids Will Have Emotions; Constructing Human-Like Actors and Communicators Based on Exact Sciences of the Mind," discusses the possibility of modeling emotions (e.g., happiness, joy) so that machines can understand and mimic them. Furthermore, this chapter proposes a new language to model human emotions, their conditions, situations, and dependent dimensions, as a way to create innovative HMI paradigms.

The third part (Part III: Chaps. 7–9) presents projects of the MMI research program related to scientific and information visualization. The system described in the first chapter of this part manipulates abstract information and as such follows the standard definition of information visualization; the other two chapters tackle HMI issues related to browsing and interaction in scientific visualizations. Chapter 7, "Evospaces: Multi-dimensional Navigation Spaces for Software Evolution," approaches software visualization from an original perspective, representing abstract information with iconic metaphors (e.g., a city map) in order to capture the architecture, evolution, or morphology of a software's source code. This metaphoric approach facilitates collaboration between people participating in the development of a common software. Chapter 8, "HOVISSE—Haptic Osteosynthesis Virtual Intra-operative Surgery Support Environment," presents a VR system for medical practitioners. It also provides a haptic interface that allows medical practitioners to "feel" the virtual world in which they are

immersed. As such, the chapter also contributes to the topic of multimodal interfaces. The BATICS project (chap. 9), "A Language and a Methodology for Prototyping User Interfaces for Control Systems," explores the possibility of building 3D graphical user interface authoring tools (in the domain of complex systems control). While the project's main focus is on software engineering issues, this contribution will also prove valuable for those building novel 3D user interfaces.

Finally, the fourth part (Part IV: Chaps. 10–11) presents research results in the domains of augmented and mixed reality. Chapter 10, "See ColOr: Seeing Colors with an Orchestra," aims at augmenting the perception of visually impaired people. It also contributes to the topic of multimodal interfaces since it targets the inclusion of blind people by substituting a deficient modality (in this case vision), with a reliable one (in this case audition). For this purpose, the machine analyzes the scene through image processing techniques and describes it to humans through meaningful sounds. This project also tackles the sonification domain, which in some ways is similar to visualization, but using a different human sense (hearing in place of vision). The final Chapter chap. 11, "6th Sense—Toward a Generic Framework for End-to-End Adaptive Wearable Augmented Reality," proposes a generic framework in the domain of wearable computing and augmented reality. The idea is to augment a user's visual perception with digital annotations displayed within his/her semi-transparent eye glasses, for example, in order to support field operators in chemical plants.

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