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STAR (Springer Tracts in Advanced Robotics) has been promoted under the auspices of EURON (European Robotics Research Network)
By the dawn of the new millennium, robotics has undergone a major transformation in scope and dimensions. This expansion has been brought about by the maturity of the field and the advances in its related technologies. From a largely dominant industrial focus, robotics has been rapidly expanding into the challenges of the human world. The new generation of robots is expected to safely and dependably co-habitat with humans in homes, workplaces, and communities, providing support in services, entertainment, education, healthcare, manufacturing, and assistance.

Beyond its impact on physical robots, the body of knowledge robotics has produced is revealing a much wider range of applications reaching across diverse research areas and scientific disciplines, such as: biomechanics, haptics, neurosciences, virtual prototyping, animation, surgery, and sensor networks among others. In return, the challenges of the new emerging areas are proving an abundant source of stimulation and insights for the field of robotics. It is indeed at the intersection of disciplines that the most striking advances happen.

The goal of the series of *Springer Tracts in Advanced Robotics (STAR)* is to bring, in a timely fashion, the latest advances and developments in robotics on the basis of their significance and quality. It is our hope that the wider dissemination of research developments will stimulate more exchanges and collaborations among the research community and contribute to further advancement of this rapidly growing field.

The edited volume by Antonio Bicchi, Martin Buss, Marc Ernst and Angelika Peer is the outcome of the TOUCH-HapSys European research project. Two bodies of research are synergically covered in the two parts of the book; namely, neuropsychology and technology. The eleven chapters discuss the recent advances in the study of human haptic (kinaesthetic, tactile, temperature) and multimodal (visual, auditory, haptic) perception mechanisms. Besides the theoretical advancement, most contributions survey the state-of-the-art in the field, report a number of practical applications to real systems, and discuss possible future developments.
As the second focused STAR volume in the popular area of haptics, this title constitutes a very fine addition to the series!

Naples, Italy                  Bruno Siciliano
February 2008                  STAR editor
Preface

It is no coincidence that in many languages, deeply involving emotions and feelings are described as "touching". Touch appears indeed to be the most direct, less intellectually mediated sense. As such, it should be a fundamental ingredient of any system aimed at providing compelling sensations of remote presence. Generation of high-definition haptic feedback will be crucially important for driving a sense of Presence in next generation immersive VR and teleoperation systems. The perspective in which this book is conceived is that of understanding and enabling an experience of presence not limited to "being there", but extended to "being in touch" with the virtual or remote surroundings.

Despite of numerous technological advances in this field it appears that the development of fully immersive haptic displays cannot proceed by technological innovations alone but requires a deep understanding and utilization of the psychophysical mechanisms of human haptic perception. On one hand, technological innovations are needed to increase the richness and accuracy of physically generated haptic stimuli. The generation of a one-to-one copy of the real world seems, however, to be unfeasible due to the inherent complexity of the necessary devices and stringent physiological and mechanical constraints. On the other hand, advances in the understanding of the information processing of the multidimensional sense of touch contribute to overcome these fundamental technological constraints. Limitations of the human perceptual system can be exploited to provide a realistic haptic sensation without getting all the physical parameters completely right. Perceptual limitations already helped in the design of advanced visual and auditory displays.

This book summarizes main results of the TOUCH-HapSys research project financially supported by the 5th Framework IST Programme of the European Union. It provides an important contribution towards a new generation of high-fidelity haptic display technologies. The uniqueness of this book is its interdisciplinary approach highlighting the field of haptic research from a neuropsychological as well as a technological point of view. It provides readers with recent advances in the study of human haptic (kinesthetic, tactile, temperature) and multimodal (visual, auditory, haptic) perception mechanisms and with innovations in the field
of haptic display technology. It shows that both lines of research are intimately connected, not only because biological sciences inspire and enable technology improvement, but also because novel devices offer new facilities for the experimental testing of psychophysical hypotheses.

This book is structured in two parts: A. Fundamental Psychophysical and Neuropsychological Research and B. Technology and Applications. Chapters in part A. concentrate on the study of the basic mechanisms of touch, involving neurophysiology, psychophysics, and functional mappings in the brain. In-depth study of the psychophysiology of the sense of touch establishes connections between haptic fundamental perception and virtual-reality oriented technology. Part B. addresses new technologies to significantly improve haptic and multimodal feedback systems. These include novel actuator designs, software solutions for haptic rendering, and applications. The two parts are not however separated, and the many connections and synergies between the two complementary domains of research are highlighted in the text.

Finally the editors would like to thank all the authors for their valuable contributions to this book. The quality and freshness found in each chapter are due to the excellent work carried out by the authors.

Italy, Germany, January 2008

Antonio Bicchi
Martin Buss
Marc O. Ernst
Angelika Peer
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