Preface

This book aims to present a new set of devices for accurate investigation of human finger stiffness and force distribution in grasping tasks. The ambitious goal of this research is twofold: (1) to advance the state of art on human strategies in manipulation tasks and provide tools to assess rehabilitation procedure, and (2) to investigate human strategies for impedance control that can be used for human robot interaction and control of myoelectric prosthesis.

The first part of this book describes two types of systems that enable to achieve a complete set of measurements on force distribution and contact point locations. More specifically, this part includes the following: (i) the design process and validation of tripod grasp devices with controllable stiffness at the contact to be used also for rehabilitation purposes, and (ii) the validation of multidigit wearable sensor system. Results on devices' validation as well as illustrative measurement examples are reported and discussed. The effectiveness of these devices in grasp analysis was also experimentally demonstrated, and applications of neuroscientific studies are discussed.

In the second part of this book, the sensorized objects are exploited in two different studies to investigate stiffness regulation principles in humans. The first study provides evidence on the existence of coordinated stiffening patterns in human hand fingers and establishes initial steps towards a real time and effective modelling of finger stiffness in tripod grasp. This pattern further supports the evidence of synergistic control in human grasping. To achieve this goal, the end point stiffness of the thumb, index and middle fingers of healthy subjects are experimentally identified and correlated with the electromyography (EMG) signals recorded from a dominant antagonistic pair of the forearm muscles. The findings suggest that the magnitude of the stiffness ellipses at the fingertips grows in a coordinated way, subsequent to the cocontraction of the forearm muscles. The second study presents experimental findings on how humans modulate their hand stiffness while grasping object of varying levels of compliance. Subjects perform a grasp and lift task with a tripod grasp object with contact surfaces of variable compliance; EMG from the main finger flexor and extensor muscles was recorded along with force and torque data at the contact points. A significant increase in the extensor muscle and cocontraction levels is evidenced with an increasing compliance at the contact points.

Overall results give solid evidence on the validity and utility of the proposed devices to investigate human grasp proprieties. The underlying motor control principles that are exploited by humans in the achievement of a reliable and robust grasp can be potentially integrated into the control framework of robotic or prosthetic hands to achieve a similar interaction performance.

Main Research Arguments

This book deals about: (i) the development and testing of suitable systems for human grasping studies, and (ii) studies on the control of finger stiffness in grasping tasks. These two topics are fundamental to understand the principles used by humans in motor control to interact with the external world. The developed knowledge, moreover, could be exploited in rehabilitation and prosthetic fields.

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