Preface

The human hand and its dexterity in grasping and manipulating objects are some of the hallmarks of the human species. For years, anatomic and biomechanical studies have deepened the understanding of the human hands' functioning and, in parallel, the robotics community has been working on the design of robotic hands capable of manipulating objects with a performance similar to that of the human hand. However, although many researchers have partially studied various aspects, to date there has been no comprehensive characterization of the human hands function for grasping and manipulation of everyday life objects.

Our hypothesis is that the confluence of both scientific fields, the biomechanical study of the human hand and the analysis of robotic manipulation of objects, greatly benefits and advances both disciplines. Additionally, we believe that the use of a simulation framework in which we could model and validate each of the processes involved in dexterous grasping is crucially important. Therefore, in this book, the current knowledge of robotics and biomechanics guides the design and implementation of a simulation framework focused on manipulation interactions that allows the study of the grasp through simulation.

In the first part of this book, we detail *OpenGRASP*, a simulation engine focused on robot manipulation interactions embedded in a real grasping cognitive system. Tactile sensor simulation is studied in detail, resulting in a new tactile sensor model. Several applications of the simulator in robot grasping are presented, demonstrating how grasp simulation is a key tool for constructing a world model and understanding the robots environment. Additionally, we demonstrate how to achieve a complete dynamic simulation of a humanoid robot.

In the second part, we use the knowledge acquired from robot simulation to create *OpenHand*, a simulation engine that provides a more comprehensive model of the human hand focused on object grasping and manipulation. It provides a realistic biomechanical hand model of the skeleton, muscles and tendons, including the simulation of the skin and the neuromuscular control. Additionally, it includes tools for grasp analysis such as mechanical contact modelling and control algorithms for closing the hand. We show an application of how the simulation can be used to solve the indeterminate problem of finding the muscular forces that ensures the equilibrium of the grasped object, by minimising different objective functions. Moreover, we propose different quality measures to evaluate various aspects of the human grasps by adapting existing robotic metrics and proposing new measures that consider its biomechanical characteristics, such as muscular fatigue. Finally, the knowledge acquired from the evaluation of grasping in humans is compared with grasping performed by a prosthetic hand demonstrating how the gap between robot and human grasp manipulation could be reduced.

As a result, a valuable framework for the study of the grasp, with relevant applications in several fields such as robotics, biomechanics, ergonomics, rehabilitation and medicine, has been made available to these communities.

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