Preface

In my previous book entitled “Control Theory of Non-linear Mechanical Systems” published in 1996 through Oxford University Press, I mentioned at its preface the difficulties of understanding human motor control and realizing in mechanical robots everyday powers inherent to humans. Regrettably, I could not discuss in that book any control–theoretic problem of dexterity in human or mechanical hands from not only biological but also computational viewpoints. Directly after my move to Ritsumeikan University in 1997, I started a research project on control of multi-fingered hands with the intention of exploring what is the underlying functionality of the human hand in prehension (stable grasping). Indeed, there was a dearth of papers that discussed the derivation of any dynamic model of grasping under rolling constraints.

In this book I attempt to provide a study of robotic prehension (stable grasping and object manipulation) from computational perspectives based upon Newtonian mechanics. The principal approach is grounded on the derivation of a faithful mathematical model of grasping that is a physical interaction between the fingerends and the object through rolling contacts. In the sequel, Lagrange’s equation of motion of the overall fingers/object system is formulated, together with holonomic or non-holonomic constraints of contact and rolling, on the basis of the variational principle developed in analytical mechanics. The most essential functionality of prehension that is referred to for designing a coordinated control signal is the fingers–thumb opposability that distinguishes the mankind from the chimpanzee and other primates, as claimed in anthropology. Stable grasping is regarded in a dynamic sense as a transient behaviour of a solution to the closed-loop equation of system dynamics that should converge to an equilibrium state or manifold satisfying the balance of forces and torques exerted on the object.

I hope that this book will facilitate further indepth research works that unveil the secrets of dexterity and versatility of the human hand and make a contribution to the technological development of dexterous robot hands.
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