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Book Reviews

Robot Hands and the Mechanics of Manipulation, by Matthew T. Mason and J. Kenneth Salisbury, The MIT Press, 1985, 298 pp.

Reviewed by Joey K. Parker[1]

This book is a combination of the authors' Ph.D. dissertations from the Massachusetts Institute of Technology and Stanford University. Mason's contribution (Section II) involves the planar manipulation of objects in the presence of friction. His topics include an analysis of object grasping, the development of a theory of pushing in the presence of friction, and an application of these theories in the automatic planning of grasping operations. Salisbury's portion of the book (Section I) concerns the requirements for the more general manipulation and constraint of objects in three-dimensional space.

Section I is organized into nine chapters with an extensive appendix. Chapter 1 is a basic introduction to the field of robotics with an emphasis on the area of robot hands. Chapter 2 presents the definitions for several types of contact between bodies and introduces the mathematical notation for screws, wrenches and twists. In the third chapter Salisbury presents a kinematic number synthesis for general-purpose robot hands. Robot hands are required to exert arbitrary forces/moments in 6 degrees-of-freedom and to completely constrain an object with all joints locked in order to be considered truly general-purpose. Chapter 4 considers the groups of contacts, both with and without friction, which lead to the two conditions given above. Chapters 5 and 6 develop the concepts of internal and external forces which are important in object manipulation. The "grip" matrix, which is similar in concept to a Jacobian matrix, is also introduced in Chapter 6. A review of force control in robotics and the requirements for stiffness sensing and control are presented in Chapter 7. The eighth chapter is concerned with the errors inherent in force control. Force sensing errors due to structural stiffness and the propagation of errors from an actuator to the point of contact are discussed. The final chapter summarizes the earlier chapters by presenting the design of the Stanford/JPL robot hand in which Salisbury played a major role. The design of this three-fingered, nine degree-of-freedom hand is shown in an excellent set of photographs and sketches. Two of the papers presented in the appendix describe different aspects of the robot hand in greater detail. A third paper given in the appendix describes a stiffness control scheme for robot manipulators while the fourth involves the description of object contact geometry from force/tactile sensor measurements. The bibliography for Section I is reasonably complete considering the publication date (1985).

Mason begins Section II with the investigation of a grasping operation using a simple parallel-jaw gripper. The object rests on a planar surface and therefore has three remaining degrees of freedom. If the exact location of the object is not known, then a planned grasping sequence can often be used for correctly positioning and orienting the object. Mason develops the analytical background for planning the grasping operation in the remainder of his section. In the second chapter the "Theory of Pushing" is developed. The planar motion of objects being pushed in the presence of Coulomb friction with fixed, rolling, and sliding contacts is considered. The conditions under which rotation will occur and a method for determining bounds on the angular rotation rate are also presented. Many of the results are developed under the assumption that the contact pressure distribution is known, but a procedure is given for use with undetermined contacts. The third chapter of Section II is devoted to applications of the concepts developed in Chapter 2. A method for rotating and positioning a rectangular block without the use of external sensors is presented along with experimental results. An automatic robot grasping motion algorithm is then presented. The grasping planner is applied to two different test cases, but experimental verification of the operation was unclear. Mason includes a listing of the LISP implementation of his planning algorithm in his appendix.

This book is clear and well written considering that it is based on Ph.D. dissertations. The examples and figures used are easily understood and are well explained in the text. Mathematical developments are presented when necessary and the terms are adequately explained. Although not intended as a textbook, it would make a valuable contribution as a reference text for graduate courses in robotics.

Taken as a whole, *Robot Hands and the Mechanics of Manipulation* is a significant addition to the field of robot hand research. There are other books devoted to robot hand design, but these tend to be compilations of short publications by many authors. Many robot hands have been designed without serious consideration of the fundamental concepts involved in the grasping of objects with robot hands. Mason and Salisbury complement one another by presenting different sides of this seemingly simple but truly complex subject.

Direct-Drive Robots, Theory and Practice, by Haruhiko Asada and Kamal Youcef-Toumi, MIT Press, 1987, 262 pp.

Reviewed by Yoram Koren[2]

The book presents the most current research in manipulator design and control of direct-drive robot arms. In direct-drive robots the shafts of revolute joints are directly coupled to the

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