

Design Aspects for Advanced Robot Hands: Sensory System

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1 Introduction

Dexterous manipulation requires devices provided with a suitable mechanical structure as well as an adequate sensory system. In fact, manipulating an object needs precise information about the configuration of the hand and the state of the interaction with the environment (typically the grasped object), and often the success (or simply the completion time) of the task depends on the level of this information.

Starting from the observation of the human hand, in Sec. 2 we outline the desirable features of a dexterous robot end-effector, in terms of manipulation capabilities. In Sec. 3 we inspect the sensing technologies currently available, and in particular, in Sec. 4, we focus on force and tactile sensors, which at the moment are the most debated topic in the field of sensors for robotic manipulation. In Sec. 5 and 6 we describe some tangible examples of this kind of transducers, as well as their application in dexterous manipulation in order to accomplish slip detection of grasped objects. Finally, we draw some conclusions about the choice of a suitable sensory equipment for a robot hand by means of a comparative analysis of the solutions adopted in some noticeable examples of dexterous end-effectors.

2 From human to robot hands

The human hand is the best example of dexterous end-effector we deal with and therefore it is often used as model and benchmark for robot hands. It is not an accident that the term *anthropomorphic* is so widely used in robotics. Not only the structure of the human hand but also its sensory system appears to be very effective. As a matter of fact, many researchers tend to adopt similar sensory configurations in devices, which are often quite simple from the mechanical point of view and not anthropomorphic at all; this is the case

of the ROTEX Gripper [1], whose equipment includes position, force and tactile sensors. In this sense it is possible to extend the meaning of term *anthropomorphic* to the sensory system; a dexterous manipulation device can not be considered fully anthropomorphic, despite its shape and its mechanical structure mimic the human hand, if not equipped with an adequate sensing apparatus.

The internal state of the human hand (position, velocity and force) is known by means of receptors collocated in the muscles, tendons, and joint capsule. But one of the reasons of the dexterity of our hand are cutaneous information (high-frequencies vibrations, small scale shape or pressure distribution, thermal properties). As a matter of fact, it has been shown that the lack of touch sensation, due for example to thick gloves (e.g. in space) degrades the human ability and prolongs the task completion time up to 80%, [23].

Two are the main skills of a human hand:

- *prehension*, such as the hand's ability to grasp and take hold of objects;
- *apprehension*, or the hand's ability to understand through active touch.

In this sense the human hand is both an *input* and *output* device (see [16]). As output device, it can apply forces in order to obtain stable grasps or perform some procedures of manipulation, while as input device, besides providing information about the state of the interaction with the object during the task, the hand is capable to explore an unknown environment. The same characteristics should be desirable in advanced robot hands; as a matter of fact, the application of robotic systems in unstructured servicing environments requires dexterous manipulation abilities and facilities to execute complex operations in a flexible way. Moreover, considering the possibility of

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5th Kuala Lumpur International Conference on Biomedical Engineering 2011 Hua-Nong Ting, 2011-06-17 The Biomed 2011 brought together academicians and practitioners in engineering and medicine in this ever progressing field This volume presents the proceedings of this international conference which was held in conjunction with the 8th Asian Pacific Conference on Medical and Biological Engineering APCMBE 2011 on the 20th to the 23rd of June 2011 at Berjaya Times Square Hotel Kuala Lumpur The topics covered in the conference proceedings include Artificial organs bioengineering education bionanotechnology biosignal processing bioinformatics biomaterials biomechanics biomedical imaging biomedical instrumentation BioMEMS clinical engineering prosthetics Robot Grippers Gareth J. Monkman, Stefan Hesse, Ralf Steinmann, Henrik Schunk, 2007-02-27 Since robotic prehension is widely used in all sectors of manufacturing industry this book fills the need for a comprehensive up to date treatment of the topic As such this is the first text to address both developers and users dealing as it does with the function design and use of industrial robot grippers The book includes both traditional methods and many more recent developments such as micro grippers for the optoelectronics industry Written by authors from academia industry and consulting it begins by covering the four basic categories of robotic prehension before expanding into sections dealing with endeffector design and control robotic manipulation and kinematics Later chapters go on to describe how these various gripping techniques can be used for a common industrial aim with details of related topics such as kinematics part separation sensors tool exchange and compliance The whole is rounded off with specific examples and case studies With more than 570 figures this practical book is all set to become the standard for advanced students researchers and manufacturing engineers as well as designers and project managers seeking practical descriptions of robot endeffectors and their applications Advanced Robotic Hands Luigi Biagiotti, 2002 **Scientific and Technical Aerospace Reports**, 1995 **Robotics Research, 1989** American Society of Mechanical Engineers. Winter Annual Meeting, 1989 **Advance Papers of the Fourth International Joint Conference on Artificial Intelligence**, 1975 Robomatrix Reporter, 1988 Robot Control 1994 (SYROCO '94) Lorenzo Sciavicco, Claudio Bonivento, F. Nicolò, 1995 **Government Reports Announcements & Index**, 1992 *Advance Papers of the Conference*, 1975 **Advance Papers**, 1975 **Wearable Robots** José L. Pons, 2008-03-17 A wearable robot is a mechatronic system that is designed around the shape and function of the human body with segments and joints corresponding to those of the person it is externally coupled with Teleoperation and power amplification were the first applications but after recent technological advances the range of application fields has widened Increasing recognition from the scientific community means that this technology is now employed in telemanipulation man amplification neuromotor control research and rehabilitation and to assist with impaired human motor control Logical in structure and original in its global orientation this volume gives a full overview of wearable robotics providing the reader with a complete understanding of the key applications and technologies

suitable for its development The main topics are demonstrated through two detailed case studies one on a lower limb active orthosis for a human leg and one on a wearable robot that suppresses upper limb tremor These examples highlight the difficulties and potentialities in this area of technology illustrating how design decisions should be made based on these As well as discussing the cognitive interaction between human and robot this comprehensive text also covers the mechanics of the wearable robot and its biomechanical interaction with the user including state of the art technologies that enable sensory and motor interaction between human biological and wearable artificial mechatronic systems the basis for bioinspiration and biomimetism general rules for the development of biologically inspired designs and how these could serve recursively as biological models to explain biological systems the study on the development of networks for wearable robotics Wearable Robotics Biomechatronic Exoskeletons will appeal to lecturers senior undergraduate students postgraduates and other researchers of medical electrical and bio engineering who are interested in the area of assistive robotics Active system developers in this sector of the engineering industry will also find it an informative and welcome resource

Industrial Education ,1987 **Robotica** ,1990 *IECON '87* ,1987 Government Reports Annual Index ,1991 **British Universities' Guide to Graduate Study** ,1993 **International Encyclopedia of Robotics** Richard C. Dorf,1988
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