

# A dual-loop control system of grasping force for prosthetic hands

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**Abstract.** Despite the rapid developments of prosthetic hands technologies in recent years, there still exists a huge gap between prosthetic hands and human hands in flexibility. The limitation of sensors attached to the prosthetic hand is one of the causes, and another reason is that the materials, weight, and stiffness of the object gripped by a prosthetic hand are unknown. Additionally, the external disturbances in prosthetic hands are not certain. The factors mentioned above lead to difficulties in controlling grasping force of prosthetic hands, and that affects the quality of prosthetic hands applications. Therefore, it is important to design a stable and reliable system to control grasping force. This paper presents a dual-loop control system of grasping force for prosthetic hands, and we carried out some relative experiments based on a single degrees of freedom prosthetic hand. The experiment results show that the proposed control system is effective.

**Keywords:** dual-loop control system; prosthetic hands; reflex control; grasping force; fuzzy controller.

## 1 Introduction

Hands are an essential part of a human body, but some people may lose their hands due to some incidents, such as diseases, work injuries, traffic incidents, etc. Those people face big challenges in their daily life, and someone even has serious mental illnesses. To solve these problems, the prosthetic hand has been created. There are different types of prosthetic hands. According to the degrees of freedom (DOF), prosthetic hands are classified into single DOF hands and multi-DOF hands; according to the ways of actuation, prosthetic hands can be classified into hydraulic-drive hands, electric-drive hands, etc. During its evolution, the prosthetic hand has experienced changes from big-sized, two-finger to small-sized, multi-fingered. Meanwhile, the prosthetic hand turns precisely-grasped and becomes more functional compared with its initial functions like simple grasp. Generally speaking, tendencies of prosthetic hands' developments are humanoid, multi-functional and highly integrated. The ultimate goal of the invention of prosthetic hands is to offer people who lose hands a normal life.

The appearance of the prosthetic hand brings hope to the disabled, but some problems arose which restrict its further developments. For getting a better and functional prosthetic hand, designing a stable and reliable control system is a key point. As demonstrated in [1-3], methods for controlling prosthetic

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Fusion of Hard and Soft Control Strategies for the Robotic Hand Cheng-Hung Chen, Desineni Subbaram

Naidu, 2017-09-13 An in depth review of hybrid control techniques for smart prosthetic hand technology by two of the world's pioneering experts in the field Long considered the stuff of science fiction a prosthetic hand capable of fully replicating all of that appendage's various functions is closer to becoming reality than ever before This book provides a comprehensive report on exciting recent developments in hybrid control techniques one of the most crucial hurdles to be overcome in creating smart prosthetic hands Coauthored by two of the world's foremost pioneering experts in the field Fusion of Hard and Soft Control Strategies for Robotic Hand treats robotic hands for multiple applications It begins with an overview of advances in main control techniques that have been made over the past decade before addressing the military context for affordable robotic hand technology with tactile and/or proprioceptive feedback for hand amputees Kinematics homogeneous transformations inverse and differential kinematics trajectory planning and dynamic models of two link thumb and three link index finger are discussed in detail The remainder of the book is devoted to the most promising soft computing techniques particle swarm optimization techniques and strategies combining hard and soft controls In addition the book includes a report on exciting new developments in prosthetic robotic hand technology with an emphasis on the fusion of hard and soft control strategies Covers both prosthetic and non prosthetic hand designs for everything from routine human operations robotic surgery and repair and maintenance to hazardous materials handling space applications explosives disposal and more Provides a comprehensive overview of five fingered robotic hand technology kinematics dynamics and control Features detailed coverage of important recent developments in neuroprosthetics Fusion of Hard and Soft Control Strategies for Robotic Hand is a must read for researchers in control engineering robotic engineering biomedical sciences and engineering and rehabilitation engineering

**Theory And Practice Of Control And Systems - Proceedings Of The 6th Ieee Mediterranean Conference** Antonio Tornambe, Giuseppe Conte, Anna Maria Perdon, 1999-01-04 This volume gathers together all the lectures presented at the 6th IEEE Mediterranean Conference It focuses on the mathematical aspects in the theory and practice of control and systems including stability and stabilizability robust control adaptive control robotics and manufacturing these topics are under intense investigation and development in the engineering and mathematics communities The volume should have immediate appeal for a large group of engineers and mathematicians who are interested in very abstract as well as very concrete aspects of control and system theory

**Advances in Mechanism, Machine Science and Engineering in China** Xinjun Liu, 2023-05-31 This book presents the conference proceedings of the 23rd IFToMM China International Conference on Mechanism and Machine Science Engineering IFToMM CCMMS 2022 CCMMS was initiated in 1982 and it is the most important forum held in China for the exchange of research ideas presentation of technical and scientific achievements and discussion of future directions in the field of mechanism and

machine science The topics include parallel hybrid mechanism synthesis and analysis theoretical computational kinematics compliant mechanisms and micro nano mechanisms reconfigurable and metamorphic mechanisms space structures mechanisms and materials structure adaptation in space environment and ground testing large scale membrane deployable structures construction and application of super scale space systems cams gears and combining mechanisms fluid power mechatronics drivetrain mechanical design theory and methods dynamics and vibration control mechatronics biologically inspired mechanisms and robotics medical rehabilitation robotics mobile robotics soft robotics heavy non road mobile machine robot applications engineering education on mechanisms machines and robotics This book provides a state of the art overview of current advances in mechanism and machine science in China The inspiring ideas presented in the papers enlighten academic research and industrial application The potential readers include academic researchers and industrial professionals in mechanism and machine science

**Advances in Mechatronics and Control Engineering II** Krzysztof Galkowski, Yun Hae Kim, 2013-10-15 Selected peer reviewed papers from the 2013 2nd International Conference on Mechatronics and Control Engineering ICMCE 2013 August 28 29 2013 Guangzhou China *Intelligent Robotics and Applications* Jangmyung Lee, Min Cheol Lee, Honghai Liu, Jee-Hwan Ryu, 2013-08-23 This two volumes set LNAI 8102 and LNAI 8103 constitutes the refereed proceedings of the 6th International Conference on Intelligent Robotics and Applications ICIRA 2013 held in Busan South Korea in September 2013 The 147 revised full papers presented were carefully reviewed and selected from 184 submissions The papers discuss various topics from intelligent robotics automation and mechatronics with particular emphasis on technical challenges associated with varied applications such as biomedical application industrial automation surveillance and sustainable mobility

**Robot Control 1988 (SYROCO'88)** U. Rembold, 2014-05-23 Containing 88 papers the emphasis of this volume is on the control of advanced robots These robots may be self contained or part of a system The applications of such robots vary from manufacturing assembly and material handling to space work and rescue operations Topics presented at the Symposium included sensors and robot vision systems as well as the planning and control of robot actions Main topics covered include the design of control systems and their implementation advanced sensors and multisensor systems explicit robot programming implicit task orientated robot programming interaction between programming and control systems simulation as a programming aid AI techniques for advanced robot systems and autonomous robots

Robotics Oliver Brock, Jeffrey C. Trinkle, Jeff Trinkle, Fabio Ramos, 2009 State of the art robotics research on such topics as manipulation motion planning micro robotics distributed systems autonomous navigation and mapping Robotics Science and Systems IV spans a wide spectrum of robotics bringing together researchers working on the foundations of robotics robotics applications and analysis of robotics systems This volume presents the proceedings of the fourth annual Robotics Science and Systems conference held in 2008 at the Swiss Federal Institute of Technology in Zurich The papers presented cover a range of topics including computer vision mapping terrain identification distributed systems

localization manipulation collision avoidance multibody dynamics obstacle detection microrobotic systems pursuit evasion grasping and manipulation tracking spatial kinematics machine learning and sensor networks as well as such applications as autonomous driving and design of manipulators for use in functional MRI The conference and its proceedings reflect not only the tremendous growth of robotics as a discipline but also the desire in the robotics community for a flagship event at which the best of the research in the field can be presented

Bionic Limb Reconstruction Oskar C. Aszmann, Dario Farina, 2021-01-04 This book presents the latest techniques in amputation rehabilitation and summarizes the most recent research findings in the field of bionic limb reconstruction Divided into seven parts written by experts in the field it provides valuable information on e g upper extremity injuries psychological considerations prosthetic engineering and surgical and rehabilitation strategies Illustrative figures and photos of real life settings further assist understanding This book is of interest not only for plastic surgeons but also for hand surgeons orthopedic and trauma surgeons as well as therapists prosthetists and engineers

Mathematical and Control Applications in Agriculture and Horticulture Yasushi Hashimoto, W. Day, 1991-08-30 This title provides a general overview of recent developments and research into types of systems and their uses in the agricultural and horticultural industry 64 papers are included containing both theoretical models and applied examples for greenhouse systems harvesting technology and plant factory systems

*Robotics Research*, 1989 Robotics Research Hideo Hanafusa, Hirochika Inoue, 1985 The sixty two contributions in this book are by the world's leading researchers from Japan the United States France The United Kingdom Australia and West Germany They provide a unique opportunity to view the future shape of robotics in such areas as arm and hand design dynamics image understanding locomotion touch and compliance systems kinematics visual inspection control assembly and sensing In five parts the book covers visual perception including topics about representation and recognition of three dimensional objects sensory interaction and vision processors the computational aspect of manipulator control with chapters on kinematics and design and control theory implementation of action covering manipulator and end effector and mobile robots task level planning and theory of manipulation and discussions of industrial applications of robots and key issues of robotics research The first international symposium on robotics research was organized around a view of robotics as the intelligent connection of perception to action Edited by Michael Brady and Richard Paul it was published by The MIT Press in 1984 Hideo Hanafusa is Professor in the Automation Research Laboratory Kyoto University Hirochika Inoue is Professor in the Department of Electrical Engineering The University of Tokyo This book is thirteenth in The MIT Press Series in Artificial Intelligence edited by Patrick Henry Winston and Michael Brady

**Automatic Control in Aerospace, 1992** D. B. DeBra, Daniel B. DeBra, E. Gottzein, 1993 Space vehicles have become increasingly complex in recent years and the number of missions has multiplied as a result of extending frontiers in the exploration of our planetary system and the universe beyond The advancement of automatic control in aerospace reflects these developments Key areas covered in these proceedings include the size and

complexity of spacecrafts and the increasingly stringent performance requirements to be fulfilled in a harsh and unpredictable environment the merger of space vehicles and airplanes into space planes to launch and retrieve payloads by reusable winged vehicles and the demand to increase space automation and autonomy to reduce human involvement as much as possible in manned man tended and unmanned missions This volume covers not only the newly evolving key technologies but also the classical issues of guidance navigation and control **IEEE Region 8, EUROCON '2001** ,2001

**International Aerospace Abstracts** ,1998 *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society* IEEE Engineering in Medicine and Biology Society. Annual Conference,1989

**Dissertation Abstracts International** ,2000 Modeling and Control of Robotic Manipulators and Manufacturing Processes American Society of Mechanical Engineers. Winter Annual Meeting,1987 *1986 Proceedings* Harold S.

Stone,1986 **Proceedings** ,1986 **AIAA Space Programs and Technologies Conference and Exhibit: 93-4055 - 90-4099** ,1993

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