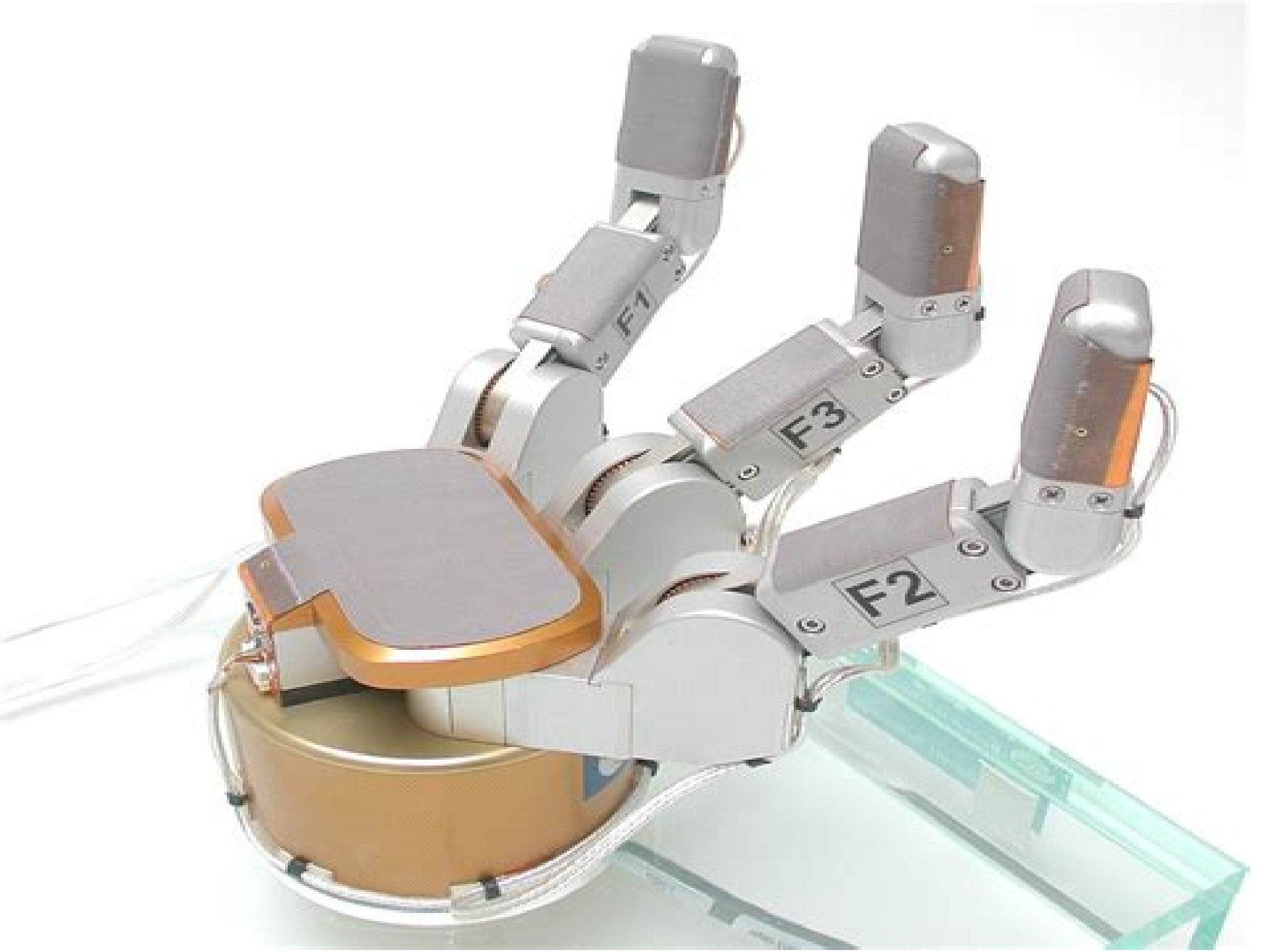
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Robot Tactile Sensing

John G. Webster

Robot Tactile Sensing:

Robotic Tactile Sensing Ravinder S. Dahiya,Maurizio Valle,2012-07-29 Future robots are expected to work closely and interact safely with real world objects and humans alike Sense of touch is important in this context as it helps estimate properties such as shape texture hardness material type and many more provides action related information such as slip detection and helps carrying out actions such as rolling an object between fingers without dropping it This book presents an in depth description of the solutions available for gathering tactile data obtaining aforementioned tactile information from the data and effectively using the same in various robotic tasks The efforts during last four decades or so have yielded a wide spectrum of tactile sensing technologies and engineered solutions for both intrinsic and extrinsic touch sensors Nowadays new materials and structures are being explored for obtaining robotic skin with physical features like bendable conformable and stretchable Such features are important for covering various body parts of robots or 3D surfaces Nonetheless there exist many more hardware software and application related issues that must be considered to make tactile sensing an effective component of future robotic platforms This book presents an in depth analysis of various system related issues and presents the trade offs one may face while developing an effective tactile sensing system For this purpose human touch sensing has also been explored The design hints coming out of the investigations into human sense of touch can be useful in improving the effectiveness of tactile sensory modality in robotics and other machines Better integration of tactile sensors on a robot s body is prerequisite for the effective utilization of tactile data The concept of semiconductor devices based sensors is an interesting one as it allows compact and fast tactile sensing systems with capabilities such as human like spatio temporal resolution This book presents acomprehensive description of semiconductor devices based tactile sensing In particular novel Piezo Oxide Semiconductor Field Effect Transistor POSFET based approach for high resolution tactile sensing has been discussed in detail Finally the extension of semiconductors devices based sensors concept to large and flexile areas has been discussed for obtaining robotic or electronic skin With its multidisciplinary scope this book is suitable for graduate students and researchers coming from diverse areas such robotics bio robots humanoids rehabilitation etc applied materials humans touch sensing electronics microsystems and instrumentation To better explain the concepts the text is supported by large number of figures **Robot Tactile Sensing** R. Andrew Russell,1990 This work introduces tactile sensing for those engaged in advanced sensor based robotics with special reference to problems of addressing arrays of sensor elements It describes tactile sensors to register contact surface profile thermal properties and other tactile sensing modes The use of robot manipulators to provide mobility for tactile sensors and techniques for applying tactile sensing in robotic manipulation and recognition tasks are also covered The various applications of this technology are discussed and robot hands and grips are detailed *Advanced Tactile Sensing for Robotics* H.R. Nicholls,1992-01-01 Advanced robot systems require sensory information to enable them to make decisions and to carry out actions in a versatile autonomous way Humans make

considerable use of information derived through touch and an emerging domain of robot sensing is tactile sensing This book considers various aspects of tactile sensing from sensor hardware design through to the use of tactile data in exploratory situations using a multi fingered robot hand Both introductory material and new research results are presented providing detailed coverage of the subject Applications from assembly automation to dextrous manipulation are examined and a particular theme is the relevance of biological touch to robotic tactile sensing The integration of these topics into a single volume make the book essential reading for all those interested in robotic sensing Contents Introduction to Tactile SensingTactile Sensor DesignsProcessing and Using Tactile Sensor Data H R Nicholls Planar Elasticity for Tactile Sensing R S Fearing Integrating Tactile Sensors ESPRIT 278 Z G Rzepczynski Distributed Touch Sensing H R Nicholls N W Hardy The Human Tactile System L Moss Salentijn Lessons from the Study of Biological Touch for Robotic Tactile Sensing S J Lederman D T Pawluck Lessons from the Study of Biological Touch for Robotic Haptic Sensing S J Lederman et al Object Recognition Using Active Tactile Sensing P K Allen Experiments in Active Haptic Perception with the Utah MIT Dextrous Hand P K Allen et al Future Trends in Tactile Sensing H R Nicholls Appendix Basic Linear Elasticity R S Fearing Readership Computer scientists and engineers *Tactile Sensing, Skill Learning, and Robotic Dexterous Manipulation* Qiang Li,Shan Luo,Zhaopeng Chen,Chenguang Yang,Jianwei Zhang,2022-04-02 Tactile Sensing Skill Learning and Robotic Dexterous Manipulation focuses on cross disciplinary lines of research and groundbreaking research ideas in three research lines tactile sensing skill learning and dexterous control The book introduces recent work about human dexterous skill representation and learning along with discussions of tactile sensing and its applications on unknown objects property recognition and reconstruction Sections also introduce the adaptive control schema and its learning by imitation and exploration Other chapters describe the fundamental part of relevant research paying attention to the connection among different fields and showing the state of the art in related branches The book summarizes the different approaches and discusses the pros and cons of each Chapters not only describe the research but also include basic knowledge that can help readers understand the proposed work making it an excellent resource for researchers and professionals who work in the robotics industry haptics and in machine learning Provides a review of tactile perception and the latest advances in the use of robotic dexterous manipulation Presents the most detailed work on synthesizing intelligent tactile perception skill learning and adaptive control Introduces recent work on human s dexterous skill representation and learning and the adaptive control schema and its learning by imitation and exploration Reveals and illustrates how robots can improve dexterity by modern tactile sensing interactive perception learning and adaptive control approaches *Tactile Sensors for Robotic Applications* Salvatore Pirozzi,2021-03-17 In recent years tactile sensing has become a key enabling technology to implement complex tasks by using robotic systems For example the successful execution of robotic grasping and manipulation tasks is strongly dependent on the knowledge of objects geometrical and physical characteristics especially when objects are deformable and can change

their shapes depending on their interaction with the environment To this aim robotic systems are more and more frequently equipped with sensorized grippers which estimate the object s features by using tactile sensors Moreover a safe and efficient physical Human Robot Interaction pHRI requires the knowledge of interaction forces and contact locations in order to perform cooperation and co manipulation tasks and to limit damage from accidental impacts This crucial information can be obtained through direct measurements by using an artificial sense of touch Very often in grasping tasks the object features can also be estimated by combining the tactile sensors with additional sensors e g the vision systems and the six axis force torque sensors Vision data are used more frequently due to the efficiency in data collection but the vision alone may not be an efficient solution due to the difficulties in extracting the image features from a complex background Many researchers have been working on integrating vision force torque and tactile data for object recognition for more than 30 years Recent papers on this field concern object pose and shape estimation combination of visual and tactile exploration procedures estimation of surface features match tactile features to visual maps reconstruct contact force torque from tactile data and object recognition by using cross modal approaches It is evident that the number of different contexts in which the sense of touch alone or in combination with other sensors can be fundamental for the robotic systems of the future is high and growing The aim of this Special Issue is to present robotic applications for which tactile sensing together with alternative sensing systems represent solutions that allow clear improvements for task automation High-resolution Tactile Sensing for Robotic Perception Wenzhen Yuan (Ph. D.),2018 Why is it so difficult for the present day robots to act intelligently in the real world environment A major challenge lies in the lack of adequate tactile sensing technologies Robots need tactile sensing to understand the physical environment and detect the contact states during manipulation A recently developed high resolution tactile sensor GelSight which measures detailed information about the geometry and traction field on the contact surface shows substantial potential for extending the application of tactile sensing in robotics The major questions are 1 What physical information is available from the high resolution sensor 2 How can the robot interpret and use this information This thesis aims at addressing the two questions above On the one hand the tactile feedback helps robots to interact better with the environment i e perform better exploration and manipulation I investigate various techniques for detecting incipient slip and full slip during contact with objects which helps a robot to grasp them securely On the other hand tactile sensing also helps a robot to better understand the physical environment That can be reflected in estimating the material properties of the surrounding objects I will present my work on using tactile sensing to estimate the hardness of arbitrary objects and making a robot autonomously explore the comprehensive properties of common clothing I also show our work on the unsupervised exploration of latent properties of fabrics through cross modal learning with vision and touch **Robotic Tactile Sensors for Changing Contact Conditions** Tae Myung Huh,2020 In recent years robots have increasingly operated in a range of relatively unstructured environments from outdoor agricultural operations to a cluttered kitchen in the

home As robots operate in these environments they interact through continuously changing contact conditions between their hands and feet and the surfaces they touch Toward allowing robots to respond to changing contact conditions this thesis presents new tactile sensors for three particularly challenging scenarios small running robots that need to sense changing contact conditions at their feet grippers that employ gecko inspired adhesion and need to sense how the adhesion is changing and frictional grippers that use controlled sliding for manipulation In each case the sensing solution is informed by models of the contacts and how they can change The first application focuses on leg ground contacts for small running robots Although legs are more complicated than wheels legged robots are gradually growing in popularity due to their agility and versatility on various outdoor terrains For best performance in terms of speed efficiency and robust operation legged robots should be equipped with sensors on their feet to monitor ground reaction forces and contact locations so that they can account for how these affect running dynamics However it has been challenging to implement force sensors on the legs of small running robots because of the scale and geometry To tackle this challenge I developed a flexible capacitive force sensor array that measures distributed normal forces and a shear force The sensor is mounted on the compliant C shaped feet of a small hexapod robot and provides information about the ground reaction forces contact locations and overall gait smoothness and stability Using the sensor information I demonstrate two adaptive gait control methods that achieve improved running in terrain transitions and that reduce trajectory disturbances arising from obstacle contacts Secondly this thesis addresses robots that rely on adhesion especially gecko inspired adhesion Grippers with astrictive force capabilities such as suction or adhesion adhere to an object surface even in with the negative grasp forces allowing to them handle challenging objects such as large flat tiles and large curved objects that they cannot enclose Among the various astrictive forces gecko inspired adhesion enjoys recent attention for its controllability it is activated simply by applying a shear force and releases when the shear force is relaxed However measuring the adhesion is difficult because it depends on the area of contact formed by microscopic fibrillar structures and a surface To tackle this challenge I devised two direct contact area sensors for a gecko adhesive gripper by using guided Lamb wave sensing and capacitive near field proximity sensing The former is relatively insensitive to the material of the adherend surface the latter provides a high spatial resolution which is useful for small grippers In both approaches I show that the sensor response matches the real contact area of the microscopic fibrillar structures sticking to a surface Using these sensors the robot can monitor contact area changes during a grasping process and evaluate the gripping quality before a failure occurs Lastly this thesis considers tactile sensing for in hand manipulation with sliding In this type of contact multimodal sensors are necessary to simultaneously monitor steady force interactions and dynamic contact events This information is useful both for stable gripping under varying load and for manipulation with respect to a hand However it has been challenging to build a compact multimodal sensor with a large taxel array that can be sampled rapidly for detecting directional dynamic events such as linear or rotational sliding To address this challenge I

devised a capacitive nib array sensor that measures local stresses as well as directional sliding motions The sensor rapidly samples the tactile array by dynamically clustering the sensing electrodes into groups that are selectively sensitive to certain types of directional sliding Using this sensor I demonstrate an in hand sliding manipulation that measures changing sliding contacts and controls the grasp force to pivot an object lying on a table to an upright pose High-resolution Tactile Sensing for Reactive Robotic Manipulation Siyuan Dong (Ph. D.),2021 This thesis explores tactile sensing to enable reactive behavior in robotic manipulation More specifically we focus on developing high resolution vision based tactile sensing hardware perceptual algorithms and controller designs for robotic manipulation Tactile sensing plays a key role in human manipulation However the existing artificial tactile sensors have multiple limitations in terms of form factor robustness and sparse measurement Tactile sensors are rarely integrated into the current robotic manipulation systems In this thesis we design new vision based tactile sensors that capture the contact surface with high resolution images and reconstruct the 3D geometry of the contact surface We first design a variation of the GelSight sensor that improves the accuracy of the depth map reconstruction To further optimize the form factor and enhance the robustness we designed another vision based tactile sensor GelSlim which keeps the high resolution sensing output but has a slimmer former sharper tip and improved robustness Based on the new sensor we propose algorithms to distill useful contact information from the raw signal output The key challenge is connecting the contact geometry directly observed from the raw image to contact signals that have meanings in the context of contact mechanics e g contact forces contact slip We use an algorithm to track the gel deformation and compare it with a rigid body motion to detect incipient slip We deploy an inverse Finite Element Method iFEM to reconstruct the contact force distribution Finally we explore how the tactile signals can be fed into the control loop in real manipulation tasks We choose 2 representative contact rich manipulation tasks that benefit from tactile control cable following and object insertion We implement cable following by sensing controlling both the state of the grasp of the cable and its configuration in realtime to allow smooth sliding of the fingers along a cable We train a general tactile based RL insertion policy in an end to end fashion to align the object pose with the insertion hole and keep sticking contact of the grasp by detecting incipient slip during the contact exploration The RL insertion policy is capable of inserting novel objects for which we show that tactile feedback is more informative than force torque feedback *Robot Tactile Sensing with Autonomous Reflexive Response* David A. Kemme,1992 *The Role of Tactile Sensing in Robot Manipulation* Sikka, Pavan,University of Alberta. Department of Computing Science,1994 **Learning Robot Tactile Sensing for Object Manipulation** Yevgen Chebotar,2014 Sensors and Sensory Systems for Advanced Robots Paolo Dario,Centro E. Piaggio,2012-12-06 This volume contains papers presented at the NATO Advanced Research Workshop ARW on Sensors and Sensory Systems for Advanced Robots which was held in Maratea Italy during the week Apri I 28 May 3 1986 Participants in the ARW who came from eleven NATO and two non NATO countries represented an i nternat i ona I assortment of d i st i ngu

i shed research centers in industry government and academia Purpose of the Workshop was to rev i ew the state of the art of sensing for advanced robots to discuss basic concepts and new ideas on the use of sensors for robot control and to provide recommendations for future research in this area There IS an almost unanimous consensus among invest i gators in the fie I d of robot i cs that the add i t i on of sensory capabi I ities represents the natural evolution of present industrial robots as wei I as the necessary premise to the development of advanced robots for nonindustrial app I i cat ions However a number of conceptua I and techn i ca I problems sti I I challenge the practical implementation and widespread appl ication of sensor based robot control techn i ques Cruc i a I among those prob I ems is the ava i lab iii ty of adequate sensors **Design of Active Sensing Smart Skin for Incipient Slip Detection in Robotic Applications** Cheng Liu (Researcher in robotic tactile sensing),2021 Tactile sensing is paramount for robots operating in human centered environments to help in understanding interaction with objects To enable robots to have sophisticated tactile sensing capability researchers have developed different kinds of tactile sensors for robotic hands to realize the sense of touch In this study we are focused on the incipient slip detection problem for robots which is known as one of the most challenging issues in robotic tactile sensing Currently most of the slip detection sensors are passive sensors which provide limited information about the sensing parameters Therefore this will usually require large amount of data and extra computation effort in accurately classifying slip conditions of robotic hands Other sensing mechanisms such as optical approaches which can provide enriched sensing parameters for slip detection often suffer from complex sensor configurations and being inflexible in terms of customization Active sensing on the other hand has the advantage of simple sensor configurations and in the meantime can provide more sensing parameters which will improve the overall efficiency of the tactile sensing capabilities for incipient slip detection In this thesis by using the active sensing method a novel active sensing smart skin technique is developed for incipient slip detection which leverages piezoelectric transducers as actuators sensors With this method a robotic fingertip with the embedded actuator and sensor were created in which the actuator generates ultrasonic guided waves received by the sensor during a slip scenario By analyzing the received signal using an attenuation based method we can monitor the entire contact area evolution during a slip scenario Therefore this method can serve as an excellent indicator for early slip detection with the advantage of accurately monitoring the contact condition In addition the frustrated total internal reflection method was used to validate the signal attenuation increases with the growing of the contact area Built on these results a unique robotic skin was then designed and fabricated which demonstrated robust and sensitive response for incipient slip detection Finally an LED slip alert system on a real gripper was developed to demonstrate the capability of our method to be applicable to real robotic finger situations **Sensors and Microsystems** Girolamo Di Francia,Corrado Di Natale,2022-06-28 This book showcases the state of the art in the field of sensors and microsystems revealing the impressive potential of novel methodologies and technologies It covers a broad range of aspects including bio physical and chemical sensors actuators

micro and nano structured materials mechanisms of interaction and signal transduction polymers and biomaterials sensor electronics and instrumentation analytical microsystems recognition systems and signal analysis and sensor networks as well as manufacturing technologies environmental food energy and biomedical applications The contents reflect the outcomes of the activities of AISEM Italian Association of Sensors and Microsystems in 2021 Co Edited by B And F Baldini G Betta D Compagnone S Conoci E Comini V Ferrari E La Salandra L Lorenzelli A G Mignani G Marrazza G Neri P Siciliano

Robotics in Industry 5.0: Human-Enhanced AI Automation Editors: Dr.K.Chandra Sekhar, Dr.N.Menaka, Mr. Arun T. A, Dr.S.Dineshkumar,Authors: Mr. R. Venkatesh, Mr. T. Kumarasan, Mr. M. Benedict, Ms. G. Subiksha, S.Maria Mercy, Mr. P. Jermia Arockia Pravin, Mr. Amit Kumar Srivastava, Dr. Vigneswaran C. M, Mr. R. Prem Kumar, Mrs. T. Mallika Devi, Mr. Prasad Nitin Varade, Mr. Mahendra M, Mr. Dasaradha Arangi, Mrs. T. Neha, Mr. Karthick. P,2026-03-27 Robotics in Industry 5 0 Human Enhanced AI Automation is a comprehensive guide that explores the next generation of industrial transformation where human intelligence and advanced robotics work collaboratively The book covers key concepts such as human robot collaboration cognitive AI smart sensing systems and advanced actuators providing a strong foundation in modern automation technologies It highlights the transition from Industry 4 0 to Industry 5 0 emphasizing human centric design sustainability and intelligent decision making systems Readers gain insights into emerging innovations like digital twins edge AI cyber physical systems and reinforcement learning in robotics The content bridges theory with real world applications across manufacturing healthcare and smart industries It also addresses ethical considerations safety and trust in autonomous systems Designed for students researchers and professionals the book enhances understanding of future ready industrial ecosystems Each chapter focuses on cutting edge developments shaping intelligent automation The structured approach ensures clarity in complex interdisciplinary topics Overall this book serves as a valuable resource for mastering human centered AI driven robotics **Springer Handbook of Robotics** Bruno Siciliano,Oussama Khatib,2016-07-27 The second edition of this handbook provides a state of the art overview on the various aspects in the rapidly developing field of robotics Reaching for the human frontier robotics is vigorously engaged in the growing challenges of new emerging domains Interacting exploring and working with humans the new generation of robots will increasingly touch people and their lives The credible prospect of practical robots among humans is the result of the scientific endeavour of a half a century of robotic developments that established robotics as a modern scientific discipline The ongoing vibrant expansion and strong growth of the field during the last decade has fueled this second edition of the Springer Handbook of Robotics The first edition of the handbook soon became a landmark in robotics publishing and won the American Association of Publishers PROSE Award for Excellence in Physical Sciences Mathematics as well as the organization s Award for Engineering Technology The second edition of the handbook edited by two internationally renowned scientists with the support of an outstanding team of seven part editors and more than 200 authors continues to be an authoritative reference for robotics researchers newcomers to the

field and scholars from related disciplines The contents have been restructured to achieve four main objectives the enlargement of foundational topics for robotics the enlightenment of design of various types of robotic systems the extension of the treatment on robots moving in the environment and the enrichment of advanced robotics applications Further to an extensive update fifteen new chapters have been introduced on emerging topics and a new generation of authors have joined the handbook s team A novel addition to the second edition is a comprehensive collection of multimedia references to more than 700 videos which bring valuable insight into the contents The videos can be viewed directly augmented into the text with a smartphone or tablet using a unique and specially designed app Springer Handbook of Robotics Multimedia Extension Portal http handbookofrobotics org Tactile Sensors for Robotics and Medicine John G. Webster,1988-11-15 A comprehensive review of the principles design and application of tactile sensors incorporating new research results Tactile sensors may be used in the augmentation or replacement of damaged human appendages and they are used in robots including applications in nuclear reactors in underwater exploration and in space Contributors examine characteristics and limitations of sensor materials the design of tactile sensors based on the physiology of the human hand and numerous applications of this emerging technology **Fuzzy Information and Engineering Volume 2** Bingyuan Cao,Tai-Fu Li,Cheng-Yi Zhang,2009-10-14 This book is the proceedings of the Third International Conference on Fuzzy Information and Engineering ICFIE 2009 held in the famous mountain city Chongqing in Southwestern China from September 26 29 2009 Only high quality papers are included The ICFIE 2009 built on the success of previous conferences the ICFIE 2007 Guangzhou China is a major symposium for scientists engineers and practitioners in the world to present their updated results ideas developments and applications in all areas of fuzzy information and engineering It aims to strengthen relations between industry research laboratories and universities and to create a primary symposium for world scientists in fuzzy fields as follows Fuzzy Information Fuzzy Sets and Systems Soft Computing Fuzzy Engineering Fuzzy Operation Research and Management Artificial Intelligence Fuzzy Mathematics and Systems in Applications etc **Tactile Sensory Information for Robots** A. B. Rombach,University of Sussex,1985 **An Overview of Tactile Sensing** Rajeev Agrawal,Ramesh Chand Jain,Rameśa Kumāra Jaina,1986

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