Review

Actuators and Sensors for Application in Agricultural Robots: A Review

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Abstract: In recent years, with the rapid development of science and technology, agricultural robots have gradually begun to replace humans, to complete various agricultural operations, changing traditional agricultural production methods. Not only is the labor input reduced, but also the production efficiency can be improved, which invariably contributes to the development of smart agriculture. This paper reviews the core technologies used for agricultural robots in non-structural environments. In addition, we review the technological progress of drive systems, control strategies, end-effectors, robotic arms, environmental perception, and other related systems. This research shows that in a non-structured agricultural environment, using cameras and light detection and ranging (LiDAR), as well as ultrasonic and satellite navigation equipment, and by integrating sensing, transmission, control, and operation, different types of actuators can be innovatively designed and developed to drive the advance of agricultural robots, to meet the delicate and complex requirements of agricultural products as operational objects, such that better productivity and standardization of agriculture can be achieved. In summary, agricultural production is developing toward a data-driven, standardized, and unmanned approach, with smart agriculture supported by actuator-driven-based agricultural robots. This paper concludes with a summary of the main existing technologies and challenges in the development of actuators for applications in agricultural robots, and the outlook regarding the primary development directions of agricultural robots in the near future.

Keywords: agricultural robots; actuator; smart agriculture; environmental perception; end-effectors

1. Introduction

In the last two decades, with the advent of the information age and unmanned farms, agricultural production methods have changed dramatically [1–3]. The development of science and technology has combined agricultural production technology with internet of things (IoT) technology more closely, making smart agriculture one of the mainstream modes of agricultural production [4–6]. In particular, the wide use of agricultural robots has revolutionized the traditional agricultural labor mode, reduced labor intensity, enhanced agricultural production efficiency, and improved agricultural products' production quality, promoting modern agriculture's development [7–9]. Agricultural robots are special robots applied in agricultural production operations and a new type of intelligent agricultural machinery, which can use multi-sensor fusion, automatic control, and other technologies to realize automatic and intelligent production of agricultural equipment, operating in the natural environment [10–12]. Nowadays, agricultural robots are being widely used in many aspects of agricultural production, completely or partially replacing or assisting people in agricultural production, improving agricultural production efficiency, and enhancing production safety performance [13–15]. According to the robot's working space, they can be divided into indoor and outdoor robots. On the one hand, indoor robots are mainly used in greenhouses and other similar scenarios, including indoor harvesting robots, fruit

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   Sensors & Actuators P. Bergveld,1984   **Sensors** Ramon Bardolet,Enrico Pigorsch,2012-12-06 This is the 5th edition of the Metra Martech Directory EUROPEAN CENTRES OF EXPERTISE SENSORS The entries represent a survey of European sensors development The new edition contains 425 detailed profiles of companies and research institutions in 22 countries This is reflected in the diversity of sensors development programmes described from sensors for physical parameters to biosensors and intelligent sensor systems We do not claim that all European organisations developing sensors are included but this is a good cross section from an invited list of participants If you see gaps or omissions or would like your organisation to be included please send details The data base invites the formation of effective joint ventures by identifying and providing access to specific areas in which organisations offer collaboration This issue is recognised to be of great importance and most entrants include details of collaboration offered and sought We hope the directory on Sensors will help you to find the right partners with whom you can cooperate successfully and reach new markets   *Silicon Sensors and Actuators* Benedetto Vigna,Paolo Ferrari,Flavio Francesco Villa,Ernesto Lasalandra,Sarah Zerbini,2022-04-12 This book thoroughly reviews the present knowledge on silicon micromechanical transducers and addresses emerging and future technology challenges Readers will acquire a solid theoretical and practical background that will allow them to analyze the key performance aspects of devices critically judge a fabrication process and then conceive and design new ones for future applications Envisioning a future complex versatile microsystem the authors take inspiration from Richard Feynman s visionary talk There is Plenty of Room at the Bottom to propose that the time has come to see silicon sensors as part of a Feynman Roadmap instead of the More than Moore technology roadmap The sharing of the author s industrially proven track record of development design and manufacturing along with their visionary approach to the technology will allow readers to jump ahead in their understanding of the core of the topic in a very effective way Students researchers engineers and technologists involved in silicon based sensor and actuator research and development will find a wealth of useful and groundbreaking information in this book   Embedded Systems Handbook Richard Zurawski,2005-08-16 Embedded systems are nearly ubiquitous and books on individual topics or components of embedded systems are equally abundant Unfortunately for those designers who thirst for knowledge of the big picture of embedded systems there is not a drop to drink Until now The Embedded Systems Handbook is an oasis of information offering a mix of basic a   *Technological Innovation for Smart Systems* Luis M. Camarinha-Matos,Mafalda Parreira-Rocha,Javaneh Ramezani,2017-04-19 This book constitutes the refereed proceedings of the 8th IFIP WG 5 5 SOCOLNET Advanced Doctoral Conference on Computing Electrical and Industrial Systems DoCEIS 2017 held in Costa de Caparica Portugal in May 2017 The 46 revised full papers were carefully reviewed and selected from 95 submissions The papers present selected results produced in engineering doctoral programs and focus on technological innovation for smart systems Research results and ongoing work are presented

illustrated and discussed in the following areas collaborative networks computational intelligence systems analysis smart manufacturing systems smart sensorial systems embedded and real time systems energy management energy optimization distributed infrastructure solar energy electrical machines power electronics and electronics   Department of Defense Catalog of Logistics Models ,1990   *Testbeds and Research Infrastructures, Development of Networks and Communities* Thomas Magedanz,Athanasius Gavras,Huu Thanh Nguyen,Jeffrey S. Chase,2010-12-02 This book constitutes the proceedings of the 6th International ICST Conference TridentCom 2010 held in Berlin Germany in May 2010 Out of more than 100 submitted contributions the Program Committee finally selected 15 full papers 26 practices papers and 22 posters They focus on topics as Internet testbeds future Internet research wireless sensors media and mobility and monitoring in large scale testbeds   *Sensors, Measurement and Intelligent Materials* Yun Hae Kim,Prasad Yarlagadda,2013-02-13 Selected papers from the 2012 International Conference on Sensors Measurement and Intelligent Materials ICSMIM 2012 December 26 27 2012 Guilin China   Complex and Composite Metal Oxides for Gas, VOC and Humidity Sensors, Volume 2 Bal Chandra Yadav,Pragati Kumar,2024-03-22 Approx 530 pages Provides an overview of the material preparation and synthesis strategies of metal oxide composite and metal oxide hybrid materials for use in gas and humidity sensors Reviews emerging advanced metal oxide materials such as perovskites spinel ferrites and quaternary materials for gas and VOC sensors Discusses the potential opportunities as well as challenges to be circumvented in the use of metal oxide materials to enable new sensor technologies   **Shaping the Future of IoT with Edge Intelligence** Rute C. Sofia,John Soldatos,2024-01-08 This book presents the technologies that empower edge intelligence along with their use in novel IoT solutions Specifically it presents how 5G 6G Edge AI and Blockchain solutions enable novel IoT based decentralized intelligence use cases at the edge of the cloud edge IoT continuum Emphasis is placed on presenting how these technologies support a wide array of functional and non functional requirements spanning latency performance cybersecurity data protection real time performance energy efficiency and more The various chapters of the book are contributed by several EU funded projects which have recently developed novel IoT platforms that enable the development and deployment of edge intelligence applications based on the cloud edge paradigm Each one of the projects employs its own approach and uses a different mix of networking middleware and IoT technologies Therefore each of the chapters of the book contributes a unique perspective on the capabilities of enabling technologies and their integration in practical real life applications in different sectors The book is structured in five distinct parts Each one of the first four parts focuses on a specific set of enabling technologies for edge intelligence and smart IoT applications in the cloud edge IoT continuum Furthermore the fifth part provides information about complementary aspects of next generation IoT technology including information about business models and IoT skills Specifically The first part focuses on 5G 6G networking technologies and their roles in implementing edge intelligence applications The second part presents IoT applications that employ machine learning and other forms of Artificial Intelligence

at the edge of the network The third part illustrates decentralized IoT applications based on distributed ledger technologies The fourth part is devoted to the presentation of novel IoT applications and use cases spanning the cloud edge IoT continuum The fifth part discusses complementary aspects of IoT technologies including business models and digital skills The Open Access version of this book available at http www taylorfrancis com has been made available under a Creative Commons Attribution Non Commercial CC BY NC 4 0 license   Handbook of Research of Internet of Things and Cyber-Physical Systems Amit Kumar Tyagi,Niladhuri Sreenath,2022-06-09 This new volume discusses how integrating IoT devices and cyber physical systems can help society by providing multiple efficient and affordable services to users It covers the various applications of IoT based cyber physical systems such as satellite imaging in relation to climate change industrial control systems e healthcare applications security uses automotive and traffic monitoring and control urban smart city planning and more The authors also outline the methods tools and algorithms for IoT based cyber physical systems and explore the integration of machine learning blockchain and Internet of Things based cloud applications With the continuous emerging new technologies and trends in IoT technology and CPS this volume will be a helpful resource for scientists researchers industry professionals faculty and students and others who wish to keep abreast of new developments and new challenges for sustainable development in Industry 4 0   Advances in Science, Engineering and Technology Tasneem Ahmed,Shrish Bajpai,Mohammad Faisal,Suman Lata Tripathi,2025-05-23 The objective of the conference was to provide a common platform for innovative academicians and industrial experts working in the fields of sciences engineering and information technology It provided a platform for knowledge exchange and the development of new ideas on the transformative technologies of quantum computing video analytics Artificial Intelligence and Machine Learning The conference also discussed the significance of cutting edge technologies specifically Machine Learning and its pivotal role in the future of science and industry   Euro-Par 2023: Parallel Processing Workshops Demetris Zeinalipour,Dora Blanco Heras,George Pallis,Herodotos Herodotou,Demetris Trihinas,Daniel Balouek,Patrick Diehl,Terry Cojean,Karl Fürlinger,Maja Hanne Kirkeby,Matteo Nardelli,Pierangelo Di Sanzo,2024-04-13 This book constitutes revised selected papers from the workshops held at the 29th International Conference on Parallel and Distributed Computing Euro Par 2023 which took place in Limassol Cyprus during August 28 September 1 2023 The 42 full papers presented in this book together with 11 symposium papers and 14 demo poster papers were carefully reviewed and selected from 55 submissions The papers cover all aspects of parallel and distributed processing ranging from theory to practice from small to the largest parallel and distributed systems and infrastructures from fundamental computational problems to applications from architecture compiler language and interface design and implementation to tools support infrastructures and application performance aspects Part I First International Workshop on Scalable Compute Continuum WSCC 2023 First International Workshop on Tools for Data Locality Power and Performance TDLPP 2023 First International Workshop on Urgent Analytics for Distributed Computing QuickPar 2023 21st

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