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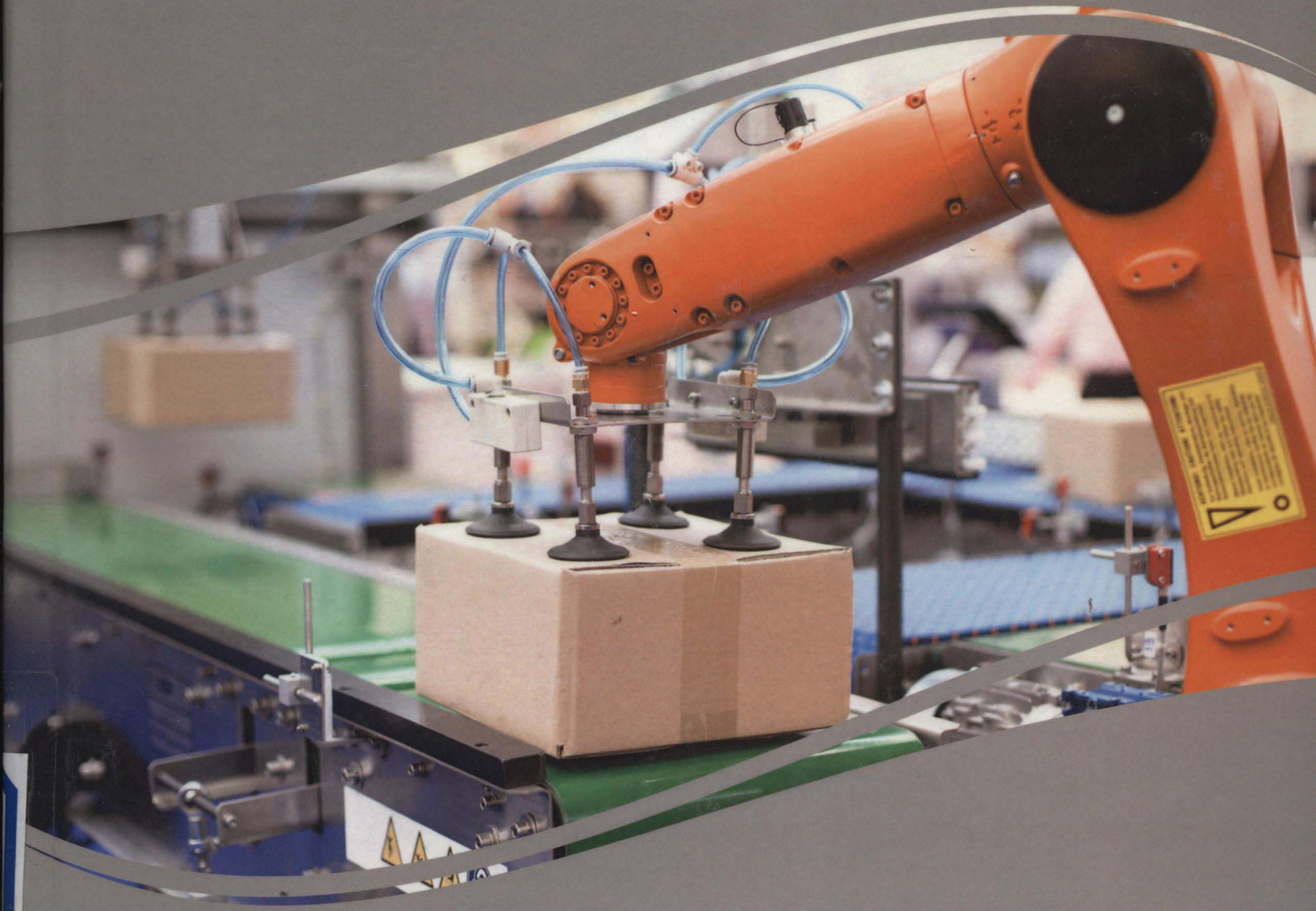

Zongwei Luo

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Robotics, Automation, and Control in Industrial and Service Settings

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A volume in the Advances in Civil and Industrial Engineering (ACIE) Book Series

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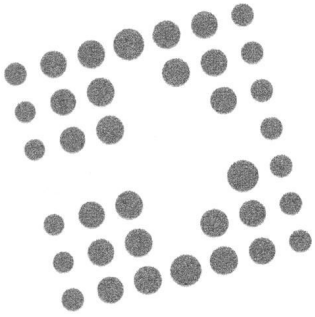

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Preface

INTRODUCTION

Robotics, as one of the representative intelligent technologies, is expected with significant demand not only to help address the labor cost rising and labor management problems, but also to provide human-like services and capabilities. Fast development in artificial intelligence and natural language processing has made robotics systems to interact with human with more friendly and natural interfaces. These user friendly and natural interfaces are especially valuable for robotics systems as expected pervasive adoption of service robotics in health-care and other human intensively-present environment would lead to humanoid robotics that are demanding more on human like interactions.

Traditional industrial robotics has less weight on Human Machine Interaction (HMI) as automation, precision, and dexterity is what is necessary. The recent industry trend of mass customization throughout whole manufacturing chains has led to attention of human intervention and relationship management in deriving agile and flexible manufacturing assembly lines. Meanwhile, robotics focused on service delivery will have to demand more on HMI performance. Typical interfaces include device interfaces like keyboards, joysticks, mouses, and touch screens, providing basic means for humans to interact with a robot. Natural language interface has become a very attractive means to allow humans to interact with a robot, thanks to fast advances of voice recognition and natural language processing technologies. Virtual reality enabled interactive technologies and motion capturing interface like MS Kinect are another means and have been becoming popular.

In enabling human like interactions, Internet of Things and Big Data Computing (IoT/Big Data) present promising ways for developing devices that sensing human and environment, and develop analytic algorithms and systems to identify and discover human motion and human affection. Cognitive service systems with human reasoning capabilities are one way towards this direction of development. While research in cognitive systems generally focuses on cognitive phenomena such as perception, attention, anticipation, planning, learning, and reasoning, it is more attractive to develop cognitive service systems based on IoT and Big Data Computing to explore new paradigms, methodologies and algorithms to develop intelligent service systems and applications.

ABOUT THIS BOOK

Vision for robotics, automation and control in industrial and service settings has been driven by fast advances in information technology (e.g. RFID, sensor, Internet of Things and Cloud). A smarter world

vision supported by ubiquitous interconnection and intelligence has generated considerable interest and demand for the next generation of robotics, automation and control technologies and their applications towards enabling smart manufacturing and human centric services.

This book would provide a forum of innovative findings in advanced robotics, automation and control research and development. It aims to promote an international knowledge exchange community involving a multidisciplinary participation from researchers, practitioners, and academics with insight addressing issues in real life problems towards smarter manufacturing and human centric services. By disseminating latest developments in robotics, automation, control innovation and transformation upon current and/or emerging technology opportunities and market imperatives, this book covers both theoretical perspectives and practical approaches for smart manufacturing and human-centric service research and development.

The target audience would include multidisciplinary participants from society, industry, academia, and government. The book would be suitable as a good reference book for college students and professors.

CONTENT OF THIS BOOK

Nowadays, there's an increasing number of robots in various environments. Intelligent robots have risen in agriculture, industry and service business. It involves fields such as food manufacturing, material processing and intelligent navigation. This book mainly focuses on robotics, automation and control, and their applications in industrial and service areas. It consists of 11 chapters classified in four sections, i.e. 1) introduction on robotics and the basic theories, algorithms and designing process, 2) introduction on automation and control, including basic information technologies and methodologies, 3) the industrial applications of robotics, automation and control, such as in bioinformatics, human-computer interaction, CNC machining optimization, etc., and 4) the service applications of robotics, automation and control, including advertising and risk management, etc. .

Section I on Introduction of Robotics Includes the Following Chapters

- **Chapter 1:** Assistive Intelligent Humanoid Robot in Human Environment, Zulkifli Mohamed, Genci Capi
- **Chapter 2:** Cooperative robots, Pablo Sánchez-Sánchez and Marco Antonio Arteaga-Pérez
- **Chapter 3:** Mobile Robot Path Planning using Voronoi Diagram and Fast Marching, S. Garrido and L. Moreno

Chapter 1 introduces a mobile humanoid robot that is able to localize itself, navigate to the target location, and generates the arm motion based on the specific task. The robot utilizes the Laser Range Finder (LRF), camera and compass sensor for localization and navigation. In addition, the robot generates the arm motion satisfying multiple motion criteria, simultaneously. This chapter evolves neural controllers that generate the humanoid robot arm motion in dynamic environment optimizing three different objective functions: minimum time, minimum distance and minimum acceleration. An advantage of proposed method is that in a single ran of Multi-Objective Genetic Algorithm, multiple neural controllers are generated. The same neural controller can be employed to generate the robot motion for a wide range of initial and goal positions.

Chapter 2 introduces the basic knowledge of cooperative robots. Cooperative robots are increasingly contributing to achieve greater flexibility optimization and application. Due to control techniques have enabled robotics implemented in different applications. Gripping objects of a set of robots require minimal integration architecture sensors, due to various factors such as the cost involved in getting encoders, the space required for integrating a manipulator, more transducers and the number of inputs and outputs can be contained in the data processing cards. A robot is a re-programmable, multi-functional manipulator designed to handle materials, tools or specialized devices through programmed movements. Movements include interaction with objects and the environment. A cooperative system consists of multiple robot manipulators which aimed to hold an object. Therefore, the position of the end-effector of each robot is limited geometrically. These constraints modeling the object and cause a reduction in degrees of freedom. This is because the end-effector of each robot must maintain contact with the object. Consequently, it cannot be moved in all directions. The degrees of freedom lost becomes in force contact. Therefore, they should be included in the dynamics of each robot to form the cooperative system.

Chapter 3 presents a new sensor-based Path Planner, which gives a fast local or global motion plan capable to incorporate the new obstacle data. For navigation in complicated environments, a robot must reach a compromise between the requirementl for having efficient and optimized trajectories and also the need for reacting to sudden events. This paper presents a new sensor-based Path Planner, which gives a fast local or global motion plan capable to incorporate the new obstacle data. Within the first step the safest areas in the environment are extracted by means of a Voronoi diagram. Within the second step the fast marching methodology is applied to the Voronoi extracted areas so as to get the trail. the strategy combines map-based and sensor-based designing operations to supply a reliable motion plan, whereas it operates at the frequency of the sensor. The most interesting characteristics are speed and reliability, as the map dimensions are reduced to a virtually one-dimensional map and this map represents the safest areas within the environment for moving the robot. Additionally, the Voronoi diagram is calculated in open areas, and with all reasonably shaped obstacles, that permits to use the planned trajectory methodology in advanced environments wherever different strategies of planning based on Voronoi don't work.

Section II on Introduction of Automation and Control Includes the Following Chapters

- **Chapter 4:** Interactive and Collaborative Virus-Evolutionary CNC Machining Optimization Environment, N.A. Fountas, N.M. Vaxevanidis, C.I. Stergiou, R. Benhadj-Djilali
- **Chapter 5:** Simulation of Manufacturing Processes via Virtual Reality, Mohamed-Amine Abidi, Barbara Lyonnet, Pierre Chevaillier, Rosario Toscano, Patrick Baert

Chapter 4 focuses on a novel approach of optimizing machining strategies applied to manufacture complex part geometries. A new genetic-evolutionary algorithm based on the virus theory of evolution is developed and new directions of manipulating manufacturing software tools are introduced. Research on the area of sculptured surface machining optimization is currently directed towards the implementation of artificial intelligence techniques. This chapter aims at presenting a novel approach of optimizing machining strategies applied to manufacture complex part geometries. Towards this direction a new genetic-evolutionary algorithm based on the virus theory of evolution is developed as a hosted module to a commercial and widely known CAM system. The new genetic algorithm automatically evaluates pairs of candidate solutions among machining parameters for roughing and finishing operations so as

to optimize their values for obtaining optimum machining programs for sculptured parts in terms of productivity and quality. This is achieved by introducing new directions of manipulating manufacturing software tools through programming and customization. The environment was tested for its efficiency and has been proven capable of providing applicable results for the machining of sculptured surfaces.

Chapter 5 introduces a new simulation system that makes it easy to understand the results of a given simulation. We deal with the main advantages of using the virtual reality (VR) to the manufacturing processes simulation and end up with a proposal of solution which allows to integrate VR with the simulation of production flows through a software architecture. In a world in continuous evolution, the different industrial actors need to be reactive to remain competitive and to conquer new market trends. To achieve this, they are constrained to improve their way of industrial management, both at the strategic level, to adapt to technological advances and follow market trends. At the strategic level, this leads manufacturers to update and adapt their ways of production management, improve the performance of manufacturing processes and reduce production deadlines to deal with the arrival of new products and certainly new competitors. In this chapter, we introduce a new simulation system that makes it easy to understand the results of a given simulation. This is of crucial importance because the design stage of a manufacturing system usually implies important actors that are not necessarily specialist of the mathematical concepts implied in the discrete event processes simulation. The objective of the chapter is to introduce the main advantages of using the virtual reality (VR) to the manufacturing processes simulation. To this end, a survey of the simulation of discrete event systems, also the main simulation tools and the different research works in VR that treats issues related to the industry will compose the greater part of this chapter. And we ends up with a proposal of solution which allows to integrate VR with the simulation of production flows through a software architecture.

Section III on Industrial Applications of Robotics, Automation and Control Includes the Following Chapters

- **Chapter 6:** Conceptual Process for Designing High-Technology Products: Case Study of a Litter-Collecting Robot, Arsalan Safari
- **Chapter 7:** Investigation of Optimum Conformations and Structure Analysis of RL and LR Nests using Ramachandran Plot, Sumukh Deshpande, Saikat Kumar Basu and Pooja Purohit
- **Chapter 8:** Strategic Role of Information and Information Technology in Shop Floor Control in Footwear Industry Sector, Sergio Ricardo Mazini
- **Chapter 9:** An Intuitive Teleoperation of Industrial Robots: Approach Manipulators by Using Visual Tracking Over A Distributed System, Andrea Bisson, Stefano Michieletto, Valentina Ferrari, Fabrizio Romanelli, Emanuele Menegatti

In Chapter 6, the authors study the design of a new high-technology product: a litter-collecting robot. The process includes problem definition and analysis, customer survey, market evaluation, requirement engineering, and product characteristics. Finally this approach we studied can be applied effectively to the design process of industrial products. In this study, a systematic and practical design process and methodology is applied to design a new high- technology product: a litter-collecting robot. Although considerable research has been conducted in product design and development, there is limited documented research on the practical design process on a detailed level. The design process discussed in this paper includes problem definition and analysis, customer survey, market evaluation, requirement engineering,

and product characteristics. These steps are followed by product design specifications, critical factors determination, and design solution generation. At the end, the system identification matrix, main system, subsystems, outputs, inputs, and product architecture schematic of the litter-collecting robot are designed and developed. The detailed and practical approach demonstrated on the design of a high- tech product in this paper, can be applied effectively to the design process of industrial products.

In Chapter 7, the study provides a demonstration of an important discovery of optimum conformations of RL and LR nests by the use of sophisticated bioinformatics automation pipeline and a unique application of automation and control in bioinformatics. They have surveyed polypeptides with the optimal conformations of nests which are the common anion-binding motifs comprising 8% of the amino acids which are characterized by a structural formation in which the main chain NH groups of three successive residues bind an anionic atom or group forming a depression or a hole. Using automated bioinformatics algorithm, novel ring structure of the nest has been found. The anion-binding site is characterized by alternating residues of αR or αL main-chain dihedral angles. Using automated algorithm, models of polypeptides were made in-silico (computationally) and oxygen atoms as if hydrogen-bonded are inserted along the extension of the NH groups. These sophisticated algorithms allow insertion of atoms along the NH group at the correct distance which causes extension of the group thus forming hydrogen bond. Optimal conformations of these structures are found from these customized models when one oxygen atom bridges two NH groups by forming an extra hydrogen bond with the next but one residue. This chapter provides a demonstration of an important discovery of optimum conformations of RL and LR nests by the use of sophisticated bioinformatics automation pipeline and a unique application of automation and control in bioinformatics.

Chapter 8 presents an approach to the strategic role of information and information technology in the shop floor control in footwear industry sector, pointing and tracking through the various stages of the production process. It discusses the importance of industries perform monitoring of production processes, with the goal of identifying information needs, actions and solutions that will contribute to the improvement and efficiency of the production process. The chapter also discusses the contribution of information technology to the information systems of companies, through the resources and solutions available today, such as Enterprise Resource Planning - ERP, Manufacturing Resource Planning - MRP and Shop Floor Control - SFC. The research method is the case study conducted in firm located in an industrial Brazilian footwear. This study examines the use of a solution called GradeSFC tracking and pointing of the production process.

Teleoperation of manipulator robots with RGB-D sensors is now mainly done using inverse kinematics techniques. In Chapter 9, instead, authors described an intuitive way to teleoperate an industrial manipulator robot using a vision sensor, in order to control directly the manipulator joints by retargeting specific human motion. In this way the human operator has the full control of robot movements with practically no training, because of the intuitivity of this teleoperation method. The remapping into the robot joints is done by computing angles between vectors built from positions of human joints, tracked by the used vision sensor. The system developed for this work uses a Comau manipulator robot and a Microsoft Kinect as vision sensor for the hardware part, and the Robot Operating System (ROS) framework for the software part in order to fulfill the teleoperation task. The system obtained is very modular which allows to change either the tracking sensor or the robot model with some small changes. Finally, the developed teleoperation system has been successfully tested on two real Comau robots, revealing to be fast and strongly reliable.

Section IV on Service Applications of Robotics, Automation and Control Includes the Following Chapters

- **Chapter 10:** A Gamification Mechanism for Advertising in Mobile Cloud, Zongwei Luo, Qixing Zhuang, Tao Jiang, Yang Liu, Feng Yi
- **Chapter 11:** Robotic Transformation and Its Business Applications in Food Industry, Anas Mathath and Yudi Fernando

In Chapter 10, authors propose a gamification mechanism for supporting advertising in mobile devices. Gamification for advertising uses game thinking and mechanism in non-game contexts to engage users in developing advertising content and delivering it into mobile devices. To support this gamification advertising mechanism, we develop a cloud based service platform for media integration and distribution, supporting flexible interactions and collaboration among media content providers, advertisers, and developers. Media content providers supply the advertising resources to the cloud. Advertisers provide requirements to customize the media contents for advertising. Developers will offer systems and tools to assemble advertising resources and integrate them with game content. Contribution of this chapter is it introduces game theory and mechanism design into gamification for advertising which is demonstrated as feasible and just in time. And the gamifiation for advertising is the first in the literature ever discussed as presented in the context of mechanism design. A layering solution with introduction of an advertising layer for developing gamified applications for mobile devices is also the first ever in the literature as we know.

Chapter 11 discusses the robotic transformation and its business applications in food industry. The role of robots is becoming substantial for industrial applications and business competitiveness. The robot transformation in food industry has increased business productivity, reduced cost and enhanced customer experiences. The usage scale of robots has an increasing trend globally when industries modernize and increase the production capacities with ability in handling complex tasks. In food industry robots should fulfill the basic requirements like hygiene and ease of programming. Robots serve mainly in production systems for material handling and packaging operations. Although robotics provides a better interface to raise productivity, small scale food companies are often reluctant to invest in robotics and infrastructure. High initial investment and maintenance costs are the obstacles. They also need to spent additional costs to employed skilled employees for its programming. Besides that the challenges of robot transformation are being faced by the large scale companies as well. There are two points raised in the discussion, would the robot technology which has been developed only capable owned by large scale food companies and the experiences gained in the restaurant which serves by robots can replace the human touch. At the end of this chapter, some solutions are given to shed light on the application of robot in food industry and deepen critical analysis for researchers, technocrats and business practitioners.

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Section 1

Introduction of Robotics

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