Springer Series in Advanced Manufacturing

Sotiris Makris

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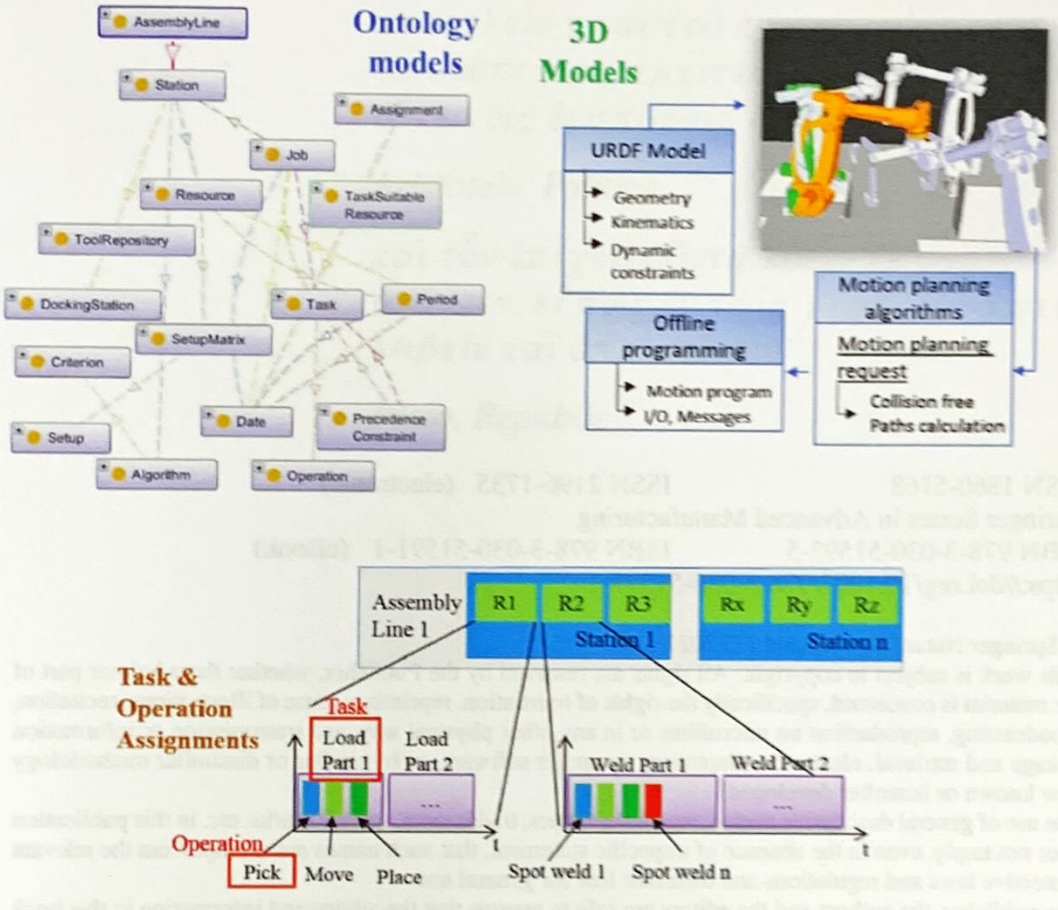




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# Preface

This book is the derivation of my research work at the Laboratory for Manufacturing Systems and Automation, University of Patras in Greece. It is based on close interaction with both industry and research colleagues. There have been many great ideas conceived over these years of research on the topic of cooperating robots for flexible manufacturing. This book writing is an effort to share these experiences with a broader audience in a format that is concise enough to summarize many different concepts but also provides adequate detail and references to allow those interested to follow similar a direction.

This book aims to consolidate the content of discussions and experiences with experts, practitioners and engineers in manufacturing systems. With the great variety of manufacturing systems, we had the opportunity to study a noteworthy set of methods and tools have been produced. The aim of the book is sharing this experience with academia and industry practitioners hoping to contribute to improving manufacturing practice. While there is a plethora of books detailed enough to teach principles of robotics, this book offers a unique opportunity to dive into the practical aspects of implementing real-world complex robotic applications.

The term "Cooperating robots" in this book refers to robots that either cooperate between themselves or cooperate with people. The book investigates aspects of cooperation towards implementing flexible manufacturing systems. Therefore, manufacturing systems are the main driver behind the discussion on implementing such robotic systems.

Numerous methods have been proposed to design and to operate manufacturing systems. This book aims to introduce a novel set of methods for designing and operating manufacturing systems consisting of cooperating robots. Many methods are available in the literature on designing or operating robotized manufacturing systems when the main priority is efficiency and robustness; the essential element of these robotized manufacturing systems is the need for flexibility.

Initially, the concept of a manufacturing system will be briefly introduced, followed by aspects of flexibility. Following the key aspects of robotic systems will be introduced while the discussion will be streamlined towards implementing systems of cooperating robots towards flexible manufacturing systems. Aspects of designing such systems, such as considering material flow, logistics, processing

times, shop floor footprint and design of flexible handling systems, are going to be discussed. Additionally, key issues in operating such systems involve decision making, autonomy, cooperation, communication, task scheduling, motion generation and distribution of control at the control level of different devices among others.

The book consolidates knowledge published in papers with co-authors; however, it introduces several novel concepts that have not been published before. It presents a number of chapters in the form of technical papers discussing industrial challenges and approaches taken. These chapters are organized in four major parts. Part I introduces the topics of cooperating robots in two dimensions. On the one hand, there are the topics of robots cooperating among themselves, and on the other hand, there are the aspects of robots cooperating with humans. Part II includes aspects of robot to robot cooperation. Part III elaborated aspects of collaborative robotics, namely humans cooperating with robots. Part IV summarizes with an outlook for the future.

I would like to thank the European Commission for the financial support in my research over the years. Thanks to a number of funding programs, namely the Factories of the Future program and the Robotics initiative it has been possible to facilitate this work in cooperation with the European industry and realize the journey towards implementing the vision discussed throughout this book. Moreover, I am grateful for a number of leading European manufacturing companies for the great cooperation, namely Daimler, PSA, FCA, Volvo, Ford, Bic Violex, Electrolux, Comau, Prima Industrie, Siemens, Festo and Pilz. I have enjoyed extensive and fruitful conversations over the years.

My very good friends and associates in our Laboratory for Manufacturing Systems and Automation, in the University of Patras, have been invaluable in both performing research activities and also achieving this first edition of the manuscript. Special thanks to the colleague and friend, Dr. George Michalos for his persistence and hard work in many fronts and for sharing the vision for researching the issues of cooperating robots in industry.

In addition, I am grateful for the support and good cooperation with Professor Dimitris Mourtzis from the manufacturing systems group in LMS, Dr. Kosmas Alexopoulos from the software development group in LMS and Professor Panagiotis Stavropoulos from the manufacturing processes group in LMS.

I would like to thank the great team I had the opportunity to cooperate with over the years, in the Laboratory for Manufacturing Systems and Automation, in the University of Patras. They have been a great help in developing these topics, and I am grateful for their passion and commitment; Niki Kousi, Panagiotis Karagiannis, Panagiotis Aivaliotis, Apostolis Papavasileiou, Dionisis Andronas, Christos Gkournelos, Stereos Matthaiakis, Andreas Sardelis, Konstantinos Dimoulas, Nikolaos Nikolakis, Charalampos Kouros, Spyros Koukas, Plato Sipsas, Evangelos Xanthakis, Dr. Loukas Renztos, Dr. Konstantinos Efthymiou and Dr. Panagiota Tsarouchi have greatly contributed to the work behind the actual manuscript over the years. There are many others not being mentioned, and I would like to thank them all.

Above all, I would like to thank my teacher and mentor, Prof. George Chryssolouris, for his encouragement and enlightenment over the years.

Finally, I would like to greatly and warmly thank my wife, Sophia, for the tolerance and support over the years as well as my children, John and Dimitra, wishing them a bright future.

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