IFIP Advances in Information and Communication Technology 530

IFIP – The International Federation for Information Processing

IFIP was founded in 1960 under the auspices of UNESCO, following the first World Computer Congress held in Paris the previous year. A federation for societies working in information processing, IFIP's aim is two-fold: to support information processing in the countries of its members and to encourage technology transfer to developing nations. As its mission statement clearly states:

> *IFIP is the global non-profit federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and application of information and communication technologies.*

IFIP is a non-profit-making organization, run almost solely by 2500 volunteers. It operates through a number of technical committees and working groups, which organize events and publications. IFIP's events range from large international open conferences to working conferences and local seminars.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is generally smaller and occasionally by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

IFIP distinguishes three types of institutional membership: Country Representative Members, Members at Large, and Associate Members. The type of organization that can apply for membership is a wide variety and includes national or international societies of individual computer scientists/ICT professionals, associations or federations of such societies, government institutions/government related organizations, national or international research institutes or consortia, universities, academies of sciences, companies, national or international associations or federations of companies.

More information about this series at http://www.springer.com/series/6102

Svetan Ratchev (Ed.)

Precision Assembly in the Digital Age

8th IFIP WG 5.5
International Precision Assembly Seminar, IPAS 2018
Chamonix, France, January 14–16, 2018
Revised Selected Papers

Springer

Editor
Svetan Ratchev
University of Nottingham
Nottingham, UK

ISSN 1868-4238 ISSN 1868-422X (electronic)
IFIP Advances in Information and Communication Technology
ISBN 978-3-030-05930-9 ISBN 978-3-030-05931-6 (eBook)
https://doi.org/10.1007/978-3-030-05931-6

Library of Congress Control Number: 2018964127

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Assembly, as one of the traditionally most difficult processes to automate, is being transformed by the advances in informatics technologies. Technological developments such as big data analytics, intelligent and autonomous machines and systems, smart devices, and the Industrial Internet of Things (IIoT) have been identified as key for how future assembly systems are designed and deployed.

This book includes a selected set of papers presented at the 8th International Precision Assembly Seminar (IPAS 2018) held in Chamonix, France, in January 2018. The International Precision Assembly Seminar, which was first held in 2003, was conceived by the European Thematic Network Assembly-Net with the objective of providing a forum for the precision assembly community to share the latest research results, discuss new ideas in a wide range of assembly theory and practice, and demonstrate new industrial applications. Now in its eighth edition, the seminar has become a traditional biennial international event bringing together researchers in precision assembly.

With every seminar the research program has evolved to better reflect new scientific and industrial challenges. Originally started with a specific focus on micro-assembly processes and systems, the scope of the seminar now includes precision assembly topics in a wide range of product types, sizes, and volumes of manufacture. The specific focus of the 8th IPAS 2018 seminar has been greatly influenced by the recent developments in digital technologies for manufacturing and the Industry 4.0 research agenda. The contributions therefore address a number of related research topics including: machine vision and metrology for assembly operations, gripping and handling technologies, numerical methods and planning in assembly, digital technologies and Industry 4.0 applications, precision assembly methods, assembly systems and platforms, human cooperation and machine learning.

The book is structured into five chapters. Chapter 1 addresses different aspects of design and deployment of assembly systems with specific emphasis on architectures, concepts, resource planning, and scheduling. Chapter 2 critically examines some of the latest developments in human–robot interactions including novel solutions for automated disassembly, gesture-based programming, zone planning and machine vision-based robot control. Some novel assembly process methods and models for trade-off analysis in design for joining, fabrication, and assembly of piezo-ceramic fiber array transducers and cloud-based data analytics framework for assembly are presented in Chapter 3. Chapter 4 considers the impact of Industry 4.0 technologies in terms of informatics-rich metrology, low-cost IIoT-enabled smart tools, informatics-enabled assembly platforms, and impact of digital technologies for SMEs. Specific research aspects of part handling and gripping are discussed in Chapter 5, including micro-grippers design and control and methods for rigid body registration.

The seminar is sponsored by the International Federation of Information Processing (IFIP) WG 5.5 and the International Institution of Production Engineering Research (CIRP).

The organizers should like to express their gratitude to the members of the International Advisory Committee for their support and guidance and to the authors of the papers for their original contributions and enthusiastic and active participation in the seminar. My special thanks go to Professor Luis Camarinha-Matos, chair of the IFIP WG 5.5, and Professor J. W. Sutherland, chair of the STC-A of CIRP for their continuous support and encouragement. My special thanks also go to Ruth Strickland, Nancy Martin, Florence Drouvin, and Sarah Hannon-Bland from the Institute for Advanced Manufacturing of the University of Nottingham and Evelyne Roudier-Poirot from the Tourist Office of Chamonix for handling the administrative aspects of the seminar, putting the proceedings together, and managing the detailed liaison with the publishers.

November 2018 Svetan Ratchev

Organization

International Advisory Committee

M. Aurisicchio	Imperial College London, UK
D. Axinte	University of Nottingham, UK
J. Barata	UNINOVA, Portugal
M. Björkman	Linköping Institute of Technology, Sweden
D. Branson	University of Nottingham, UK
A. Delchambre	ULB, Belgium
M. Desmulliez	Heriot-Watt University, UK
M. Dickerhof	Karlsruhe Institute for Technology, Germany
S. Dimov	University of Birmingham, UK
G. Dini	University of Pisa, Italy
A. Drouot	University of Franche-Comté, France
K. Ehmann	Northwestern University, USA
I. Fassi	ITIA-CNR, Italy
P. Felli	Free University of Bozen-Bolzano, Italy
J. Jacot	EPFL, Switzerland
M. Krieger	CSEM, Switzerland
P. Lambert	ULB, Belgium
M. Lanz	Technical University of Tampere, Finland
R. Leach	University of Nottingham, UK
N. Lohse	Loughborough University, UK
P. Lutz	ENSMM, France
H. Maekawa	AIST, Japan
B. Nelson	ETH, Switzerland
M. Onori	KTH, Sweden
D. Pham	University of Birmingham, UK
M. Pillet	University of Savoie Mont Blanc, France
G. Putnik	University of Minho, Portugal
A. Raatz	Leibniz University of Hannover, Germany
K. Ridgway	University of Sheffield, UK
J. Segal	University of Nottingham, UK
W. Shen	National Research Council, Canada
M. Tichem	TU Delft, The Netherlands
T. Tolio	Milan Polytechnic, Italy

Contents

Assembly Methods and Models

Digital Technologies and Industry 4.0 Applications

Gripping and Handling Solutions in Assembly