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The Handbook of Formal Methods in Human-Computer Interaction

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ISSN 1571-5035

Human—Computer Interaction Series

ISBN 978-3-319-51837-4

ISBN 978-3-319-51838-1 (eBook)

DOI 10.1007/978-3-319-51838-1

Library of Congress Control Number: 2016963425

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Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer International Publishing AG

The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The aim of this book was to present a snapshot of the use of Formal Methods in Human-Computer Interaction. Through contributed chapters and edited reviews, its goal was to capture the state of the art and suggest potential future topics for theoretical research and practical development.

Formal Methods have a long history in Human-Computer Interaction studies and play a central role in the engineering of interactive systems. Modelling, execution and simulation, as well as analysis, validation and verification, are key aspects for the application of formal methods in the engineering of interactive systems. This Handbook on Formal Methods in Human-Computer Interaction was motivated as an outcome of a workshop conducted at the 7th ACM SIGCHI Symposium on Engineering of Interactive Computing Systems (EICS) 2015 which took place in Duisburg, Germany. The main goal of this workshop was to offer an exchange platform for scientists who are interested in the formal modelling and description of interaction, user interfaces and interactive systems. The workshop further picked up the goal of a workshop organized at ACM SIGCHI conference on Human Factors in Computing Systems (CHI'96) in Vancouver, which was the initiation of a book publication released in 1997 edited by Palanque and Paternò.

Since then, various workshops have been conducted, among these the workshop on Formal Aspects of the Human Computer Interface (FAHCI) in 1996 in Sheffield and the series of workshops on “Formal methods and interactive systems” in 2006 in Macau, 2007 in Lancaster, 2009 in Eindhoven, 2011 in Limerick and 2013 in London. Nevertheless, the last comprehensive collection of work in Formal Methods in Human-Computer Interaction is published by Palanque and Paternò (1997). It succeeded the book published by Harrison and Thimbleby (1990), which presents a wide collection of techniques comparable to that by Palanque and Paternò. In this regard, this book presents an update after nearly two decades of work in the field.

Formal modelling in the description of interaction, user interfaces and interactive systems is still of great interest in current research and modelling strategies. Formal models offer advantages such as computer-based validation and verification, formal modification capabilities and the ability to be executable. In domains such as

aeronautics, formal methods are required by standards (such as DO 178-C supplement 333¹) making the use of both declarative formal approaches for requirements and property's description and procedural state-based formal approaches for systems descriptions mandatory. This use of formal methods is meant to complement (and not replace) testing approaches. Nevertheless, formal modelling has undergone various discussions identifying disadvantages, such as inflexibility, high modelling effort, high learning curve or inefficiency in a wider sense. The EICS 2015 workshop was intended to discuss existing formal modelling methods in this area of conflict. Therefore, participants were asked to present their perspectives, concepts and techniques for formal modelling by means of one or two case studies. The recommended case studies defined a basic structure for the workshop and further dealt as seed for discussions during the workshop. This idea has been picked up for this book, which provides an extended set of case studies that are used by authors throughout all chapters, which makes the presented methods and concepts comparable to a certain degree and offers indications to which focus the presented approaches address. The chapters are comprised of extended versions of the workshop's submissions as well as of chapters provided by invited authors who present their additional perspectives on the topic of Formal Methods in Human-Computer Interaction, complementing the workshop's submissions.

In this regard, the Handbook on Formal Methods in Human-Computer Interaction presents a comprehensive collection of methods and approaches, which address various aspects and perspectives on formal methods and highlight these by means of a compilation of case studies. The latter have been selected as relevant scenarios for formal methods in HCI each focusing on different aspects, such as multi-user versus single-user scenarios, safety critical versus non-critical situations, or WIMP-based versus multi-modal and non-WIMP-based interaction techniques. The book offers an extensive discussion of the state of the art, highlights the relevant topics in HCI for the application of formal methods, presents trends and gaps in the field of study and finally introduces the previously mentioned set of case studies. Furthermore, it contains three thematic sections in its main part.

The first section presents approaches and methods that focus on the use of formal methods for the modelling, execution and simulation of interactive systems. It introduces various methods for the modelling of user interfaces, description of the user's behaviour and a concept for the characterization of physical devices. Furthermore, it presents a concept for the description of low-intention interaction as well as a rule-based formalization of adaptable user interface models.

The second section focuses on the analysis, validation and verification of interactive systems using formal methods. Topics in this section address the verification of interaction through task-centric approaches, e.g. based on task decomposition or methods including models of the user's behaviour. It further presents an

¹DO-178C/ED-12C, Software Considerations in Airborne Systems and Equipment Certification, published by RTCA and EUROCAE, 2012 and DO-333 Formal Methods Supplement to DO-178C and DO-278A, December 2011.

approach on the use of reasoning for the verification of interactive systems in dynamic situations as well as the specification and analysis of user properties of safety critical systems.

Finally, the third section concentrates on future opportunities and developments emerging in the field of Formal Methods in Human-Computer Interaction. It discusses an approach for enhanced modelling support using domain-specific descriptions, a tool suite for the specification of interactive multi-device applications as well as a method for the modelling of app-ensembles. Furthermore, work on the interactive support for validation and verification is presented as well as a perspective on dealing with faults during operations, describing fault-tolerant mechanisms for interactive systems using formal methods.

With this selection of topics, the book targets scientists interested in and working on formal methods for the description and analysis of interaction, user interfaces and interactive systems as well as practitioners who are interested in employing formal methods in the engineering of interactive systems. Through its thematic organization, the reader can approach the topics either by diving directly into one of these or by letting themselves be inspired by the various case studies. Furthermore, the reader can start with an overview of the past work or with a perspective on possible future investigations. A well-structured start to read is offered by the chapter on topics of Formal Methods in Human-Computer Interaction as it summarizes all chapters and puts them into context.

Finally, we would like to acknowledge all authors and contributors of this handbook as without their enthusiasm, work and large investment of time it would not have been possible to bring together this great compilation of methods, concepts and approaches that characterize the field of Formal Methods in Human-Computer Interaction. Furthermore, we would like to thank our families and supporters who first and foremost made it possible to write this book.

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*The original version of the book was revised:
For detailed information please see erratum.
The erratum to this book is available at
[10.1007/978-3-319-51838-1_21](https://doi.org/10.1007/978-3-319-51838-1_21)*

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