

SpringerBriefs in Computer Science

Series editors

Stan Zdonik, Brown University, Providence, Rhode Island, USA

Shashi Shekhar, University of Minnesota, Minneapolis, Minnesota, USA

Xindong Wu, University of Vermont, Burlington, Vermont, USA

Lakhmi C. Jain, University of South Australia, Adelaide, South Australia, Australia

David Padua, University of Illinois Urbana-Champaign, Urbana, Illinois, USA

Xuemin Sherman Shen, University of Waterloo, Waterloo, Ontario, Canada

Borko Furht, Florida Atlantic University, Boca Raton, Florida, USA

V. S. Subrahmanian, University of Maryland, College Park, Maryland, USA

Martial Hebert, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

Katsushi Ikeuchi, University of Tokyo, Tokyo, Japan

Bruno Siciliano, Università di Napoli Federico II, Napoli, Italy

Sushil Jajodia, George Mason University, Fairfax, Virginia, USA

Newton Lee, Newton Lee Laboratories, LLC, Tujunga, California, USA

More information about this series at <http://www.springer.com/series/10028>

Rae Earnshaw

Research and Development in Digital Media

Rae Earnshaw
Centre for Visual Computing,
Faculty of Engineering and Informatics
University of Bradford
Bradford
UK

and

School of Creative Arts
Wrexham Glyndŵr University
Wrexham
UK

ISSN 2191-5768 ISSN 2191-5776 (electronic)
SpringerBriefs in Computer Science
ISBN 978-3-319-73079-0 ISBN 978-3-319-73080-6 (eBook)
<https://doi.org/10.1007/978-3-319-73080-6>

Library of Congress Control Number: 2017963839

© The Author(s), under exclusive licence to Springer International Publishing AG, part of Springer Nature 2018

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG part of Springer Nature

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

*This book is dedicated to my parents
for providing inspiration and educational
opportunities.*

Foreword

It has always been a pleasure working with Prof. Rae Earnshaw the professional, dedicated researcher, and educationalist. His broad knowledge of digital media, his association with international professionals around the world, and above all the respect he commands from his peers, are rare qualities. So when Rae asked me to write the Foreword for his latest book, I accepted with pleasure, as I believe that I can write about his mastery of the subject with some authority.

Today's digital revolution has spawned many parallel revolutions including in computer animation, data visualization, film special effects, digital music, digital medical diagnosis, information systems, autonomous vehicles, the human-computer interface and more recently, artificial intelligence. These are not only influencing our personal lives, but are changing and improving industrial processes, academic practices, and research directions.

Trying to predict the future in such a dynamic environment is fraught with problems—nevertheless, we all seek guidance in order to plan for our short-term and long-term goals. In the field of digital media, there are few people one can consider asking, but one of these is Rae Earnshaw. Rae has witnessed the revolution in digital media and he possesses an incredible historical perspective with first-hand practical experience of digital technology, academia, and research. Fortunately, he has transferred much of this knowledge into *Springer Briefs in Computer Science* to inform readers in their quest for guidance in this digital minefield.

Rae has recently published four books in this series:

Research and Development in Art, Design and Creativity focusses Rae's specialist knowledge of digital computers in art, design and creative activities, and provides a unique insight into some large European projects he has worked on.

Research and Development in the Academy, Creative Industries and Applications includes chapters on models of interaction between academia and industry, technology transfer and some relevant case studies.

Art, Design and Technology: Collaboration and Implementation considers independent and collaborative working strategies, using and implementing digital systems and installation artworks.

State of the Art in Digital Media and Applications reflects upon the historical origins of digital media and offers a vision of the future for digital imaging, digital libraries, applications, social media, and cultural implications.

This fifth book: *Research and Development in Digital Media* is essential reading for anyone working on digital media research programs. Its chapter on *Digital Media Theory* reviews media theory and the changes caused by the transition to digital environments and digital forms of media. It also addresses the role of the individual in content generation, informing communities via viral communication, which impact on social and political events. Another chapter on *Grant Funding for Research and Development in Digital Media Applications*, reviews a wide variety of grant funding agencies in Europe, USA, and the UK. Rae highlights their potential contributions to various digital media themes. The chapter on *Visual Analytics and Big Data* is very timely and covers data streaming, visual communication, knowledge generation, machine learning and autonomous analytics. The fourth chapter on *Visual Information Interfaces*, encompasses the different ways we interact with computers such as virtual reality, augmented reality, simulated walk-throughs, and the human-computer interfaces required to support mobile technologies. This is followed by a companion chapter on *Research and Development on Interfaces of the Future*, which explores the R&D opportunities to develop new interaction modes, multiuser interfaces, universal access methods, perceptual user interfaces, and ways of reducing cognitive load. Chapter 6 is entitled *Digital Humanities* and explores the potential of computer systems in the field of humanities and explores new computational tools, very large data sets, collaborative systems design, imaging of artifacts and digital archives.

This fifth addition to this unique series of books will make essential reading, especially for anyone contemplating undertaking research and development in digital media. Even for me, it will be informative and a joy to delve into this latest work.

Hereford, UK
October 2017

John Vince
Professor Emeritus (Digital Media)

Preface

The first book¹ in this subject area covered the key aspects of collaboration and communication in Research and Development (R & D), and how technology may be used to support creativity in the R & D process. The second book² covered the collaboration between the academy and industry to support developments in the creative industries and more general industrial applications. The third book³ covered collaboration and implementation between art and design, and technology. The fourth book⁴ addressed the field of digital media as whole, giving primarily a user view and providing a number of indicative applications.

This book is about research and development in digital media. It is intended to complement the fourth book which gave a user view of digital media. It could be argued that technical developments are primarily driven by manufacturers in that they bring new technology to market and also design, build, and sell new devices and systems which they hope will be attractive to users and meet their needs. Thus they are motivated primarily by profit and share price rather than seeking to develop the field in an optimum way. However, governments and industry are funding research and development programs in the area of digital media, with the objective of generating economic and cultural value. A number of these initiatives generate spin-out companies which seek to migrate their intellectual property into products and services. However, they can be vulnerable to take over by larger companies, particularly if the offer is an attractive one. The larger company then determines the priorities for the smaller one, which may result in a shift of overall direction.

There is insufficient space in a brief book of this nature to provide full detail of any particular area and, where relevant, the more detailed material in the Further

¹Earnshaw, R. A.: Research and Development in Art, Design and Creativity. Springer (2016) <https://doi.org/10.1007/978-3-319-33005-1>.

²Earnshaw, R. A.: Research and Development in the Academy: Creative Industries and Applications. Springer (2017) <https://doi.org/10.1007/978-3-319-54081-8>.

³Earnshaw, R. A.: Art, Design and Technology: Collaboration and Implementation. Springer (2017).

⁴Earnshaw, R. A.: State of the Art in Digital Media and Applications. Springer (2017).

Reading and References at the end of each chapter are for the reader to gain more detail where they feel they need it. The References concentrate on recent years as these represent the latest developments and advances, and these are probably of most interest to readers. Some older references are included where they detail significant pioneering advances in the field in earlier years. The Further Reading includes some references which are more tutorial or review in nature and these contain further lists of key references throughout the time frame of the development of the particular subject area.

Therefore this review of research and development of digital media is very much a “bird’s eye view” of the field. There is only space therefore to review those areas where it is felt that some of the key developments are taking place. The nature of these developments is presented, but not the technical detail. The reader is therefore referred to the Further Reading and the References for this detail.

The convergence of IT, telecommunications, and media is bringing about a revolution in the way information is collected, stored, and accessed. There are three principal reasons why this is happening—reducing cost, increasing quality, and increasing bandwidth.

A wide range of applications such as computer games, multimedia production, animation, graphics and video editing, and digital video film making are examined in general terms only. These topics fall more within the generally accepted definition of creative industries and these are covered in more detail in the second book which examines this area.

Media content is now created in digital form and can be repurposed across different media types such as DVD, Internet, or traditional print. This offers scope for different forms of advertising, and providing added value to consumers by providing dynamic links to other relevant information. This provides new value chains and ecosystems. This in turn affects social and cultural contexts, and interacts with them. The user as content creator, publisher, and broadcaster is challenging and changing the traditional roles of news media, publishers, and entertainment corporations. This in turn changes social and governmental structures and affects their power, influence, and cultural impact.

This revolution is having effects on the development, organization, and distribution of information and artifact repositories such as libraries, museums, exhibitions, and conferences, and the way in which physical and digital aspects are mediated to users. There also current issues in ensuring digital archives remain accessible to users into the long term future and are not rendered obsolete by future shifts in technology. The changes that digital media and digital convergence is bringing about are substantial and are also likely to be long-lasting.

The University of Bradford, UK pioneered the area of digital media in the mid-1990s by tripartite collaborations between technology, art and design, and media and broadcasting. It was done by setting up a new academic department because it did not sit easily within existing academic disciplines and structures. It was very successful in attracting students and also meeting the needs and

requirements of industry. It also highlighted the benefits and advantages of interdisciplinary collaborations. Involvement in a number of large interdisciplinary European Projects over the years at the Universities of Leeds and Bradford required research and development in a number of application areas, such as multimedia assets for design, collaborative visualization over networks, and virtual entertainment, and led to a number of important results. These are detailed in the first book referred to above.

Involvement as a professor in the School of Creative Arts at Glyndwr University, Wales, over recent years has provided opportunity to think about these aspects, and publish a number of papers in collaboration with the faculty.

The book is being published in the Springer Briefs series which are summaries of the state of the art in a particular area. It is being published as a print book, a Kindle book, and an e-book. In the latter, each chapter will be downloadable separately. This is why the Further Reading and References appear at the end of each chapter. Thus a chapter contains the main points in the area and the reasons for their significance. It is not intended to examine each of these points in detail—there is insufficient space to do this. However, the interested reader can follow up in the Further Reading or References for further detail and information. There is also an Abstract at the front of the chapter (rather longer than usual) to set out what is covered in the chapter. This is so that readers who only want to download one chapter have a clear idea of what is in it, as the Abstracts are visible in the Preview facility for each chapter that are available on the Springer web site for the book.

There are many references to online sources on the Internet. Readers of the e-book can access these directly as they are embedded in the text as hot links. Some URLs of web pages change over time due to site names being changed by their owners, or the position of the web site in the site hierarchy being changed. Where the link does not access the required page, the correct page can often be located by putting the URL into Google. If this doesn't work due to Google's cached copy of the original web site having been over-written, then the title of the reference can be typed into Google.

It is hoped that this book makes a useful contribution to an important area of discussion and debate.

Acknowledgements

Thanks and appreciation are due to all those who read draft versions of the chapters and provided comments to improve technical content and readability. However, responsibility for the final text rests with the author.

Thanks are expressed to colleagues and students at the School of Creative Arts at Wrexham Glyndwr University, Wales, for many useful discussions.

Thanks are expressed to Prof. John Vince for providing the Foreword to the book.

Thanks and appreciation are also due to Springer for assistance and support with the production of the book and e-book.

Bradford, UK
October 2017

Rae Earnshaw

Contents

1	Digital Media Theory	1
1.1	Introduction	2
1.2	Media Theories	2
1.3	Digital Media Theories	3
	Further Reading	6
	References	6
2	Grant Funding for Research and Development in Digital Media and Applications	7
2.1	Introduction	7
2.2	European Research Council	8
2.3	European Union Horizon 2020 (H2020)	8
2.4	The United States National Science Foundation (NSF)	9
2.5	UK Arts and Humanities Research Council (AHRC)	14
2.6	UK Engineering and Physical Sciences Research Council (EPSRC)	14
2.7	Grant Funding by Innovate UK	16
2.8	UK Knowledge Transfer Partnerships (KTPs)	17
2.9	National Endowment for Science, Technology and the Arts (Nesta)	17
2.10	Collaboration Opportunities Between Academia and Local, National, and International Companies	18
2.11	Grant Funding by Google	18
2.12	Grant Funding by Microsoft	18
2.13	The Ten Largest Research and Development Spenders Worldwide	20
2.14	The Future	20
2.15	Conclusions	21
	Further Reading	22
	References	22

3	Visual Analytics and Big Data	25
3.1	Introduction	25
3.2	Computer Graphics	26
3.3	Scientific Visualization	27
3.4	Visualization	31
3.5	Information Visualization	32
3.6	Visual Analytics	32
3.7	Data Handling	34
3.7.1	Big Data—A Definition	34
3.7.2	Structured Versus Unstructured Data	35
3.7.3	Data Wrangling	35
3.7.4	Text Analysis	35
3.7.5	Analyzing Social Network Data	36
3.8	Virtual and Augmented Reality	36
3.9	Current Developments and Advances	36
3.9.1	Key Developments	36
3.9.2	Increase in Computation Requirements	40
3.9.3	Storing and Processing Big Data	41
3.9.4	Component-Based Analytical Tools	41
3.9.5	Autonomous Analytics	41
3.9.6	The Human Brain Project	42
3.9.7	Further Work	42
3.10	Conclusions	43
	Further Reading	43
	References	44
4	Visual Information Interfaces	47
4.1	Introduction	48
4.2	Post-wimp User Interfaces	48
4.3	Virtual Reality Environments	49
4.4	Virtual Reality Equipment	52
4.5	Augmented Reality	53
4.5.1	Review of Augmented Reality	53
4.5.2	Google Glass	57
4.5.3	Microsoft HoloLens	57
4.5.4	Google Tango	57
4.5.5	Apple iPhone 8	57
4.5.6	Comparison of Google Tango and Apple iPhone 8	57
4.6	Mixed Reality	59
	Further Reading	60
	References	61

5	Research and Development on Interfaces of the Future	63
5.1	Introduction	63
5.2	Human–Human Interaction	64
5.3	Scenario and Application Drivers	65
5.4	User Interface Attributes	65
5.5	Interface Functionality	66
5.6	Quantifying Design	67
5.7	Design Guidelines	67
5.8	Matching to Human Needs and Requirements	67
5.9	Research Issues	68
5.9.1	Super Display to Match Vision Capabilities	68
5.9.2	Low-Cost Panoramic Display	69
5.9.3	Peripheral Displays	69
5.9.4	3D Spatial Sound	69
5.9.5	Electronic Nose	70
5.9.6	Haptic/Tactile	70
5.9.7	Infinite Plane Treadmill	70
5.9.8	Robust Speech and Gesture Recognition	70
5.9.9	Tracking	71
5.9.10	Noninvasive User Authentication	71
5.9.11	Interface Entities	72
5.9.12	Scene Acquisition and Reconstruction	72
5.9.13	Authoring and Development Environments	72
5.9.14	3D + Time Interfaces and Metaphors	73
5.9.15	Unifying Direct and Indirect Control	73
5.9.16	Physically Based Models	73
5.9.17	Mobility	74
5.9.18	Models of Users, Computers, and Objects	75
5.9.19	Usability Studies in General	75
5.9.20	Smart Spaces and Users	76
5.9.21	Creativity Support	77
5.9.22	Causes and Prevention of Cyber-Sickness	77
5.9.23	Meta-Issues Underlying the Research Problems	78
	Further Reading	78
	References	78
6	Digital Humanities	79
6.1	Introduction and Definitions	80
6.2	Humanities in the European Research Area	81
6.3	Research Projects and Collaboration	82
6.4	Digital Humanities Research Supported by the European Commission	82

6.5	Digital Humanities Research Supported by the Arts and Humanities Research Council	83
6.6	European Association for Digital Humanities	84
6.7	Digital Humanities Centers and Networks	84
	Further Reading	85
	References	85