Handbook of Human Computation

Pietro Michelucci
Editor

Handbook of Human Computation

Springer

Editor
Pietro Michelucci
ThinkSplash, LLC
Fairfax, VA, USA

ISBN 978-1-4614-8805-7 ISBN 978-1-4614-8806-4 (eBook)
DOI 10.1007/978-1-4614-8806-4
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2013954962

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword: Making a Difference

Mary Catherine Bateson

Mary Catherine Bateson is a cultural anthropologist and author.

A volume of papers on human computation (HC) has been needed to lay the foundation of a field and establish a framework in which researchers can effectively build on each other's work. It is also likely to set off alarm bells in many quarters. Yet there is a possibility that the thinking collected here will constitute an important step toward solving a fundamental ethical problem in human society, namely, the increasingly widespread conviction that "nothing I can do will make any difference." Kant's Categorical Imperative[1] was an attempt to solve the problem by eliminating the question of scale and proposing that an action be evaluated as if it were universal, but this has not proved particularly effective in ever larger populations. The problem of taking responsibility for individual and local actions is most severe at the global level. Thus, for instance, individuals have difficulty believing that leaving

an extra electric light burning in their suburban backyard is connected to the likelihood of lethal storms thousands of miles away. Exactly the same kind of reasoning discourages voters from going to the polls for local elections. How will people learn that what they do "counts"? By counting.

We badly need models of interdependence and connectivity that will convey to those who work with them the conviction that individual voices and actions *count*, a message conveyed through many different modalities, both in science and in popular culture. At the same time, the very term "human computation," accompanied by fascinating analogies to insect communities, may suggest a dystopic loss of individual autonomy and value. Human computation for socially useful goals will depend on giving individuals a sense of agency – a sense that they indeed can make a difference.

Agency has been the central issue for patient communities, so that enrolling patients as active collaborators in research has been an important new model for citizen science. One of the earliest examples of citizen science was the St. Louis baby tooth collection organized by Barry Commoner, in which scientists "took over the tooth fairy"[2] to demonstrate the dangers of nuclear testing in the atmosphere. The demonstration that Strontium 90 was being transferred in mothers' milk was a significant element in the banning of atmospheric testing, but so no doubt was the engagement it evoked in the parents.

There is a long history, going back to the Greeks and Romans, of attempting to use voting (an early form of human computation), with various modifications, to create a sense of agency that supports responsibility, and some of the hazards are known. Experience suggests, for instance, that plebiscites are easily manipulated by autocrats (as in the rise of fascism), so that it makes more sense to vote for individuals who are then able to deliberate together about issues and act systemically as surrogate decision makers in a second round of voting than it does to decide policy by majority popular vote. Other variations such as proportional representation also attempt to avoid the dangers of simple majority rule. Voter initiatives may appear to increase democracy but when overused may lock in dysfunctional policies. And at the same time, voters are increasingly taking the libertarian position that all legislation and regulation is pernicious. A central promise of human computation, already partially realized, is the possibility of creating an awareness of the vast number of decisions we all make every day, including the decision involved in where attention is focused from minute to minute,[3] along with information about the aggregate effect of those decisions and how they are shifting.

At the same time, information about new ideas and emerging patterns needs to be accessible and individual voices need to be audible. Human computation may run the risk of simply reinforcing existing trends, which may be negative, by facilitating conformity. The popularity of SUVs and violent movies and games tends to be self-reinforcing, and the most popular restaurant in town may not be the most pleasant place to go on a Saturday night. Thus, simply waiting to see what "goes viral" on YouTube or Twitter is not sufficient. A noteworthy variation on regenerative feedback, however, is Kickstarter.com, which works like a chain letter to raise funds for nonprofit projects.

A significant effort related to human computation is the effort to create interactive contexts for the expression of greater diversity of knowledge and imagination. Interdisciplinary conferences (such as the Macy conferences on Cybernetics and on Group Process after World War II) can be seen as an example of taking a group of individuals and turning them into a thinking system, a kind of superorganism.[4] With the decline in support for exploratory interdisciplinary work, there has been a rise in designs for interactive processes, such as America Speaks, the 21st Century Town Hall Meeting format devised by Carolyn Lukensmeyer,[5] and Laura Chasin's Public Conversations Project,[6] as well as research on conflict resolution and mediation[7] simultaneously alas with the steady increase in what Deborah Tannen calls the *Argument Culture, in which issues are approached antagonistically.*[8] Such innovative techniques can be regarded as forms of computation.

Human beings change in response to their habitual interactions, and there is already concern about deleterious effects of electronic communication, which will play a major role in human computation as we move forward. Much of human computation depends on persuading large numbers of individuals, acting separately, to contribute personal information, which is then combined, both processes facilitated by electronic technology. But it is important to notice that the implicit message of such an operation is *membership in a larger whole*. Any living system processes quantities of material and information, in ways that affect the state of that system and other systems to which it is connected, and attending to such processes potentially creates a sense of unity and an awareness of the reality of interdependence.

We know today that our entire planet can be looked at as a living system[9] with some capacity for self-regulation, and that the circulation of water and atmospheric gases is such that disruption or pollution in one place on the planet has measurable effects elsewhere. Indeed, earth systems are far more closely integrated than the present human capacity to respond to them, even in the preparation for and response to major disasters. The emphasis on individual autonomy that underlies American culture is a product of the circumstances under which Europeans settled the North American continent, but it is descriptively inaccurate for the human condition and inhibits effective cooperation in problem solving and humanitarian relief as we experience and attempt to mitigate the global effects of climate disruption. Arguably, then, if increased reliance on human computation shifts attitudes away from the fetish of individual autonomy and teaches us, by implication, to recognize that we are connected parts of a larger whole, this is a goal to be pursued. Perhaps too, the awareness of inescapably "making a difference," for better or for worse, by our individual choices will come to be seen as an essential aspect of human dignity.

Mary Catherine Bateson

Notes

1. “There is, therefore, only one categorical imperative. It is: Act only according to that maxim by which you can at the same time will that it should become universal law.” Kant I, Foundations of the metaphysics of morals (trans: Beck LW, ed: Wolff RP, section 2, p. 44.
2. Bateson MC (1972) Our own metaphor: a personal account of a conference on conscious purpose and human adaptation. New York: Alfred A. Knopf, pp 140–141.
3. Jackson M (2009) Distraction: the erosion of attention and the coming dark age. Amherst: Prometheus Books.
4. Heims SJ (1991) The cybernetics group. Cambridge, MA: MIT Press.
5. Lukensmeyer C (2007) The change handbook: the definitive resource on today’s best methods for engaging whole systems. San Francisco: Burrett-Koehler.
6. Fostering dialogue across divides: a nuts and bolts approach. www.publicconversations.org/docs/resources/Jams_website.pdf
7. Fisher R (1991) Getting to yes: negotiating agreement without giving in. New York: Penguin Books.
8. Tannen D (1998) The argument culture: moving from debate to dialogue. New York: Random House.
9. Lovelock J (1995) A new look at life on earth. Oxford/New York: Oxford University Press.

Preface

In all of your deliberations in the Confederate Council, in your efforts at law making, in all your official acts, self-interest shall be cast into oblivion. Cast not over your shoulder behind you the warnings of the nephews and nieces should they chide you for any error or wrong you may do, but return to the way of the Great Law which is just and right. Look and listen for the welfare of the whole people and have always in view not only the present but also the coming generations, even those whose faces are yet beneath the surface of the ground – the unborn of the future Nation.

– Great Law of the Haudenosaunee[1]

Why a Book About Human Computation?

In the new techno-culture of buffered sociality, in which young people spend more time wearing earbuds and texting frenetically than having real live conversations in a café, we consider the mounting existential challenges that our children and subsequent generations will face. Though human computation may not be a panacea, it does represent an opportunity for us to draw together more effectively as a global people to address such challenges. However, there is a practical issue.

The problem that exists today is that human computation (HC) research is fragmented across isolated communities. That is, HC is developed and implemented in multifarious ways across diverse fields of inquiry and application; yet each of these efforts occurs as an offshoot of some other discipline or as a novel method in some

[1] The Haudenosaunee league of Native American nations is known in Western culture as the Iroquois. However, "Iroquois" is a French transliteration of a derogatory name used historically by a competing tribe. The correct and proper name, "Haudenosaunee," means "people of the longhouse," which implies that member nations should live together as families in the same longhouse (Wikipedia 2013).

applied domain. But there is very little cross-fertilization, due to typical aversions to crossing community boundaries, philosophical differences, and terminology confusion. One even gleans cultural differences, such as an emphasis in Eastern cultures on systems that support collective rather than individual stakeholders. Thus, this book responds to the need for a clear, comprehensive, current, and interdisciplinary treatment of HC.

Rather than just reporting on the state of practice, we have challenged the confines of our conceptual comfort zones and engaged in bold analysis and risky ideation – something humans still do much better than machines. Ultimately, we have sought to collectively assess the state of the art and anticipate future directions, presenting the combination as a foundation and inspiration for future work and unlikely collaborations.

The Collaboration Has Already Begun

It has been both a tremendous honor and an exercise in humility to collaborate with such a talented, globally distributed (see Fig. 1), and remarkably genuine community of over 115 authors and editors. Perhaps it is the promise of human computation that draws out the humanity in us, that somehow echoes the mantra "we want to own our destiny." Indeed, the goals of this book have already begun to be realized as a consequence of its very development. Authors have formed new, respectful cross-disciplinary relationships, spawning new ideas, many of which appear on the pages of this book. From this chrysalis, we hope to nurture the emergence of human computation as a formal discipline, a charter for which is conveyed in the final chapter of the book.

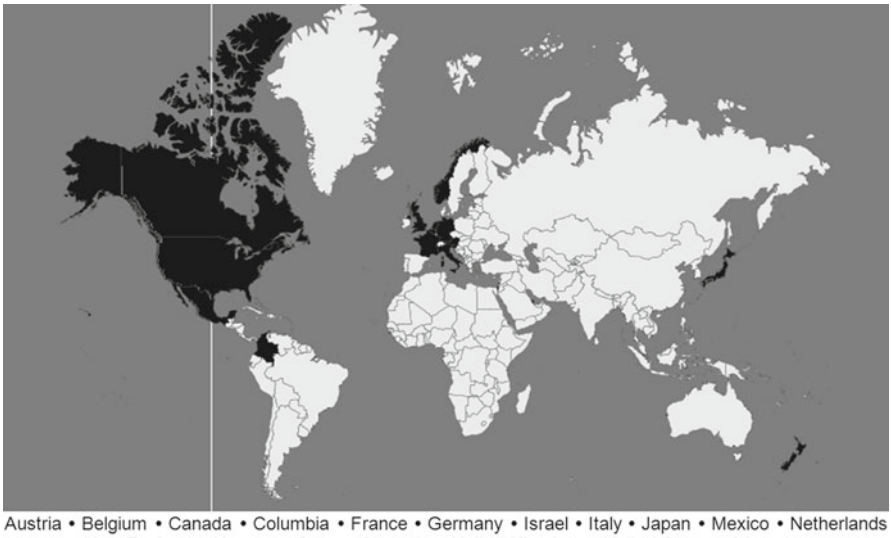

Fig. 1 Geographic representation of handbook contributors

About the Editor-in-Chief

Pietro Michelucci

Pietro Michelucci is an Indiana University–trained cognitive scientist and mathematical psychologist. He has been supporting the US Government as a science consultant since 2006. In that capacity, he developed a 2009 SBIR solicitation called "Massively Distributed Problem Solving" toward developing "a problem-solving system that combines an automated optimizing infrastructure with myriad distributed human processing agents." He also conducted a pilot study to assess the affordances of shared sensing, collective reasoning, and coordinated action on group efficacy. He speaks on various topics related to human computation and to advocate for its advancement as a formal discipline. More recently, in response to a recommendation from the Presidential Committee for the Advancement of Science and Technology (PCAST), he has been serving on the executive committee of an NITRD working group to develop a federal cross-agency initiative in social computing. Dr. Michelucci is currently founding the first-ever journal of human computation.

About the Section Editors

Matthew Blumberg

Editor, *Foundations*

Matthew Blumberg is an entrepreneur focusing on digital media and technology. He is founder and Executive Director of GridRepublic, a nonprofit organization that uses "volunteer computing" to provide supercomputing resources to public interest research (www.gridrepublic.org).

Haym Hirsh

Editor, *Applications*

Haym Hirsh is Dean of Computing and Information Science at Cornell University. His research has focused on foundations and applications of machine learning, data mining, information retrieval, and artificial intelligence, especially targeting questions that integrally involve both people and computing. Most recently, these interests have turned to crowdsourcing, human computation, and collective intelligence. From 2006 to 2010, he served as Director of the Division of Information and Intelligent Systems at the National Science Foundation, from 2010 to 2011, he was a Visiting Scholar at MIT's Center for Collective Intelligence at the Sloan School of Management and from 2011 to 2013 he was Chair of Computer Science at Rutgers University. Haym received his B.S. from the Mathematics and Computer Science Departments at UCLA and his M.S. and Ph.D. from the Computer Science Department at Stanford University.

Kshanti A. Greene

Editor, *Techniques and Modalities*

Kshanti received her Ph.D. in Computer Science from the University of New Mexico (UNM). She specializes in developing models that integrate and utilize intelligence derived from large groups of people. Her ambition is to provide tools to society that enable communities to self-organize to make decisions, form policy, and solve the problems that face them. Dr. Greene has been PI on DARPA, Army, and Navy research grants relevant to human computation and cofounded the Social Logic Institute to apply this research toward social and environmental welfare.

Michael Witbrock

Editor, *Infrastructure and Architecture*

Michael Witbrock is VP for Research for Cycorp, one of the world's leading AI research companies, and founder and CEO of Curious Cat Company, the maker of Curious Cat, a mobile social guide and companion based on strong AI. In his youth, he was a founder of NZ.COM, one of the very first web-based travel advice sites. He has also acted as CTO of Envigence d.o.o., a Slovenian Green Infrastructure firm, and as principal scientist at Lycos, one of the first web search engines. To encourage the positive use of AI technology, Michael acts as an advisor and is a frequent speaker at European agencies working in the area of eGovt, and as a scientific advisor to European research projects. Michael has a Ph.D. in Computer Science from Carnegie Mellon University and a B.Sc. (Hons) in Physiological Psychology from the University of Otago, in his home country of New Zealand.

Remco Chang

Editor, *Algorithms*

Remco Chang is an Assistant Professor in the Computer Science Department at Tufts University. He received his B.S. in Computer Science and Economics from Johns Hopkins University in 1997, M.Sc. from Brown University in 2000, and Ph.D. in Computer Science from UNC Charlotte in 2009. Prior to his Ph.D., he worked for Boeing, developing real-time flight tracking and visualization software, followed by a position at UNC Charlotte as a research scientist. His current research interests include visual analytics, information visualization, human–computer interactions, and computer graphics.

Caroline Ziemkiewicz

Coeditor, *Algorithms*

Dr. Caroline Ziemkiewicz is an Associate Research Engineer in the Analytics, Modeling, and Simulation Division at Aptima, Inc., where she contributes expertise in visualization and cognition-driven visual analytics. Her research interests cover topics in cognition-motivated visual information design and understanding users of complex analytical interfaces. Specific research interests include visual metaphors, information structure in design, individual differences in analytical task performance, and user-adaptive interfaces. Dr. Ziemkiewicz holds a Ph.D. in Computer Science and a Graduate Certificate in Cognitive Science from the University of North Carolina at Charlotte, and a B.A. in Computer Science from Ithaca College.

Winter Mason

Editor, *Participation*

Dr. Mason received his B.Sc. in Psychology from the University of Pittsburgh in 1999 and his Ph.D. in Social Psychology and Cognitive Science from Indiana University in 2007. He worked as a Visiting Scientist at Yahoo! Research from 2007 to 2011, when he joined the Stevens Institute of Technology as an Assistant Professor. Dr. Mason's research can be described as "Computational Social Science" and is focused on social networks, social media, crowdsourcing, and group dynamics. Methodologically, his research spans traditional psychological methods including laboratory experiments, new methods such as online data collection with crowdsourcing, and computer science methods such as data mining.

Kristina Lerman

Editor, *Analysis*

Kristina Lerman is a Project Leader at the Information Sciences Institute and holds a joint appointment as a Research Associate Professor in the Computer Science Department of the USC Viterbi School of Engineering. Her research focuses on applying network- and machine learning–based methods to problems in social computing.

Dan Thomsen

Editor, *Policy and Security*

Mr. Thomsen's career has focused on computer security research ranging from high-assurance operating systems and multilevel database security to security policy management. Mr. Thomsen has also contributed research into the effective communication of ideas from one person to another. At SIFT, Mr. Thomsen works to improve the effectiveness of computer security using artificial intelligence and human factors research to manage the complexity of modern computer security mechanisms. Mr. Thomsen also leads an effort in human computation using games to increase the chance of innovation for solving problems that have never been solved before.

Pietro Michelucci

Editor, *Impact*

See section "About the Editor-in-Chief."

Acknowledgments

Perhaps firstly, I am grateful to the reader. The future of human computation lies with you; whether as a researcher, developer, analyst, or even a participant, you will ultimately have the potential to be instrumental in the development of this technology and practice. Furthermore, by reading from these pages, you will be better equipped to approach and understand the implications of your involvement so that you can make conscientious and informed decisions.

This book was built on the generosity, brilliance, creativity, diligence, patience, and sacrifice of many kind people. Andrew Spencer at Springer-Verlag took the initiative to connect me to his States-based counterpart, Melissa Fearon, with whom I first began this journey. Aside from being a very nice person, Melissa has been outstanding to work with. She is a veritable font of publishing wisdom and has been quick to develop creative solutions to sundry issues. I am grateful to Melissa for having the courage to take a chance on this speculative project. Courtney Clark, Patrick Carr, and Jennifer Malat have kept me on the straight and narrow to ensure adherence to an aggressive publication timeline that would best serve the HC community.

I could not have hoped for a more industrious and visionary group of editorial collaborators. Each editor cast a distinctive, sometimes unexpected, but always beneficial framing to his or her section. It was a true privilege and education to work with each of them.

Perhaps the most personally gratifying aspect of this enterprise has been interacting with the other contributors. Despite stresses of work, academia, and myriad competing obligations, the chapter authors have been consistently thoughtful and responsive in their writing and correspondence, demonstrating genuine investment and ownership in this shared product. It is no small reflection of this level of dedication that the book is being published exactly one year from its November 2012 launch.

I also wish to acknowledge the population of "would-be" authors, whose circumstances precluded active participation, but who nonetheless recommended colleagues or engaged in fruitful discourse. And in particular, I want to thank Edith Law for elevating my sensitivity to "cultural nuances" that helped me more effectively draw collaborators across community boundaries.

Mary Catherine Bateson has honored this book and community with her foreword. I am grateful to her for her patient and enlightening conversation and for seeking not just human but *humanistic* computation.

Finally, my deepest and most heartfelt gratitude goes to Pamela K. Michelucci, whose selflessness, grace, and wisdom made this endeavor possible.

Yours collectively,

Pietro Michelucci
Editor-in-Chief

Contents

Part II Application Domains

Part III Techniques and Modalities

Contributors

Maribel Acosta Karlsruhe Institute of Technology, Germany

Luke Barrington Digital Globe Corporation, USA

Carol R. Beal University of Arizona, USA

Anamaria Berea George Mason University, USA

Jeffrey P. Bigham University of Rochester, Pittsburgh, USA

Mark Billinghurst HITLab – University of Canterbury, Christchurch, New Zealand

Matthew Blumberg GridRepublic, USA

Luka Bradeško Institut Jožef Stefan/Curious Cat Company, Slovenia

Marco Brambilla Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria, Milano, Italy

François Bry LMU Munich, Germany

Christopher J. Budnick Northern Illinois University, USA

Scott Butner Pacific Northwest National Laboratory (PNNL), USA

Karen Carney Adler, Planetarium, USA

Gabriella Castelli University of Modena and Reggio Emilia (UNIMORE), Italy

James Caverlee Texas A&M, USA

Irene Celino CEFRIEL – ICT Institute – Politecnico di Milano, Italy

Jon Chamberlain University of Essex, UK

Jesse Chandler Princeton University, USA

Remco Chang Tufts University, Medford, USA

Derrick L. Cogburn American University/Syracuse University, USA

Ryan Cook Adler Planetarium, USA

R. Jordan Crouser Tufts University, Medford, USA

Peng Dai Google Inc., 1600 Amphitheater Pkwy, Mountain View, CA, USA

Christopher Dance Xerox Research Centre Europe, France

Thomas W. Deutsch IBM Research, San Jose, USA

Dominic DiFranzo Rensselaer Polytechnic Institute, USA

Edmond H. Durfee University of Michigan, Ann Arbor, USA

Daniel Estrada University of Illinois, Urbana-Champaign, Champaign, USA

Alek Felstiner Law Clerk, United States District Court for the District of Columbia, Washington, DC, USA

Elena Ferrari Dipartimento di Scienze Teoriche e Applicate (Department of Theoretical and Applied Sciences), Università degli Studi dell'Insubria (University of Insubria), Varese, Italia

Vladimir Filkov UC Davis, USA

Tatiana Flanagan University of New Mexico, Albuquerque, New Mexico

Fabian Flöck Karlsruhe Institute of Technology, Germany

Piero Fraternali Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria, Milano, Italy

Matthew Fricke University of New Mexico, Albuquerque, New Mexico

Liane Gabora U British Columbia, Kelowna, Canada

Aram Galstyan USC – Information Sciences Institute, USA

Carlos Gershenson Universidad Nacional Autónoma de México, Mexico

Arpita Ghosh Cornell University, USA

Yolanda Gil USC – Information Sciences Institute, USA

Kshanti A. Greene Social Logic Institute, USA

David A. Grier The George Washington University, USA

Ido Guy IBM Research, Haifa, Israel

Jereme Haack Pacific Northwest National Laboratory (PNNL), USA

Manas Hardas Spigit Inc, Pleasanton, CA, USA

Christopher G. Harris SUNY Oswego, Oswego, New York, USA

Nada Hashmi Massachusetts Institute of Technology, USA

James Hendler Rensselaer Polytechnic Institute, USA

Francis Heylighen The Free University of Brussels/Principia Cybernetica, Belgium

Haym Hirsh Cornell University, USA

Tad Hogg Institute for Molecular Manufacturing, USA

Juan Pablo Hourcade University of Iowa, Des Moines, USA

Andrew Huynh University of California, San Diego, USA

Markus Krause Leibnitz University, Germany

Udo Kruschwitz University of Essex, UK

Gert Lanckriet University of California, San Diego, USA

L.J. Larson-Prior Washington University in St. Louis, St. Louis, USA

Walter S. Lasecki University of Rochester, Rochester, USA

Neal Lathia Cambridge University, UK

Jonathan Lawhead Columbia University, New York, USA

Kristina Lerman USC – Information Sciences Institute, USA

Kenneth Letendre University of New Mexico, Albuquerque, New Mexico

Albert Yu-Min Lin UCSD/National Geographic Society, USA

Chris Lintott University of Oxford, UK

Max Little Aston University, Aston, UK

Aidan Lyon University of Maryland, USA

Marco Mamei University of Modena and Reggio Emilia (UNIMORE), Italy

Winter Mason Stevens Institute of Technology, USA

Patrick Meier Harvard Humanitarian Initiative/Qatar Computing Research Institute, Qatar

Filippo Menczer Indiana University, USA

Pietro Michelucci ThinkSplash LLC, Fairfax, USA

Atsuyuki Morishima University of Tsukuba, Japan

Clayton T. Morrison University of Arizona, USA

Melanie Moses University of New Mexico, Albuquerque, New Mexico

Pam Mueller Princeton University, Princeton, USA

Bonnie Nardi UC Irvine, Irvine, USA

Lisa P. Nathan University of British Columbia, Vancouver, Canada

Helmut Nechansky Nechansky, Vienna, Austria

Jeffrey V. Nickerson Stevens Institute of Technology, USA

Jasminko Novak University of Applied Science Stralsund, Berlin, Germany

Alvitta Ottley Tufts University, Medford, USA

Eric Pacuit University of Maryland, USA

Gabriele Paolacci Erasmus University, Rotterdam, Netherlands

Theodore P. Pavlic Arizona State University, USA

Massimo Poesio University of Essex, UK

Stephen C. Pratt Arizona State University, USA

Lisa Purvis Spigit, USA

M. Jordan Raddick Johns Hopkins University, USA

Jason T. Reed Adler Planetarium, USA

Stuart Reeves University of Nottingham, UK

Scott Rettberg University of Bergen, Bergen, Norway

Peter J. Richerson UC Davis, Davis, USA

Roderick Riensche Pacific Northwest National Laboratory (PNNL), USA

Alberto Rosi University of Modena and Reggio Emilia (UNIMORE), Italy

Joel Ross University of Puget Sound, USA

Antonio Sanfilippo Pacific Northwest National Laboratory (PNNL), USA

Alecia M. Santuzzi Northern Illinois University, USA

Daniel Schall Siemens Corporate Technology, Austria

Elena Simperl University of Southampton, UK

Paul E. Smaldino Johns Hopkins University, Baltimore, USA

Padmini Srinivasan University of Iowa, USA

Yu-An Sun Xerox Corporation, USA

Dan Thomsen Smart Information Flow Technologies, USA

Juan C. Villegas Universidad de Antioquia, Medellín, Medellín, Colombia

Marco Viviani University of Insubria, Italy

Lilian Weng Indiana University, USA

Paul Wicks PatientsLikeMe, USA

Michael Witbrock Cycorp Inc./Curious Cat Company, USA

Anita Williams Woolley Carnegie Mellon University, USA

Qi Xuan UC Davis, USA

Thomas A. Young Social Logic Institute, USA

Franco Zambonelli University of Modena and Reggio Emilia (UNIMORE), Italy

Caroline Ziemkiewicz Aptima, USA

Introduction

A more descriptive title for this book would have been "The application, design, infrastructure, and analysis of heterogeneous multi-agent distributed information processing systems and their political, societal, and ethical implications," but as brevity is the soul of wit, I decided to go with simply *Handbook of Human Computation*.

Human computation means different things to different people. To some, it means using a computer to combine answers from many people into a single best answer. To others, it means taking a problem that is too big for any one person and splitting it into smaller, more manageable pieces that can be delegated to many people. Human computation can be the analysis of human behavior in a social network to better understand the spread of ideas or to predict outcomes on the world stage. And possibly it even represents an opportunity to recognize or engineer a new life-form with superhuman intelligence. Regardless of which of these things human computation might be, they all involve interconnected humans and machines that process information as a system, and they all serve a purpose.

What This Book Is Not

Though you will find much discussion of crowdsourcing herein, this is not a handbook of crowdsourcing. Crowdsourcing does not require computation; the term derives simply from "outsourcing to crowds." The individual contribution of each crowd member need not be computational nor give rise to computational analysis or output. Crowdsourcing is, however, a common method for engaging many participants in human computation; so they often coincide.

Nor is this a handbook of social computing. Social computing is defined as the intersection of social behavior and computational systems (Wikipedia 2013). However, social behavior is not a prerequisite for human computation. In fact, a workflow process may elicit human input, transform that input, and then pass the

result to another human, in a pipeline that involves no social behavior or interaction whatsoever, yet is very much a manifestation of human computation. Thus, human computation subsumes social computing.

Then What Do We Mean by Human Computation?

To answer that question, we must first consider what we mean by "computation." Computation in this context refers not just to numerical calculations or the implementation of an algorithm. Computation refers more generally to *information processing*. This definition intentionally embraces the broader spectrum of "computational" contributions that can be made by humans, including creativity, intuition, symbolic and logical reasoning (though we humans suffer so poorly in that regard), abstraction, pattern recognition, and other forms of cognitive processing. As computers themselves have become more capable over the years due to advances in artificial intelligence and machine learning techniques, we have broadened the definition of computation to accommodate those capabilities. Now, as we extend the notion of computing systems to include human agents, we similarly extend the notion of computation to include a broader and more complex set of capabilities.

With this understanding of computation, we can further generalize our notion of human computation to encompass not only computation by an individual human but also machine-mediated computation by groups of individuals (e.g., pipelined problem solving systems), aggregate analytic results by groups that result from individual information processing (e.g., prediction markets), distributed networks of human sensors (e.g., mash-ups), and many other varieties of information processing that derive from the computational involvement of humans in simple or complex systems.

While this is what is meant by human computation for the purpose of establishing conceptual guideposts for this handbook, it is itself among the directives of the handbook to not only formally define this space of research and practice but to explore the past, present, and future scope of this frontier.

Why Is Human Computation Important?

Each of this book's many contributors may have a distinct answer to this question. My short answer is the following. As a species, we face multifarious challenges stemming directly and indirectly from our use of technology, and many of these challenges pose an existential threat to humanity. I believe that one promising avenue of recourse is to use technology to help us cooperate more effectively to solve the problems we have created. Thus, I believe our very survival depends upon the

rapid advancement of human computation as a theoretical and applied science, to help us mitigate the effects of climate change, cure disease, end world hunger, protect human rights, and resolve conflicts.

Synopsis of Sections

Though the high-level structure of the book is ordinal by design, the following section synopsis will help point the reader who has specific areas of interest to the section of most immediate relevance. For the armchair reader, you may embark on a guided tour of human computation by beginning at page one. But if you happen to have a mercurial spirit, just open the book to a random chapter and see where that might lead you.

Foundations

The foundations section, edited by Matthew Blumberg, seeks to cast new light on the subject matter by asking basic questions, like "What is thinking?" "What is information?" and even "What is mental disease?" Answers come in novel forms that recast the interrelationship of foundational disciplines toward a deeper understanding of human computation.

Applications

The applications section, edited by Haym Hirsh, seeks to convey the value proposition of human computation by examining recent examples of how people have been brought together in new ways to achieve desired outcomes. This section surveys a broad range of human computation applications, in domains such as disaster relief, archaeology, medicine, science, education, literature, finance, innovation, business management, and others.

Techniques and Modalities

This section, edited by Kshanti A. Greene, catalogs an expansive and growing list of human computation techniques – that is, repeatable methods defined jointly by their applications, interaction paradigms, and/or computational methods. It is essentially a set of "design patterns" for human computation that facilitates modeling a new HC system on prior work.

Infrastructure and Architecture

The infrastructure and architecture section, edited by Michael Witbrock, seeks to balance the logistics of humans as computational resources with goals of actualization and empowerment. Thus, it covers the broad space of computational structures such as state space, communication protocols, human device drivers, reward structure programmability, as well as HC-specific interaction modeling techniques that are sensitive to the quality of human experience.

Algorithms

This section, coedited by Remco Chang and Caroline Ziemkiewicz, describes a variety of "systematic and general ways to treat humans as computational units" as well as new methods for formalizing the properties of human computation algorithms. Thus, this section may be useful for assessing, identifying, and constructing algorithms to fit specific use cases.

Participation

This section, edited by Winter Mason, explores a range of factors and associated techniques that influence the decision to participate in human computation activities. Importantly, it also considers dynamics that affect the quality of participation.

Analysis

This section, edited by Kristina Lerman, considers several analytic methods that can be used to predict emergent collective behavior and to inform the design of future human computation systems. These analytic methods are also considered in the context of quality control and performance assessment.

Policy and Security

This section, edited by Dan Thomsen, examines near-term ethical, regulatory, and economic considerations relevant to the emergence and growing prevalence of human computation and associated labor markets. It also delves into security and

privacy issues germane to HC systems, along with relevant technical and policy-based solutions.

Impact

The impact section, which I had the privilege of editing, is a collection of forward-thinking essays on the near- and long-term implications of human computation on individuals, society, and the human condition. It asks hard questions and considers carefully the potential risks and rewards associated with the advancement of this new technology. It attempts to characterize a future with pervasive human computation and considers how we might prepare for it.

Bon Voyage!

Whatever your interest in human computation might be, by reading from this book you will hear from a coalescent community of communities and perhaps begin to understand our place in the world in a new way.

Fairfax, VA, USA Pietro Michelucci

Reference

Wikipedia (2013) Social computing. In: Wikipedia, the free encyclopedia. Retrieved from http://en.wikipedia.org/w/index.php?title=Social_computing&oldid=553413728