The Cambridge Handbook of Computational Psychology

This book is a definitive reference source for the growing, increasingly important, and interdisciplinary field of computational cognitive modeling, that is, computational psychology. It combines breadth of coverage with definitive statements by leading scientists in this field. Research in computational cognitive modeling (or, simply, computational psychology) explores the essence of cognition and various cognitive functionalities through developing detailed, process-based understanding by specifying computational mechanisms, structures, and processes. Given the complexity of the human mind and its manifestation in behavioral flexibility, process-based computational models may be necessary to explicate and elucidate the intricate details of the mind. The key to understanding cognitive processes is often in fine details. Computational models provide algorithmic specificity: detailed, exactly specified, and carefully thought-out steps, arranged in precise yet flexible sequences. These models provide both conceptual clarity and precision at the same time. This book substantiates this approach through overviews and many examples.

Ron Sun is professor of cognitive science at Rensselaer Polytechnic Institute. A well-known researcher in the field of cognitive science, Sun explores the fundamental structure of the human mind and aims for the synthesis of many interesting intellectual ideas into one coherent model of cognition. The goal is to form a generic cognitive architecture that captures a variety of cognitive processes in a unified way and, thus, to provide unified explanations for a wide range of cognitive data. To do so, for the last two decades, he has been advocating the use of hybrid connectionist-symbolic systems in developing cognitive models, and he has been developing theories of human skill learning and human everyday reasoning as the centerpieces of the cognitive architecture.

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Preface

The goal of the *Cambridge Handbook of Computational Psychology* is to provide a definitive reference source for the rapidly growing, increasingly important, and strongly interdisciplinary field of computational cognitive modeling – that is, computational (and theoretical) psychology. It is part of the *Cambridge Handbook in Psychology* series.

This volume combines the breadth of coverage of the field with the authoritative statements by leading scientists in this discipline. It should thus appeal to researchers and advanced students working in this research field, as well as to researchers and advanced students working in cognitive science (in general), philosophy, experimental psychology, linguistics, anthropology, neuroscience, and artificial intelligence. For example, it could serve as a textbook for a course in a cognitive science program or, more generally, in social and behavioral sciences programs. This book could also be used by social science researchers, education researchers, intelligent systems engineers, and psychology and education software developers.

Models in cognitive science are often roughly divided into computational, mathematical, or verbal-conceptual models. Although each of these types of models has its role to play, in this volume, we are mainly concerned with computational modeling. The reason for this emphasis is that, at least at present, computational modeling appears to be the most promising approach in many ways and offers the flexibility and the expressive power that no other approaches can match. (Mathematical models may be viewed somehow as a subset of computational models, as they may lead readily to computational implementations.) A computational model may often be viewed as a theory of the phenomena it aims to capture and may be highly intellectually enlightening in this way.

Each chapter in this volume introduces and explains basic concepts, techniques, and findings for a major topic area within the realm of computational cognitive modeling (e.g., computational models and theories of a particular cognitive domain or functionality); sketches its history; assesses its

successes and failures; and evaluates the directions of current and future research. This handbook thus provides quick overviews for experts in each topic area and also for researchers in allied topic areas. However, equally important, the book provides an introduction to the field of computational cognitive modeling (computational psychology). It discusses the methodologies of computational cognitive modeling and justifies its use in cognitive science. It introduces influential approaches, describing in detail these approaches and providing ample examples. Thus, this volume provides an entry point into the field for the next generation of researchers by supplying a text for courses for graduate students and upper-level undergraduate students and for self-study.

I would like to thank all the contributing authors. Many of them not only contributed chapters, but also participated in mutual reviews of draft chapters, thus helping to ensure the quality of this book.

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I would also like to thank the members of the advisory board, who contributed suggestions that made the volume more comprehensive and more interesting. The members of the advisory board include: Thomas Shultz, Wayne Gray, and Jay McClelland.

Finally, I would like to thank Phil Laughlin for inviting me to put together this volume. It has been a pleasure working with Eric Schwartz, Phil Laughlin, Armi Macaballug, Peggy Rote, and others at Cambridge University Press in the process of developing this book.

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