Preface

Truth is verified only by creation or invention.
—Gianbattista Vico

Artificial intelligence (AI), machine learning, and robotics have become household terms following recent significant advances in AI for various applications in health care, in banking, and on the web and in the testing of robots in nuclear-decommissioning sites, as social companions for children and older people, and, very recently, as potential technologies to manage infection risks in the COVID-19 era. Notwithstanding this significant progress and momentum and the overpromising, in some cases, of what robots endowed with AI algorithms can actually do, the challenge of building machines with humanlike behavioral, cognitive, and social capabilities is a daring enterprise.

What cognitive robotics offers is a novel and insightful way to address the bold challenges of building AI-powered intelligent robots by taking inspiration from the way natural cognitive systems (i.e., humans, animals, biological systems) develop intelligence by exploiting the full power of the interactions between their bodies and their brains, the physical and social environments in which they live, and their phylogenetic, developmental, and learning dynamics. This is consistent with Vico's philosophical approach that "truth is verified only by creation or invention." That is, by creating or inventing something new, such as designing a computational cognitive architecture to control a cognitive agent, or developing a machine-learning model of intrinsic motivation and consciousness capabilities in robots, or running experiments to test a robot's capabilities to sense, plan, and act in the world, we can verify the validity of a scientific theory, hypothesis, or model.

The term and field of *cognitive robotics* have their origins in the 1990s, and it is somewhat surprising that over the last thirty years of research in this field, no comprehensive publication has covered the breadth and depth of cognitively inspired intelligent robotic systems. This is exactly the aim of this book: to provide the first comprehensive, state-of-the-art coverage of cognitive robotics research and of its definition, approaches, methods, and applications. We will set the scene in part I ("Definition and Approaches") by providing a systematic definition of the term *cognitive robotics* and an overview of its historical developments. This part will also include a detailed discussion of the five main, seminal approaches to cognitive robotics: developmental, neuro-, evolutionary, swarm, and soft

robotics. Part II ("Methods and Concepts") further expands the primary methodologies and concepts employed in this field. These range from the analysis of the most commonly used cognitive robotics platforms and robot simulators to the case of biomimetic skin as an example of a hardware-based approach to cognitive robots. Two further methodological chapters examine the use of machine-learning methods and of cognitive architectures. Additionally, we look at theoretical considerations in cognitive robots, such as embodiment and the ethical implications of robotics and AI. The final part, III ("Behavioral and Cognitive Capabilities"), comprises a set of chapters covering the broad spectrum of robotics models, experiments, and applications with regard to various behavioral and cognitive capabilities. This ranges from intrinsic motivation and perception to social cognition and language and up to robot consciousness issues. Each of these chapters will also explicitly discuss the psychology and neuroscience findings and principles that have inspired the cognitive robots' models and experiments.

The target readership of this volume includes master's and PhD students who want to learn about the concepts and methods in the field as well as researchers interested in specific cognitive robotics models and experiments. The book is written for an interdisciplinary audience, balancing technical details and examples for the computational reader as well as theoretical issues and high-level descriptions of robot experiments for the empirical sciences reader.

We hope the reader will enjoy learning about the beneficial connection between psychology and neuroscience findings on cognitive development and learning in humans and animals and the design of intelligent robots.

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