Preface: A Forum at the Dawn of the Era of Biologically Inspired Intelligent Machines

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Abstract
The emergence of biologically inspired cognitive architectures (BICA) challenges researchers across many disciplines with a new frontier: computational replication of the human mind, taken in all its essential aspects, as a functional unit of a team or a society. The mission of the international conference series on BICA is to facilitate interaction and collaboration among researchers who devoted themselves to solution of this BICA Challenge, by bridging cross-disciplinary and cross-cultural barriers. BICA annual conference series are now seven years old. Initially organized under the auspices of AAAI, the conference grew up into a world-wide forum coordinated and organized by the BICA Society, a nonprofit US corporation. In recent years, the BICA conference traveled around the globe: from Washington, D.C. to Palermo, Kiev, and Boston. Today BICA is a mainstream interdisciplinary field, promising solutions to urgent problems that resisted traditional approaches for decades. Over all its years, the BICA conference was a huge success in growing progression.

Keywords: Cognitive architectures; BICA Challenge; human-level artificial intelligence; outreach activities

1 Introduction

Biologically Inspired Cognitive Architectures (BICA) are computational frameworks for building intelligent agents that are inspired from biological intelligence. Biological intelligent systems, notably animals such as humans, have many qualities that are often lacking in artificially designed systems including robustness, flexibility and adaptability to environments. At a point in time where visibility into naturally intelligent systems is exploding thanks to modern brain imaging and recording techniques allowing us to map brain structures and functions, our ability to learn lessons from nature and to build biologically inspired intelligent systems has never been greater. At the same time, the growth in computer science and technology has unleashed enough computational power at sufficiently low prices, that an explosion of intelligent applications from driverless vehicles to augmented reality, to ubiquitous robots, is now almost certain. The emergence on these fronts presents the challenge of computational replication of all essential aspects of the human mind (the BICA Challenge.) The

challenge is interdisciplinary in nature and promises to yield bi-directional flow of understanding between all involved disciplines.

This volume includes selected papers from the Fifth Annual International Conference on Biologically Inspired Cognitive Architectures, BICA 2012, which is also the Fifth Annual Meeting of the BICA Society. Beginning with the AAAI Fall Symposia (Samsonovich, 2008, 2009), the Annual International Conference on BICA has been held every year since 2010, demonstrating progressively growing popularity. Locations of the conference included Arlington, Virginia (near Washington, DC): (Samsonovich, 2010; Samsonovich et al., 2010; Samsonovich & Jóhannsdóttir, 2011); Palermo, Italy (Chella et al., 2012); Kiev, Ukraine (Samsonovich, 2013); and this year – Cambridge, Massachusets (2014). The conference was held on the MIT campus in the Stata Center and in the nearby Cambridge Marriott hotel. Unlike in previous years, in this year the BICA conference included a number of symposia and a workshop. The number of registered participants for some of these parts exceeded the number of main track registrants. All this clearly demonstrates the impressively growing success of the BICA conference series. In this year we received over 100 submissions to the conference, all of which were peer-reviewed. In making the selection, our goal was to cover all domains and aspects of the BICA Challenge, while maintaining the scientific standards. We are grateful to all authors who contributed their works to this conference.

Both, the BICA conference and the Elsevier journal BICA, were founded and are being run by the BICA Society as a means to fulfill its mission, which includes bringing together researchers from disjoint fields and communities who devote their efforts to solving the BICA Challenge. This challenge calls for an integrated understanding of artificial and natural intelligent systems, including their biological functions, cognition and learning. The BICA paradigm is the approach that allows us to integrate theories, computational models and results developed in different disciplines, from neuroscience to cognitive science, artificial intelligence and robotics. This approach allows us, on the one hand, to better understand the complex operation of the brain in order to suggest new horizons for research in neuroscience and psychology, and on the other hand, to use inspirations from these fields for modern robotics and intelligent agent design.

Since the emergence of computers people were dreaming about making them similar to humans; however, only today are we in a position to solve this challenge practically. It is unlikely that a single laboratory, no matter how big and advanced, can succeed in this fantastic effort. This huge challenge can only be tackled by a multinational effort of many laboratories, scientists, institutions, and research facilities around the world that continuously exchange their ideas, knowledge and results. Therefore, one of the aims of the BICA conference is to provide a general forum for researchers and scholars from different scientific communities, who may be speaking different scientific languages and pursuing different research goals, yet implicitly or explicitly they contribute efforts to solving the BICA Challenge. This forum facilitates interdisciplinary collaborations and allows researchers to freely share their ideas, tools and results in pursuit of the overarching goal.

2 Scientific Program: Topics and Speakers

Many fields and communities in computational, cognitive and brain sciences were represented at the conference. Among invited participants of BICA 2014 were top-level scientists like David Aha, Patrick Winston, Frank Ritter, Walter Schneider, and many more, many of whom are also top-level current and prior Program Managers (including Michael Cox, Robert Laddaga, Loius Lome, Dan Hammerstrom), top-level Publishers (Sweitze Roffel), or young rising stars (e.g., Terry Stewart, Chris Dancy, Tarek Besold). With the general broad focus of BICA 2014 on perception, attention, language, learning, goal reasoning and metacognition, some of the addressed key questions were:

- What can we learn from biological systems about how perception, attention, decision making, and action work together to produce intelligent behavior that is robust in natural environments?
- What have we learned about information flow in biological systems that can aid us in building better artificial systems that combine perception, action, language, learning, and decision making in robots and intelligent agents?
- What have we learned recently about information flow in the brain that can lead to better cognitive models that combine perception, attention, decision making, action, language, and learning?
- What role is played by emotions in perception, attention, decision making, language, and learning?
- How have we, or can we incorporate into cognitive architectures new evolving understandings about flow of information in biological cognitive systems?
- What mathematical foundations are emerging today that can support perception and learning?

Specifically, the following topics of the field of BICA research and fields related to the BICA Challenge were covered by talks and papers of the conference, including its symposia and the workshop (only some of which are included in the volume of Procedia Computer Science).

Neuroscience:

- "B" in BICA: useful biological constraints for cognitive architectures
- Bridging the gap between artificial and natural information processing
- Cognitive and learning mechanisms informed by neuroscience
- Neural correlates of cognitive and meta-cognitive processes
- Robustness, scalability and adaptability in neuromorphic systems
- Neurophysiological underpinnings of reinforcement learning
- Physiological mechanisms of memory formation and (re)consolidation
- Representation of contextual and conceptual knowledge in neural systems

Social, Economic and Educational Sciences:

- Mixed-initiative systems based on inspirations from biology
- Agents possessing human-level social and emotional intelligence
- BICA in learning and tutoring technologies and education
- BICA models of self and their application to perception and action
- Representation, perception, understanding and expression of emotions
- Virtual characters, artificial personalities and human-compatibility
- Agent-based modeling of intelligent social phenomena

Cognitive Science:

- Perception, reasoning, decision making and action in BICA
- Combining natural and artificial approaches to cognition
- Comparison of different forms of learning and memory
- Theory-of-Mind, episodic and autobiographical memory in cognitive systems
- Introspection, metacognitive reasoning and self-awareness in BICA
- Models of learning and memory: robustness, flexibility, transferability
- Natural language and its role in intelligence, cognition and interaction
- Unifying frameworks and constraints for cognitive architectures

Artificial Intelligence:

- Creativity, goal reasoning and autonomy in artifacts
- Embodied vs. ambient intelligence
- Language capabilities and social competence
- Learning by reading, by observation, by reasoning and analogy
- Robust and scalable machine learning mechanisms
- Self-regulated learning, bootstrapped and meta-learning
- The place for BICA in the textbook of artificial intelligence

General:

- Mathematical basis for BICA and fundamental theoretical questions in BICA research
- Alternative substrates for implementation of BICA: smart materials, quantum and biocomputing
- Alternative approaches to the development of BICA such as: evolutionary, system-theoretic, educational.
- Fundamental practical and theoretical questions in BICA research and technology
- Cognitive Decathlon and Grand Challenges for BICA as components of the BICA Challenge
- Critical mass for a universal human-level learner and a roadmap to the BICA Challenge
- Metrics, tests, proximity measures and the roadmap to human-level / human-compatible AI
- Leveraging the cloud, world-wide-web, and social-media: possible role for BICA?
- Interdisciplinary research opportunities
- International trends in funding BICA related research

3 Outreach Activities and Social-Cultural Program

For the first time in this year, the BICA conference included as its parts a number of symposia and special tracks. The symposia covered topics from self-conscious robotics and cognition-emotion interaction, through brain mapping and neural-symbolic modeling, to reservoir computing and logical circuits. The Industry Track facilitated establishment of partnership and collaboration between the Academia and Industrial sectors. Of a special interest to the audience was the Early Career Researcher Workshop Track (ECRT): an outreach event sponsored by Elsevier B.V. The purpose of ECRT was to help students and young scientists learn how to:

- Plan and conduct research
- Get published in mainstream journals
- Market results to a funding agency
- Present results and talk about own work
- Promote own research through new media

Invited speakers of ECRT included: Patrick H. Winston, Ford Professor of AI and CS at MIT (Cambridge, MA); Louis Lome, a retired DoD S&T Program Manager (Arlington, VA); Sweitze Roffel, sr. Publisher from Elsevier B.V. (Amsterdam); Paul Robertson, Chief Scientist, Dynamic Object Language Labs (Boston, MA); and Jennifer Chang, Global director from Mendeley (New York).

As always, this BICA conference included a rich cultural and social program. Events like a three-hour Atlantic cruise with a banquet on the lower deck and a cocktail party on the upper deck, with an organized panel and spontaneous discussions among young and senior scientists, are hard to forget.

4 Acknowledgments

It is impossible to give credit here to all who contributed to the success of BICA 2014. In short, it took a lot of effort to put this conference together. We are grateful to all members of the Organizing and Program Committees for their valuable help in reviewing submissions, for their generous work and initiatives that together resulted in the great success of our conference. Our greatest thanks go to our sponsors: Elsevier B.V.; the MIT CSAIL; Dynamic Object Language Labs, Inc.; and, of course, the BICA Society. We are grateful to all Members of the BICA Society for their continuous support and participation in all BICA Society enterprises, including this conference series, the most impressive event of which has been BICA 2014.

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