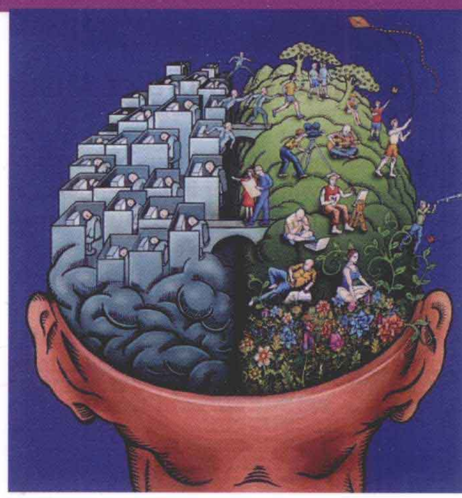
Progress of Advanced Intelligence

Volume II



Proceedings of
2010 International Conference on
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20 – 23 August, 2010, Beijing, China

Zhongzhi Shi, Ben Goertzel, Fuji Ren (Eds.)

Chinese Association for Artificial Intelligence (CAAI)

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PREFACE

Artificial Intelligence is now stepping into a new era that can be symbolized as Advanced Intelligence. Professor Loft A. Zadeh, chairman of International Advisory Committee of the Conference, proposed the following features as good marks: (*a*) the natural intelligence and artificial intelligence should be closely interacted in Advanced Intelligence, instead of separate from each other like what it was during the past and (*b*) the significant frontiers in natural and artificial intelligence should receive much more attentions in the research of Advanced Intelligence, in addition to the elementary issues. These explanations have been accepted unanimously. This, of course, all the other issues related to artificial intelligence will also be concerned, such as large-scale distributed intelligence, Web intelligence, artificial emotion, intelligent robotics, reasoning, and pattern recognition. In response to these new features and demands, the International Conferences on Advanced Intelligence (ICAI) was collectively initiated through the representatives from five continents in Beijing on August 1, 2006. It was decided that ICAI will be a serial conference held every other year, starting from 2008.

ICAI2010 provides a leading international forum for the sharing of original research results and practical development experiences among researchers and application developers from all areas related to the Advanced Intelligence.

ICAI2010 conference has 5 keynotes speakers who will give interesting talks from active areas in advanced intelligence. 18 regular papers are selected for this volume. Each paper is reviewd by two internationally renowned program committee members.

This volume is structured into 4 parts according to the contents:

1. Intelligence Science
2. Humanoid Robotics
3. Artificial Emotion
4. Reasoning and Recognition

Thanks to the outstanding contributions from all keynotes speakers, authors, organizers, reviewers and participants all over the world, ICAI2010 will be a very successful conference. We would pass our deepest gratitude to all of you and wish you a fruitful exchange in academy in Advanced Intelligence research and an enjoyable stay in Beijing.

Zhongzhi Shi
Ben Goertzel
Fuji Ren
PC Chairs of ICAI2010
August 2010, Beijing

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On Advanced Intelligence

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Abstract

The terminology of "Advanced Intelligence" was formally proposed and accepted, as a new direction, program and paradigm for the Intelligence Science and Technology research, at the 2006 International Conference on Artificial Intelligence which was jointly organized by the Chinese Association for Artificial Intelligence (CAAI), the American Association for Artificial Intelligence (AAAI) and the European Coordination for Artificial Intelligence (ECAI) for the celebration of 50th anniversary of the birth of Artificial Intelligence.

Compared with the current state of the art in artificial intelligence research, the major features of Advanced Intelligence include (1) it should have a unified approach to the intelligence research instead of many inconsistent approaches as it is, (2) it should have closely cooperation with natural intelligence research (Brain and Cognitive Science) instead of separation from them as it is, and (3) it should make endeavor for the study on deeper issues like Consciousness, Emotion, Intelligence, and their interrelationship instead of ignoring the other two as it is.

The study on Advanced Intelligence has made encouraging progress since 2006. The new approach to intelligence research has been established based on Mechanism of Intelligence Formation and is expressed the Information Conversion Approach that converses information to Knowledge and further to Intelligence. It has been proved that the three dominant, and mutually inconsistent, approaches existed in artificial intelligence so far, i.e., the structuralism, the functionalism, and the Behaviorism approaches, are in fact the harmonious examples of the new approach. The Information Conversion approach is also proved to be a rational, and thus effective, tool leading to the deep understanding of Consciousness, Emotion and Cognition.

It is interesting to note that the line of thought of Advanced Intelligence is highly coincident with that of Artificial General Intelligence (AGI). Both Advanced Intelligence and AGI are seeking the human-like and human-level artificial intelligence although they may have different approaches. This makes them complementary to each other. Therefore, it would be a good idea for both Advanced Intelligence group and AGI group to have close cooperation in research in the future.

Biography

Yixin Zhong, Professor from Beijing University of Posts and Telecommunications (BUPT), Beijing, China. He is Chairman of Academic Committee of BUPT, President of Chinese Association for Artificial Intelligence, Vice President of World Federation of Engineering Organizations (WFEO) and Chairman of WFEO Committee on Information and Communication. His major interests in research and teaching include Information Science, Artificial Intelligence, Neural Networks and Cognitive Science. He has published 16 books and over 480 journal and conference papers in the areas related to his interests. He is the major contributor to the establishment of Comprehensive Information Theory, Advanced Intelligence, and the theory of Information Conversions.

Artificial General Intelligence: Past, Present and Future

Ben Goertzel

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Abstract

The original goal of the AI field, from its founding in the 1950s, was the construction of "thinking machines" — that is, computer systems with human-like general intelligence. Due to the difficulty of this task, for the last few decades the majority of AI researchers have focused on what has been called "narrow AI" — the production of AI systems displaying intelligence regarding specific, highly constrained tasks.

In recent years, however, more and more researchers have recognized the necessity — and feasibility — of returning to the original goals of the field. Increasingly, there is a call for a transition back to confronting the more difficult issues of "human level intelligence" and more broadly "artificial general intelligence (AGI)."

In this talk I will review the conceptual and mathematical foundations of AGI; discuss the relationship between AGI and other disciplines such as neuroscience, cognitive psychology and philosophy of mind; and review a number of current projects aimed at achieving AGI, including MicroPsi, SOAR, LIDA and my own open-source OpenCog project. Finally I will describe a concrete "Roadmap to Human-Level AGI" that was created by a dozen AGI researchers in a workshop at the University of Tennessee Knoxville in October 2009, which involves creating AGI systems that can control robotic and virtual agents operating in preschool environments and achieving milestones based on the instruments used to evaluate the intelligence of human children.

Biography

Dr. Ben Goertzel is CEO of AI software company Novamente LLC and bioinformatics company Biomind LLC, and External Research Professor in the Artificial Brain Lab at Xiamen University in China. He is also the leader of the open-source OpenCog AI software project; Vice Chairman of Humanity+; and Advisor to the Singularity University and Singularity Institute.

He received his PhD in Mathematics from Temple University in 1989, then served as an Assistant Professor of Mathematics at the University of Nevada; a Senior Lecturer in Computer Science at the University of Waikato in Hamilton, New Zealand; a Research Fellow in Cognitive Science at the University of Western Australia in Perth; an Associate Professor at the City University of New York; and a Research Fellow in Computer Science at the University of New Mexico. During 1998–2001 he was CTO of Webmind Inc., a venture capital funded AI software firm with 130+ employees.

His current research work encompasses artificial general intelligence, natural language processing, cognitive science, data mining, machine learning, computational finance, bioinformatics, virtual worlds and gaming and other areas. He has published a dozen scientific books, nearly 100 technical papers, and numerous journalistic articles, and has organized numerous conferences and workshops, including a role as Chair of the Artificial General Intelligence conference series.

Towards a New Generation of Cognitive Architectures

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Abstract

A cognitive architecture provides a hypothesis about the fixed mechanisms underlying intelligence and how they combine to yield appropriate environmental behavior in the presence of knowledge. Such an architecture will generally at least include memories, an ability to make decisions, learning mechanisms, and external interfaces. However, it may also embody additional mechanisms in support of more advanced capabilities such as reasoning, problem solving and planning, reflection, collaboration and emotion. A cognitive architecture may be intended as a model of human cognition and/or as the basis for artificially intelligent (AI) systems.

The ideal architecture provides an effective combination of functionality and uniformity. Functionality concerns the range of intelligent behaviors that are realizable. Uniformity involves providing such behaviors through interactions among a small number of general mechanisms, rather than postulating a new mechanism for each additional behavior. Functionality and uniformity jointly determine the utility and elegance of the architecture. Yet they are often in conflict in existing architectures, as the desire for new functionality constantly strains what can be realized with existing combinations of mechanisms. Reconciling functionality and uniformity demands a continual search for new mechanisms capable of increased generality and integrability.

For fifteen years (1983–1998) I co-led the Soar project, a multidisciplinary, multi-institutional effort to develop, understand and apply a cognitive architecture capable of combining functionality and uniformity in service of modeling human cognition and building AI systems. From a small set of mechanisms Soar yielded a wide range of intelligent behaviors across many task domains, with the most striking results often due to interactions among these mechanisms. However, as more and more functionality was desired, the strain ultimately became too great for the existing uniform approach to sustain. In response, over the past decade the Soar 9 architecture has sacrificed uniformity for functionality, with addition of new memories, new learning mechanisms, and other capabilities.

I have recently returned to research in cognitive architecture with the goal of developing new architectures that dramatically extend the functionality of the existing generation while simultaneously reconstructing them on a more uniform base. The goal is thus a new generation of architectures with significant improvements in both functionality and uniformity. With respect to functionality, the goal is to develop a broadly capable *hybrid mixed architecture*. Cognitive architectures traditionally emphasize symbolic processing, although possibly with limited forms of numeric processing in perceptuomotor modules or via incorporation of forms of activation, as in neural networks. A hybrid architecture tightly integrates symbolic and numeric/signal processing, enabling close coupling of perceptuomotor and cognitive behavior. A mixed architecture integrates symbolic and uncertain/probabilistic reasoning, enabling

general reasoning under uncertainty. A hybrid mixed architecture supports signals, probabilities and symbols in an integrated manner.

Uniformity is being tackled by developing a common implementation of signal, probability, and symbol processing based on *graphical models*. Bayesian networks are the best-known form of graphical model, but other varieties include Markov networks (aka Markov random fields) and factor graphs. Factor graphs provide efficient computation with complex multivariate functions by decomposing them into a product of subfunctions that can be mapped onto undirected bipartite graphs. In conjunction with the summary-product algorithm, factor graphs yield state-of-the-art methods for many standard signal, probability and symbol processing problems, raising the possibility of supporting uniform yet broadly functional hybrid mixed architectures. The long-term hope is that this approach will yield the next generation of general mechanisms in support of new architectures surpassing today's best in terms of both functionality and uniformity.

This talk will begin with a brief review of the earlier work on Soar plus an introduction to Soar 9. This will be followed by presentation of the new graphical approach to hybrid mixed architectures, progress so far in creating such an architecture, and future plans.

Biography

Paul S. Rosenbloom is a Professor of Computer Science at the University of Southern California (USC), a Project Leader at USC's Institute for Creative Technologies (ICT) and Deputy Director of the Center for Rapid Automated Fabrication Technologies (CRAFT). He was a member of USC's Information Sciences Institute (ISI) for twenty years, most recently as its Deputy Director. Prior to coming to USC in 1987, he was an Assistant Professor of Computer Science and Psychology at Stanford University from 1984 to 1987, and a Research Computer Scientist at Carnegie Mellon University from 1983 to 1984. He received a B.S. degree in Mathematical Sciences (with distinction) from Stanford University in 1976 and M.S. and Ph.D. degrees in Computer Science from Carnegie Mellon University in 1978 and 1983, respectively. Prof. Rosenbloom was elected a Fellow of the Association for the Advancement of Artificial Intelligence (AAAI) in 1994, and has served as Chair of the Association for Computing Machinery (ACM) Special Interest Group on Artificial Intelligence (SIGART), Councilor of the AAAI, Conference Chair for the AAAI, and Program Co-Chair of the National Conference on Artificial Intelligence (AAAI-92).

From 1983 until 1998, Prof. Rosenbloom was a co-PI of the Soar Project, a multi-disciplinary, multi-site attempt at developing, understanding, and applying a cognitive architecture capable of supporting general intelligence. Research on Soar spanned areas such as machine learning, problem solving and planning, production systems, intelligent agents, virtual humans, multi-agent systems, knowledge-based systems, neural networks, and cognitive modeling. The most significant applications were intelligent automated pilots and commanders for synthetic battlespaces, as deployed in Synthetic Theater of War'97 (STOW-97). From 1998 until 2007 Prof. Rosenbloom's focus was on exploring and developing new directions for ISI, such as blending entertainment expertise and computing technologies for military training; virtual organizations consisting of mixtures of people, agents, robots, and/or computational systems; responding to the unexpected; high performance computing, scalable distributed computing, and computational science; biomedical informatics; automated construction; and technology and the arts. Currently, Prof. Rosenbloom is working on a new approach to cognitive architecture based on graphical models and writing a book tentatively titled *What is Computing? The Architecture of the Fourth Great Scientific Domain.*

Multi-Context Systems: From Knowledge Integration Towards Knowledge Mediation

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Abstract

The IT developments of the last decade have rapidly changed the opportunities for data and knowledge access. The World Wide Web and the underlying Internet provide a backbone for the information systems of the 21st century, which will possess powerful reasoning capabilities that enable one to combine various pieces of information, stored in heterogeneous formats and with different semantics. To fully exploit the wealth of knowledge, one has to mix semantically rich sources like domain ontologies, expert knowledge bases, temporal reasoners etc. in a suitable manner.

However, more than a simple integration of data and knowledge is desirable. Gio Wiederhold was the first to express the vision of powerful knowledge mediation. Mediation provides services at an abstract level that go far beyond mere integration, and take aspects such as situatedness, social context, and goals of a user into account. Like many visions of AI, it has not yet materialized satisfactorily.

Driven by the need to combine (possibly heterogenous) knowledge bases, numerous proposals were made to solve this problem, and extensions of declarative KR formalisms were conceived that allow to access external data and knowledge sources. A promising recent framework are nonmonotonic multi-context systems (MCSs), which allow for a principled integration of different logic-based formalisms. Intuitively, each context consists of a knowledge base, expressed in terms of a local language. So-called bridge rules specify the information flow between the contexts depending on presence or absence of beliefs in other contexts. MCS empower the combination of "typical" monotonic KR logics like Description Logics, and nonmonotonic formalisms like Logic Programs or Default Logic. However, they are still far away from the vision of knowledge mediation.

Argumentation Context Systems (ACSs), which specialize (all contexts are based on Dung argumentation frameworks) and generalize MCSs at the same time, illustrate some important next steps. In an ACS, a context M1 may influence another context M2 in a much stronger way than in an MCS; M1 may directly affect M2's KB and reasoning mode, by invalidating arguments or attack relationships in

M2's argumentation framework, and by determining the semantics to be used by M2. In addition, ACSs feature an integration-oriented mediation service, by special mediator components in the modules which manage inconsistencies. A mediator collects the information coming in from connected modules and turns it into a consistent configuration for its module, using a pre-specified consistency handling method.

An obvious next step we are currently working on is the development of a framework which captures both MCSs and ACSs.

Biography

Gerhard Brewka is Professor for Intelligent Systems at Leipzig University, Germany. His research interests lie in the fields of knowledge representation, non-classical reasoning (e.g. nonmonotonic or default reasoning), inconsistency and preference handling, answer set programming, reasoning about action, and multi-context systems. He wrote and edited several books in these areas and published numerous articles.

Gerhard Brewka was Program Chair of the European Conference on Artificial Intelligence (ECAI), Italy, 2006, of LPNMR (Logic Programming and Nonmonotonic Reasoning), USA, 2007, of KR (Principles of Knowledge Representation and Reasoning), Australia, 2008, and several other conferences and workshops. He will be General Chair of KR 2012 in Rome, Italy. He currently serves as an Associate Editor for the *Artificial Intelligence Journal* and the *Journal of Artificial Intelligence Research.*

Gerhard Brewka is a Fellow of ECCAI, the European Coordinating Committee on Artificial Intelligence, since 2002. Since 2006 he is a member of the board of ECCAI which represents 26 European Artificial Intelligence Associations. In 2008 he was elected President of ECCAI.

Anxiety and Decision-Making: Evidence from Neuroimaging Studies

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Abstract

Conceptually, decision-making can be divided both temporally and functionally into three distinct processes: the assessment of possible options; the selection and execution of an action; and outcome evaluation. According to previous research, all of these processes could be influenced by anxiety. Specifically, anxiety is suggested to be associated with pessimistic outcome expectation, an increased likelihood of making risk-avoidant choice, and higher subjective costs of the negative outcomes.

The aim of the current studies is to examine the relationship between (trait) anxiety and decision-making, as well as the neurobiological basis of this relationship. For the purpose of investigating the stage of outcome evaluation, a version of Gehring & Willoughby's (2002) monetary gambling task was applied while under EEG recording. The ERP results associated with outcomes were compared between groups. Compared to non-anxious group, the anxious group exhibited a smaller feedback-related negativity (FRN) following negative outcome, and a larger FRN following ambiguous outcome. It is widely believed that the amplitude of FRN is influenced by both the valence and the expectation of the outcome. In our opinion, the first finding reflected the impact of anxiety on outcome expectancy, while the second one reflected the impact of anxiety on the interpretation of ambiguous outcomes.

Besides, we investigated the potential relationship between anxiety and so-called "framing effect" by means of fMRI, since the framing effect is suggested to reflect how emotional information influence decision-making process. Damasio et al.'s (2006) financial decision-making task is used. According to our behavioral data, the anxious participants demonstrated a stronger framing effect, suggesting that they are more likely to be influenced by emotional information during decision-making. In addition, the fMRI results revealed that, compared with low-anxious group, the anxious group exhibited significant activation in the anterior prefrontal cortex and caudate, when subjects chose in accordance with the frame effect.