Reports on the 2014 AAAI Fall Symposium Series

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■ *The AAAI 2014 Fall Symposium Series was held Thursday through Saturday, November 13–15, at the Westin Arlington Gateway in Arlington, Virginia, adjacent to Washington, DC. The titles of the seven symposia were Artificial Intelligence for Human-Robot Interaction; Energy Market Prediction; Expanding the Boundaries of Health Informatics Using AI; Knowledge, Skill, and Behavior Transfer in Autonomous Robots; Modeling Changing Perspectives: Reconceptualizing Sensorimotor Experiences; Natural Language Access to Big Data; and The Nature of Humans and Machines: A Multidisciplinary Discourse. The highlights of each symposium are presented in this report.*

Artificial Intelligence for Human-Robot Interaction

The primary goal of the AI for Human-Robot Interaction symposium was to bring together and strengthen the community of researchers working on the AI challenges inherent to human-robot interaction (HRI). HRI is an extremely interesting problem domain for AI and robotics research. It aims to develop robots that are intelligent, autonomous, and capable of interacting with, modeling, and learning from humans. Humans, and human environments, bring with them inherent uncertainty in dynamics, structure, and interaction. As a result, the problem of developing models and autonomous capabilities of interactive robots lies at the core of AI research. The research community showed a tremendous positive response to the symposium, with 60 contributed abstracts and more than 100 attending participants. Each of the authors of contributed abstracts gave a three-minute lightning talk, which served to showcase the breadth of activity within the space of AI+HRI. The program also included six keynote presentations, a funding panel, a community panel, and multiple breakout sessions.

The keynote presentations, given by speakers that have been working on AI for HRI for many years, focused on the larger intellectual picture of this subfield. Each speaker was asked to address, from his or her personal perspective, why HRI is an AI problem and how AI research can bring us closer to the reality of humans interacting with robots on everyday tasks. Speakers included Rodney Brooks (Rethink Robotics), Manuela Veloso (Carnegie Mellon University), Michael Goodrich (Brigham Young University), Benjamin Kuipers (University of Michigan), Maja Mataric (University of Southern California), and Brian Scassellati (Yale University). Promi-

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nent topics appearing in the keynote presentations included caution against building nongeneralizable models and against studying unimportant phenomena, to do a better job articulating the science of the HRI field to others, and to remain open-minded regarding what advances can be counted as contributions to this young field.

An important part of growing this research community will be the cultivation of funding opportunities. Toward that goal, the symposium included an invited panel session of program managers from the NSF, ONR, NASA, and DARPA. The discussion focused on existing funding opportunities in this area, as well as steps toward establishing new opportunities. The meeting concluded with a planning session on the last morning of the symposium that focused on discussing a roadmap for the field of AI-HRI. A summary of this planning session will be presented at the follow-up AI-HRI symposium that is being planned for fall 2015.

The organizing committee for this symposium included Sonia Chernova (Worcester Polytechnic Institute), Kris Hauser (Duke University), Odest Chadwicke Jenkins (Brown University), Maja Mataric (University of Southern California), Andrea Thomaz (Georgia Institute of Technology), and Manuela Veloso (Carnegie Mellon University). The papers from the symposium were published as AAAI Press Technical Report FS-14-01.

Energy Market Prediction

Efforts to tackle climate change require the development of new, clean technologies as well as their adoption, diffusion, and use. Solar panels, battery storage, and energy-efficient technologies must be broadly purchased, installed, and exploited to have measurable carbon impacts. Unlike past energy innovations, these clean technologies will not be centrally sited and owned by a small number of large corporations. Instead, there are millions of individuals, families, and businesses that will decide when, where, and how these energy products are plugged into the electricity grid. The goal of this symposium was to advance computational social science as a tool for energy planners and marketers to select the most efficient, effective, and cost-effective methods for incenting the diffusion of clean technology.

This symposium brought together researchers and practitioners from a variety of domains including multiagent simulation, machine learning, geoinformatics, signal processing, behavioral economics, econometrics, market science, and political science. A major theme of the papers presented at the symposium was the need for close feedback between clean technology adoption records, numerical simulations, and field experimentation. Invited speakers gave talks on this theme. Andy Rossmeissl (chief executive officer of Faraday) focused on how his company's use of large-scale demographic data, predictive algorithms, and randomized control trials can make advertising campaigns for solar companies more effective. Juliet Shavit (president of SmartMark Communications) discussed how computational social science can be harnessed to shape how electric utilities communicate to their customers. Irina Feygina (White House Office of Science and Technology Policy) described how the federal government is applying behavioral insights and rigorous measurement and evaluation to improve the effectiveness of energy programs.

Another major theme was the development of accurate multiagent simulations that can reliably forecast the impacts of new energy policies, programs, incentives, and regulations. Brian Bush (National Renewable Energy Laboratory) introduced a novel methodology for grouping this complex set of today's and tomorrow's national and subnational incentives. Ben Sigrin (National Renewable Energy Laboratory) presented results on a decision framework used by clean tech adopters. Unni Pillai (University of Albany College of Nano Science and Engineering) described a new model for understanding competition between solar companies. Haifeng Zhang (Vanderbilt University) and Joshua Latchford (Sandia National Laboratories) presented numerical models for predicting the adoption of residential solar energy systems trained on real data from San Diego, California. These papers illustrate how a wide variety of datasets can be used to understand and predict future patterns and trends for energy market dynamics.

The symposium participants discussed ways to more quickly integrate new knowledge from the social sciences into numerical models, how the output from numerical models can be tested in real-world pilots, and how pilots can inform local, state, and national energy policies. The value of big data and behavioral insights are becoming in vogue among energy researchers and policymakers. New tools must be generated that couple these approaches, especially with the global need to accelerate adoption rates for clean energy technologies.

The symposium chairs acknowledge support from the U.S. Department of Energy SunShot Initiative. Kiran Lakkaraju (Sandia National Laboratories), Eugene Vorobeychik (Vanderbilt University), and Adam Cohen served as cochairs of this symposium; the papers from the symposium were published as AAAI Press Technical Report FS-14-02.

Expanding the Boundaries of Health Informatics Using AI

The 20th century laid a foundation of evidence-based medicine that relied on populations and large groups of patients to derive generalized results and observations that were applied to (mostly passive) patients. Yet, the 21st century is shaping up as a time where the

patient and personalized health data is the driver of health-care innovation and delivery. This is a significant shift from the paradigm where physicians made patient treatment decisions based on their clinical experience and by evidence-based results derived from general population studies. The rise of novel methods and tools for collecting and storing large amounts of personalized health data (for example from various types of electronic health records and from new sensors) has made vast amounts of data available. Several projects have shown that sharing this data offers multiple advantages to both physicians and patients, enabling them to globally identify similar patient cases and discover successful therapies from other patients and physicians. Access to this information, from a multitude of data channels, allows for shared decision making that enables physicians to personalize care decisions and, at the same time, supports patients' engagement in their own care. This paradigm shift, termed *participatory medicine*, will eventually lead to improved patient outcomes and reduced health-care costs, but significant challenges must be addressed before its full promise is realized.

In addition to providing physicians with the necessary tools to effectively take advantage of available medical data, patients will need guidance so they can embrace their new roles as active participants in their care. The physician-patient relationship will transition from one- to two-way communication where patient treatment becomes a feedback rather then a feed-forward process. Similarly, information technology will need to evolve to improve communication, collaboration, and teamwork among patients, their families, and care teams involving practitioners from different fields and specialties. All of these changes require novel solutions and the AI community is well positioned to provide both theoretical- and application-based methods and frameworks.

This symposium received a large number of submissions that were divided into several themes. In addition to these themes, three invited speakers provided crucial insights into and directions for health informatics research. The first day began with an invited talk by Mark Boddy (Adventium Labs), Be Careful What You Wish For: The Perils and Pitfalls of Artificial Intelligence in Healthcare. Boddy discussed past, present, and future applications of AI techniques to health care, describing the complications arising from those applications and, where possible, suggesting some potential ways of addressing them. The talk served as a cautionary tale and jumping off point for the symposium's technical presentations. The first day included presentations and posters pertaining to large scale data analysis, with discussions on improving randomized trials through automated meta-analysis and how to scale personalized feedback to a national scale. The afternoon saw talks on semantic health information assistants and using social media for preference elicitation in shared decision making.

Dr. Emek Demir (Memorial Sloan Kettering Cancer Center) kicked off the second day with an applied talk, Harnessing Experts, Machines, and the Crowd to Beat Cancer. Dr. Demir discussed his work with the Pathway Commons project, specifically describing solutions to expand and accelerate precision oncology, combining big data, crowdsourcing, NLP, open data standards, and knowledge bases. The talk provided a poignant introduction to the day's talks on complex patient-oriented care, including work on using AI to support teamwork for coordinated care and a first-order logic-based approach to represent clinical practice guidelines and to mitigate adverse interactions when caring for multimorbid patients. Additional work on semantic integration was presented that tackled the problems of health data interoperability and AI-based argumentation in participatory medicine.

The symposium's final invited talk, MobiGuide: Guiding Patients Any Time, Everywhere in a Personalized Way, was given by Mor Peleg (University of Haifa). Peleg described the multinational MobiGuide project and its work on providing continuous clinical guideline-based guidance for mobile patients. The symposium concluded with a presentation and group discussion led by the symposium's chair, Martin Michalowski, surrounding the current funding landscape for health informatics research. Michalowski also presented various research problems in need of attention as the field moves forward along with opportunities for collaboration and publication between the symposium participants.

Martin Michalowski served as the symposium chair with Dympna O'Sullivan, Jay M. Tenenbaum, and Szymon Wilk serving as cochairs. The papers of the symposium were published as AAAI Press Technical Report FS-14-03.

Knowledge, Skill, and Behavior Transfer in Autonomous Robots

Autonomous robots have achieved high levels of performance and reliability at specific tasks. However, for them to be practical and effective at everyday tasks in our homes and offices, they must be able to learn to perform different tasks over time, demonstrating versatility. Learning each task in isolation is an expensive process, requiring large amounts of both time and data. In robotics, this expensive learning process also has secondary costs, such as energy usage and joint fatigue. Recent developments in transfer and multitask learning provide a potential solution to this problem, enabling robots to minimize the time and cost of learning new tasks by building upon knowledge learned from other tasks. This ability is essential to enable the development of versatile autonomous robots that are expected to perform a wide variety of tasks and rapidly learn new abilities.

Various aspects of this problem have been addressed

by research across several different communities, including machine learning, knowledge representation, optimal control, and robotics. This symposium brought together researchers from these different communities toward the goal of enabling autonomous robots to support a wide variety of tasks, rapidly and robustly learn new abilities, adapt quickly to changing contexts, and collaborate effectively with other robots and humans to achieve a common goal.

One of the main themes of the symposium was human-robot interaction, that is, how knowledge can be effectively transferred from humans to robots or vice versa. This was related to both single skill transfer, for instance teaching a robot how to clean the table, and to more general interaction through which robots can affect humans' behaviors, such as in healthier life choices. Three invited speakers explored various aspects of human-robot interaction: Yiannis Demiris (Imperial College London), Andrea Thomaz (Georgia Institute of Technology), and Maja Mataric (University of Southern California).

Another major theme was skill abstraction in a reinforcement learning setting. Understanding the similarities between different problems, and exploiting such similarities in order to generalize and transfer behaviors is an area increasingly active in reinforcement learning, although the applications to robotics are still limited. Two invited speakers discussed different methods for hierarchical learning and control: Peter Stone (University of Texas at Austin), and Nathan Ratliff (Max Planck Institute for Intelligent Systems). Manuela Veloso (Carnegie Mellon University) also gave an invited talk on an historical perspective of transfer learning, from when similarities across tasks were studied in symbolic reasoning under different names, to more recent results in the reinforcement learning setting.

The symposium participants discussed with interest the diversity of the methods in this emerging area, and the difficulties that still arise in their application to physical robots. The challenge of knowledge transfer can take different shapes in the different fields related to artificial intelligence and robotics. Participants agreed that future symposia on this topic will help identify connections across such fields, in order to overcome the difficult problem of overly specialized robots, unable to be generalized to similar contexts and exhibit versatile behaviors.

Matteo Leonetti served as chair of the symposium, with the collaboration of Eric Eaton and Pooyan Fazli as cochairs. The papers of the symposium were published as AAAI Press Technical Report FS-14-04.

Modeling Changing Perspectives: Reconceptualizing Sensorimotor Experiences

The Modeling Changing Perspectives symposium took inspiration from William James's observation that objects can be perceived in quite different ways depending on one's needs at the time. He gives the example of a piece of paper that could be conceived of as a surface for inscription or a combustible material, depending on one's needs. Some objects have well-established conventional uses and are conventionally perceived in a particular way, but James points out that there "are no truer ways of conceiving them than any others." If we take this idea into AI, to subareas that deal with perception, such as in computer vision and robotics, then we must question whether it is unduly limiting to focus only on obtaining the ground truth of a scene. Humans have a capacity to reinterpret experiences, to fluidly change perspectives and dynamically reframe a stimulus, when prompted by needs or external suggestions, for example. This is a key process at work when humans stretch their concepts to fit similar categories, or see deep similarities between things that are superficially different. It may be one of the key processes that make human cognition robust enough to deal with everyday variability, to effortlessly see analogies with past experiences and how to apply them to the present, and to engage in creative thinking: finding divergent ways to conceptualize a situation, rather than just one conventional way. These are key areas where existing artificial intelligence techniques are lacking.

The symposium focused on the representational basis of divergent thinking that allows humans to change perspectives and reconceptualize stimuli with apparent ease. Divergent choices can be made at the boundaries of different representations and computational levels. Cognitive systems need to interpret low-level experiences (such as neuronal, physiological sensors) using high-level concepts (such as belief, intention, identity). Recent advances in bottom-up machine learning allow computational systems to go from low-level sensor data up to useful midlevel features, and to even higher-level features still. Humanlike cognition also employs a top-down process to meaningfully frame our perceptual experiences. It is the top-down processes that allow an agent to interpret an object or an experience in divergent ways. For example, a household object like a frying pan may be used conventionally to fry an egg, or creatively to swat a fly or bash a burglar. This divergence is closely related to imaginative play and may also be integral to modeling social phenomena like empathy, since empathy demands that we adopt another's viewpoint, that we see things through a different lens (reconceptualization).

A number of related and overlapping strands of research were represented in this symposium, including computational techniques for reconceptualization; using analogies to facilitate and guide the process of reconceptualization in problem solving and education; how humans judge similarities, and how these judgments differ from those made by

computational systems; modeling emergence of linguistic concepts based on the sensorimotor information; the problem of discovering novel connections between linguistics concepts by looking at how these concepts are used with other concepts.

Over two days of intense discussion, we identified a few interdisciplinary, collaborative research themes that we plan to pursue in the near future. These include how to develop a computational system that discovers novel tool use to solve problems; and how to incorporate creative, playful interpretations in a machine vision system.

Bipin Indurkhya, Georgi Stojanov, Frank Guerin, and Tony Veale served as cochairs of this symposium. The papers of the symposium were published as AAAI Press Technical Report FS-14-05.

Natural Language Access to Big Data

Today's enterprises need to make decisions based on analyzing massive and heterogeneous data sources. More and more aspects of decision making are driven by data, and as a result, more and more business users need access to data. Offering easy access to the right data to diverse business users is of growing importance. There are several challenges that must be overcome to meet this goal. One is the sheer volume: enterprise data are predicted to grow by 800 percent in the next five years. The biggest part (80 percent) are stored in unstructured documents, most of which are lacking informative metadata or semantic tags (beyond date, size, and author) that might help in accessing them. A third challenge comes from the need to offer access to these data for different types of users, most of whom are not familiar with the underlying syntax or semantics of the data.

Natural language interfaces and question-answering systems, such as Watson, Smartweb, Siri, Start, or Evi, have been successfully implemented in various domains, for example, in encyclopedic knowledge bases (such as IBM's Jeopardy Challenge), in the field of energy (such as DGRC), or in the domain of mathematics (such as Wolfram Alpha). Following up on prior work in natural language interfaces to databases (NLIDB) and question answering (QA) systems, this workshop brings together experts from both academia and industry to present their most recent work related to problems that leverage natural language in the context of big data. They can share information on their latest investigations and exchange ideas and thoughts in order to push the research frontier toward new technologies that tackle the aspect of natural language access to large-scale and heterogeneous data.

The symposium addressed three different themes in particular. First, the challenge of leveraging large-scale structured and unstructured text collections, as most of available data are stored in unstructured documents; second, the aspect of entity contextualization to support natural language access by means of information extraction and disambiguation at web scale; and third, the aspect of translating the users' information needs into formal queries. We brought together researchers both from academia and industry from a variety of AI subfields such as natural language processing, decision support, and cognitive systems.

The talks included two invited talks emphasizing the aspects of cognitive computing and weighted deduction as an abstraction level for AI. The first invited talk, given by Frank Stein (IBM), focused on the industry perspective of the recent advances of the IBM Watson system and outlined the current challenges of cognitive assistants that leverage big data. The second invited talk, given by Jason Eisner (Johns Hopkins University), presented an overview in nonprobabilistic programming for probabilistic reasoning by means of the Dyna program. The symposium participants discussed the importance of information extraction algorithms as an important precondition for a natural language access, as well as natural language processing for document analysis including semantic role labeling and coreference resolution.

Ulli Waltinger, Dan Tecuci, and Daniel Sonntag served as cochairs of this symposium. The papers of the symposium were published as AAAI Press Technical Report FS-13-06.

The Nature of Humans and Machines: A Multidisciplinary Discourse

Recent advances in artificial intelligence (AI) — such as the development and use of human-computer interfaces to augment human capabilities, introducing technological products that replace the need for some human activities, and creation of machines that exhibit increasingly complex cognitive capabilities (inclusive, perhaps of some form of sentience) — while still formative are nonetheless prompting questions about both what it means to be human, and how such sentient machine systems should be regarded. Recent large-scale agendas such as the United States' Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative, the European Union's Human Brain Project, and the Asian Decade of the Mind are dedicated, at least in part, to the iterative development and use of neurally modeled, derived, and mimetic technologies. Such increasing support for and commitment to convergent neurocomputational technology and reverse-engineering neural (if not brainlike) systems fosters an escalating pace and scope of neurally modeled AI developments.

This pacing of technical advancement frequently surpasses that of the discourses that are important, if not required, to both pragmatically assess potential

trajectories of progress and instantiate preparedness for the effects that such progress can and will incur within the social sphere. To be sure, cultural constructs, values, norms, and mores — such as what it means to be human, a person, an autonomous being — involve definitions (and their potential revisions) that affect public life, law, politics, and social conduct. Yet, far too often, AI scientists have little opportunity for discussion with scholars in disciplines that work to define and advance the understanding of what new technological advances may imply. Thus, this symposium provided an initial venue for the thoughtful engagement of multidisciplinary scholars focusing upon more finely grained insights to the realistic potential of AI, and a shared understanding of the ways that novel discovery and innovation in this field can influence the human condition.

Relevant science and technology aspects presented during the symposium included the emphasis of discourse focused upon the computational explanatory gap, specifically as it relates to: the inability to develop high-level cognitive algorithms of AI and neurocomputational processing; conceptualization and constructs for engineering a "brain system"; and framing certain fundamental aspects of the human cognition and foundational elements of brain-based computation so as to allow their integration within a single quantitative representation.

Philosophy, ethics, and theology discussions centered on the nature of consciousness, embodiment, and the self relative to development and expression of these functions in machine or computational systems; the case for employing extant constructs of neuroethics to address issues, questions, and problems generated by efforts to create machines that develop higher-order cognitive functions, relational capabilities, and some form of consciousness; and secular and particular religious perspectives on the nature of human-human relationships, as extended to analyses of the evolving relationship between humans and ever more cognitively capable machines.

Individual and societal impacts, policy, and law discussions centered on the plausibility and validity of the notion of agency in machines, and how such agency could have an effect on various realms of society. As well, the current and future capabilities of autonomous weapon systems were addressed, with emphasis upon the viability of existing ethical and legal frameworks to guide their use, and if and how new ethico-legal approaches may or may not be necessary. A final discussion related the rise of human-machine systems and AI platforms to the potential for, and possible issues arising from, extending human lifespans.

The symposium conjoined multiple disciplines (both within AI, and from other fields) to establish more robust discourse and dialectic. We opine that continuing such a dialectical approach will be important, if not essential, to inform current and future efforts to guide, direct, and in some cases govern research, development, and articulations of increasingly intelligent machines and humanoid robots in society. Moreover, we posit that such discourse and dialectic should not be confined to the academic sphere, but rather should be conducted more broadly, to enable interactive conversations to inform the public, media, and policy makers. We believe that this exchange of information will better enable both society and the scientific-political estate to be prepared for and responsive to addressing near-term and future issues that are likely to be incurred from the momentum of such scientific and technological advancements.

Larry Medsker, chair, was joined by committee members James Giordano, Ilia Delio, and Cindy Mason to organize the symposium. This report was written by Larry Medsker and James Giordano. The papers of the symposium were published as AAAI Press Technical Report FS-14-07.

Adam B. Cohen in an independent consultant in Washington, DC.

Sonia Chernova is an assistant professor in the Computer Science Department at Worcester Polytechnic Institute.

James Giordano is a professor of neurology and interdisciplinary neuroscience at Georgetown University Medical Center.

Frank Guerin is a lecturer in the School of Natural and Computing Sciences at University of Aberdeen.

Kris Hauser is an associate professor in the Pratt School of Engineering at Duke University.

Bipin Indurkhya is a visiting professor in the Department of Computer Science at AGH University of Science and Technology.

Matteo Leonetti is a postdoctoral fellow at the University of Texas at Austin.

Larry Medsker is a professor of physics and computer science at Siena College.

Martin Michalowski is a senior principal research scientist at Adventium Labs in Minneapolis, MN.

Daniel Sonntag is a principal researcher, investigator, and project leader at the German Research Center for Artificial Intelligence.

Georgi Stojanov is a professor of computer science at the American University of Paris.

Dan G. Tecuci is a researcher at IBM Watson in Austin, Texas.

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