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JUDEA PEARL WINS ACM A.M. TURING AWARD FOR CONTRIBUTIONS THAT TRANSFORMED ARTIFICIAL INTELLIGENCE

Developed Novel Framework for Reasoning under Uncertainty that Changed How Scientists Approach Real World Problems

NEW YORK, March 15, 2012 – ACM, the Association for Computing Machinery http://www.acm.org today named Judea Pearl of the University of California, Los Angeles the winner of the 2011 ACM A.M. Turing Award for innovations that enabled remarkable advances in the partnership between humans and machines that is the foundation of Artificial Intelligence (AI) http://www.acm.org/pearl. Pearl pioneered developments in probabilistic and causal reasoning and their application to a broad range of problems and challenges. He created a computational foundation for processing information under uncertainty, a core problem faced by intelligent systems. He also developed graphical methods and symbolic calculus that enable machines to reason about actions and observations, and to assess cause-effect relationships from empirical findings. His work serves as the standard method for handling uncertainty in computer systems, with applications ranging from medical diagnosis, homeland security and genetic counseling to natural language understanding and mapping gene expression data. His influence extends beyond artificial intelligence and even computer science, to human reasoning and the philosophy of science.

The ACM A.M. Turing Award, widely considered the "Nobel Prize in Computing," carries a $250,000 prize, with financial support provided by Intel Corporation and Google Inc. It is named for the British mathematician Alan M. Turing, whose 100th anniversary will be celebrated in June at the ACM 2012 Turing Centenary Celebration http://turing100.acm.org that includes 34 past Turing Award winners along with Pearl.

"Like Alan Turing himself, Pearl turned his thinking to constructing procedures that might be harnessed to perform tasks traditionally associated with human intelligence," said Vint Cerf, chair of the ACM 2012 Turing Centenary Celebration, and a former ACM Turing Award recipient. "His accomplishments over the last 30 years have provided the theoretical basis for progress in artificial intelligence and led to extraordinary achievements in machine learning, and they have redefined the term 'thinking machine.' " Cerf pointed to Pearl's innovation as a quantum leap from Turing's "test" dating to the 1950s, when Turing set out to discover if machines could think. "Pearl's work on reasoning with uncertainty as well as his game-changing contributions to machine reasoning about causality have had a pervasive influence not only on machine learning but on natural language processing, computer vision, robotics, computational biology, econometrics, cognitive science, and statistics," Cerf said.

"Dr. Pearl's work provided the original paradigm case for how to do statistical AI," said Dr. Limor Fix, Director of the University Collaborative Research Group, Intel Labs. "By placing structured knowledge representations at the heart of his work, and emphasizing how these representations enabled efficient inference and learning, he showed the field of AI how to build statistical reasoning systems that were *actually* telling us something about intelligence, not just statistics."

Alfred Spector, Vice President of Research and Special Initiatives at Google Inc, said, "Judea Pearl has been the most prominent advocate for the use of probabilistic models within artificial intelligence. He developed representations and algorithms that made it feasible to tackle large, complex problems that handle uncertainty. Before Pearl, most AI systems reasoned with Boolean logic – they understood true or false, but had a hard time with 'maybe.' " This meant, he said, that early AI systems tended to have more success in domains where things are black and white – like chess, for example. "But modern applications of AI, such as robotics, self-driving cars, speech recognition, and machine translation deal with uncertainty. Pearl has been instrumental in supplying the rationale and much valuable technology that allow these applications to flourish, and his clear and persuasive speaking and writing convinced the vast majority of the field to adopt these new techniques."

Heuristics – Finding a Firm Mathematical Foundation

Pearl's early work on heuristic search – a trial-and-error method of problem-solving – propelled the evolution of AI into a mature field with sound scientific foundations. He challenged and ultimately overturned the prevailing approach to reasoning embodied in expert systems and other technologies developed in AI. In his 1984 book *Heuristics: Intelligent Search Strategies for Computer Problem Solving*, he set a new standard where algorithms, even heuristic ones, had to be analyzed rigorously in terms of their correctness and performance. He subsequently devised ways of programming machines to discover their own heuristics.

Probability and Bayesian Networks – Establishing a Dialogue between Man and Machine

Pearl went on to develop the theoretical foundations for reasoning under uncertainty using a "Bayesian network," a term he coined in 1985, named for the 18th century English mathematician Thomas Bayes. An extremely general and flexible modeling tool, a Bayesian network mimics the neural activities of the human brain, constantly exchanging messages without benefit of a supervisor. These networks revolutionized AI by providing a compact way of representing probability distributions and reasoning about them. Prior to this time, the AI community had ignored the problem of uncertainty due to its apparent lack of connection to human cognitive process and its computational cost. Pearl showed how Bayesian networks and their belief-updating algorithms provide an intuitive, elegant characterization of complex probability distributions, and the way they track new evidence. This development was a critical step toward achieving human-level AI that can interact with the physical world.

Pearl's framework with its combination of rich representational structure and a powerful inference engine remains the most successful approach to solving problems of representing, organizing, and exploiting information. His approach has changed the face of research in machine learning, which relies fundamentally on probabilistic and statistical inference. Bayesian networks have also altered the analysis of biological data, with applications in medicine ranging from the design of HIV vaccines to the search for genetic causes of disease. They also underlie most systems for speech recognition, fault diagnosis, and machine translation. His 1988 book *Probabilistic Reasoning in Intelligent Systems* offers techniques based on belief networks that provide a mechanism for making semantics-based systems operational.

Causality – Advancing the Computer's Learning Process

In addition to their impact on probabilistic reasoning, Bayesian networks completely changed the way causality is treated in the empirical sciences, which are based on experiment and observation. Pearl's work on causality is crucial to the understanding of both daily activity and scientific discovery. It has enabled scientists across many disciplines to articulate causal statements formally, combine them with data, and evaluate them rigorously. His 2000 book *Causality: Models, Reasoning, and Inference* is among the single most influential works in shaping the theory and practice of knowledge-based systems. His contributions to causal reasoning have had a major impact on the way causality is understood and measured in many scientific disciplines, most notably philosophy, psychology, statistics, econometrics, epidemiology and social science.

Recent Research – Focusing on Computers and Morality

Pearl's later research explores ways of programming computers to reason introspectively and to take responsibility for their actions. This work evolved from his efforts to understand precisely the conditions under which predictions can be made regarding the effect of interventions on outcomes, and conversely, how backward reasoning can identify the most plausible explanation of an observed outcome. Pearl identified counterfactual sentences – conditional statements whose antecedents are contrary to real-world observations – as the building blocks of scientific thought and moral behavior, and developed algorithms to reason about these statements, or test them against data. He has argued that equipping machines with these building blocks is necessary for achieving cooperative behavior among robots and humans.

Background

Judea Pearl is a professor of computer science at UCLA, where he was director of the Cognitive Systems Laboratory. Before joining UCLA in 1970, he was at RCA Research Laboratories, working on superconductive parametric and storage devices. Previously, he was engaged in advanced memory systems at Electronic Memories, Inc. Pearl is a graduate of the Technion, the Israel Institute of Technology, with a Bachelor of Science degree in Electrical Engineering. In 1965, he received a Master's degree in Physics from Rutgers University, and in the same year was awarded a Ph.D. degree in Electrical Engineering from the Polytechnic Institute of Brooklyn.

Among his many awards, Pearl is the recipient of the 2012 Harvey Prize in Science and Technology from the Technion, Israel, the 2011 Rumelhart Prize from the Cognitive Science Society, and the 2008 Benjamin Franklin Medal in Computers and Cognitive Science from the Franklin Institute. He was presented with the 2003 Allen Newell Award http://awards.acm.org/citation.cfm?id=2658896 &aw=150 from ACM and the AAAI (Association for the Advancement of Artificial Intelligence). His groundbreaking book on causality won the 2001 Lakatos Award from the London School of Economics and Political Science "for an outstanding significant contribution to the philosophy of science."

Pearl is a member of the National Academy of Engineering and a Fellow of AAAI and the Institute for Electrical and Electronic Engineers (IEEE). He is President of the Daniel Pearl Foundation http://www.danielpearl.org named after his son.

ACM will present the 2011 ACM A.M. Turing Award at its annual Awards Banquet on June 16, in San Francisco, CA. The 2012 ACM Turing Centenary Celebration takes place on June 15-16, immediately preceding the ACM Awards Banquet http://turing100.acm.org.

About the ACM A.M. Turing Award

The ACM A.M. Turing Award http://amturing.acm.org was named for Alan M. Turing, the British mathematician who articulated the mathematical foundation and limits of computing, and who was a key contributor to the Allied cryptanalysis of the German Enigma cipher and the German "Tunny" encoding machine in World War II. Since its inception in 1966, the Turing Award has honored the computer scientists and engineers who created the systems and underlying theoretical foundations that have propelled the information technology industry.

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