The Annual Computer Poker Competition

Nolan Bard, John Hawkin, Jonathan Rubin, Martin Zinkevich

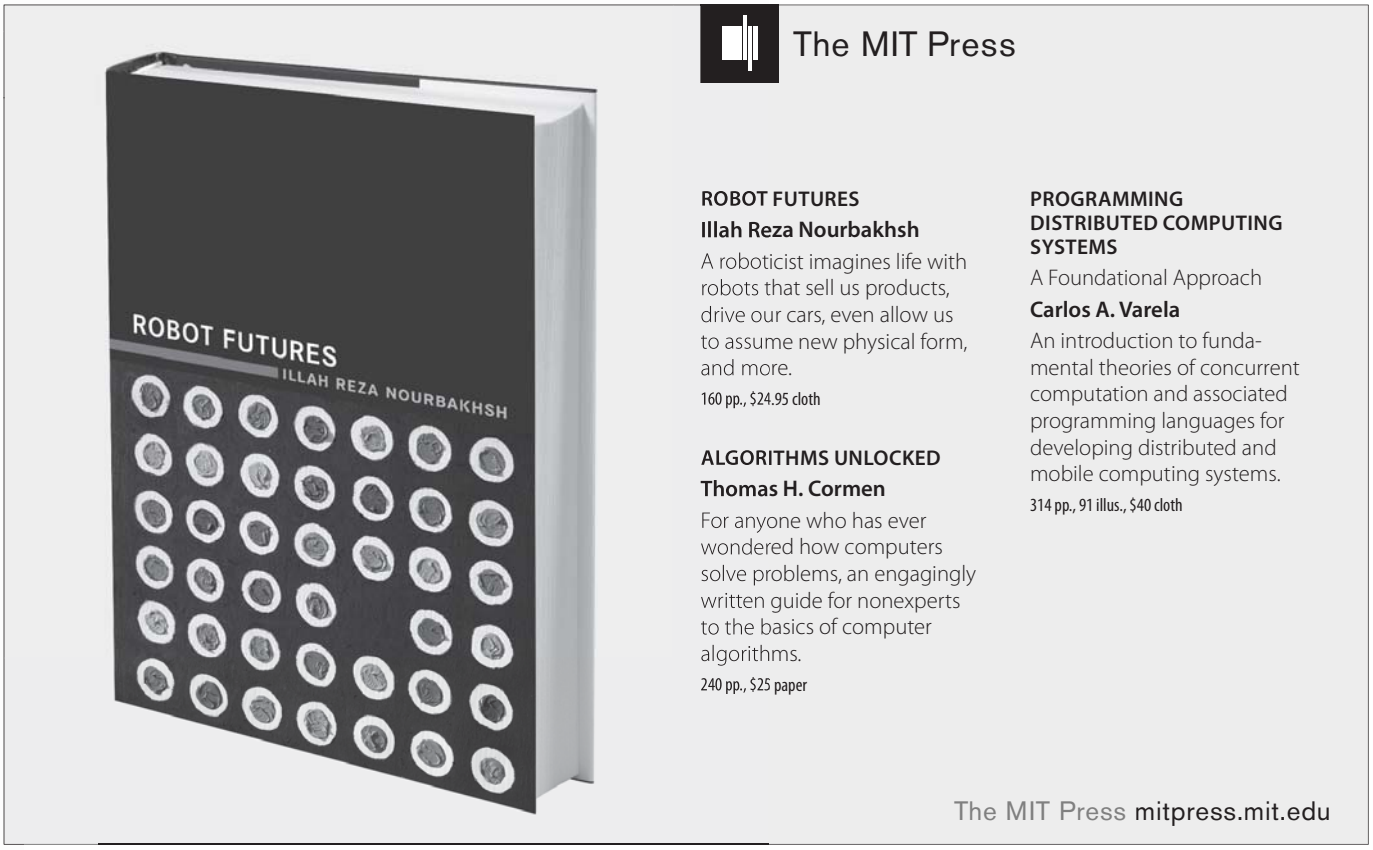
■ *Now entering its eighth year, the Annual Computer Poker Competition (ACPC) is the premier event within the field of computer poker. With both academic and nonacademic competitors from around the world, the competition provides an open and international venue for benchmarking computer poker agents. We describe the competition's origins and evolution, current events, and winning techniques*

The Annual Computer Poker Competition began in 2006 (Littman and Zinkevich 2006) as an effort to develop a system to compare poker agents that were being developed by the University of Alberta and Carnegie Mellon University. The competition has been held annually since 2006, open to all competitors, in conjunction with top-tier artificial intelligence conferences (AAAI and IJCAI). In 2006 the competition began with only 5 competitors. Since then, the total number of competitors has increased. The 2012 competition had 29 agents submitted from 10 different countries by 7 universities and a number of nonacademic teams. The competition is organized by a five-member steering committee, including two competition cochairs responsible for running the competition.

The first competition in 2006 only had a two-player limit Texas Hold'em event. As the competition grew new events were added. Since 2009, three events based on variants of Texas Hold'em poker have been offered by the competition: two-player limit, two-player no-limit, and three-player limit. Aside from the number of players, the key difference between these games is in the number of possible actions. In limit games, agents select from at most three actions: fold, call, or raise (by some predefined quantity). In contrast, no-limit games have a much larger action space as agents can raise by any (integer) quantity up to their total available money (or "stack"). Two-player limit has consistently seen the largest number of competitors, 13 last year, while the other events recently had between 5 and 11 agents. In 2012, more than half of the agents in the two-player no-limit and three-player limit events were submitted by academically affiliated teams of either researchers or students participating as part of a class.

The competition evaluates agents according to two winner

 Copyright © 2013, Association for the Advancement of Artificial Intelligence. All rights reserved. ISSN 0738-4602



determination rules because outcomes in poker are not only in terms of who won or lost, but also by how much was won or lost. The total bankroll evaluation attempts to elicit agents capable of maximally exploiting opponents by ranking agents according to their expected winnings against the field of competitors. In contrast, the bankroll instant runoff iteratively ranks agents by expected winnings (as in total bankroll) and then removes the worst agent from consideration. Since weak agents are progressively removed, maximally exploiting opponents becomes secondary to minimizing potential losses, which elicits stronger Nash-equilibrium-based agents.

The competition attempts to mitigate the effects of luck and ensure statistically significant results by using duplicate poker, a variance reduction technique. For example, let's say bot *A* plays one seat and bot *B* plays the other seat. We deal out the cards and play the match, consisting of 3000 hands. Then, we reset bot *A* and bot *B*, they switch seats, and we play another 3000-hand match with the same set of cards for each seat. If bot *A* is dealt two aces in the first match, then bot *B* will be dealt two aces in the second match. The process for multiplayer games is similar. As many duplicate matches as possible are run each year — the 2012 competition saw approximately 70 million hands of poker played.

While competitors use a wide variety of (occasionally undisclosed) techniques to develop their agents, every agent must handle large state spaces, ranging from 10^{18} game states up to 10^{71} game states. Each event also poses unique challenges for competitors whether it is no-limit's large action space or three-player's multiple opponents. Regret minimizing techniques, such as the counterfactual regret minimization (CFR) algorithm (Zinkevich et al. 2007) or CFR variants with chance and action sampling (Lanctot et al. 2009), are common and have obtained the most top three finishes. Another technique for finding Nash equilibria that has been used in the competition is a variant of the excessive gap technique (Hoda et al. 2010). Between the years 2009 and 2011, an independent competitor won the two-player limit total bankroll competitions with agents using a simple neural network trained on winning entries from previous years. Finally, another set of strong agents, created using a case-based reasoning approach (Rubin and Watson 2011; 2010), obtained five top three finishes in the 2011 competition.

Because of the size of the state space, abstractions (which aim to group together cards that should be played similarly) are generally required. Some agents group hands based on well-established metrics such as hand strength, while others use expert-crafted similarity metrics. One success-

ful abstraction technique involves clustering hands using a *k*-means algorithm and grouping together hands based on these one-dimensional metrics. Imperfect recall abstractions, where some information about what cards came on earlier rounds is traded for more information about the present state (Waugh et al. 2009), have become increasingly common.

The ACPC has established standard protocols that allow the direct comparison of independently designed poker agents. The testing methodology has been adopted by the community, given the high statistical significance of the results. The competition has also helped the community understand the importance of various aspects of abstraction. To a large degree, it has been established that the size of the strategy is the limiting factor in learning a model. While card abstraction has progressed at a great rate, action abstraction in the no-limit poker domain has only recently been highlighted as an important area for future research (Hawkin, Holte, and Szafron 2012). The competition has particularly highlighted the difficulties involved with exploiting opponents, given the degree of incomplete information, stochasticity, and the complexity of the space of strategies.

Expert Limit Texas Hold'em human players have twice been challenged by poker programs. While the first match in 2007 was a narrow victory for humanity, a 2008 match in Las Vegas saw the AI contenders emerge victorious against some of the best human players in the world. The opportunity afforded by the ACPC to practice against highly competitive poker agents was instrumental in the success of this match (Bowling et al. 2009).

The Eighth Annual Computer Poker Competition will be held at the Twenty-Seventh Conference on Artificial Intelligence (AAAI-13) in Bellevue, Washington, USA. Further details about the competition can be found at the competition's website (www.computerpokercompetition.org).

References

Bowling, M.; Risk, N. A.; Bard, N.; Billings, D.; Burch, N.; Davidson, J.; Hawkin, J.; Holte, R.; Johanson, M.; Kan, M.; Paradis, B.; Schaeffer, J.; Schnizlein, D.; Szafron, D.; Waugh, K.; and Zinkevich, M. 2009. A Demonstration of the Polaris Poker System. In *Proceedings of the 8th International Conference on Autonomous Agents And Multiagent Systems,* 1391–1392. Richland, SC: International Conference on Autonomous Agents and Multiagent Systems.

Hawkin, J.; Holte, R. C.; and Szafron, D. 2012. Using Sliding Windows to Generate Action Abstractions in Extensive-Form Games. In *Proceedings of the 26th AAAI Conference on Artificial Intelligence,* 1924–1930. Palo Alto, CA: AAAI Press.

Hoda, S.; Gilpin, A.; Peña, J.; and Sandholm, T. 2010. Smoothing Techniques for Computing Nash Equilibria of Sequential Games. *Mathematics of Operations Research* 35(2): 494–512.

Lanctot, M.; Waugh, K.; Zinkevich, M.; and Bowling, M. 2009. Monte Carlo Sampling for Regret Minimization In Extensive Games. In *Advances in Neural Information Processing Systems 22,* 1078–1086. Cambridge, MA: The MIT Press.

Littman, M., and Zinkevich, M. 2006. The 2006 AAAI Computer Poker Competition. *Journal of the International Computer Games Association* 29(3).

Rubin, J., and Watson, I. 2010. Similarity-Based Retrieval and Solution Re-Use Policies in the Game Of Texas Hold'em. In *Proceedings of the 18th International Conference on Case-Based Reasoning,* 465–479. Berlin: Springer.

Rubin, J., and Watson, I. 2011. Successful Performance Via Decision Generalisation in No-Limit Texas Hold'em. In *Proceedings of the 19th International Conference on Case-Based Reasoning,* 467–481. Berlin: Springer.

Waugh, K.; Zinkevich, M.; Johanson, M.; Kan, M.; Schnizlein, D.; and Bowling, M. 2009. A Practical Use of Imperfect Recall. In *Proceedings of the 8th Symposium on Abstraction, Reformulation, and Approximation,* 175–182. Menlo Park, CA: AAAI Press.

Zinkevich, M.; Johanson, M.; Bowling, M.; and Piccione, C. 2007. Regret Minimization in Games with Incomplete Information. In *Advances In Neural Information Processing Systems 20,* 1729–1736. Cambridge, MA: The MIT Press.

Nolan Bard chaired the Annual Computer Poker Competition in 2010 and cochaired in 2011. He is currently a Ph.D. student and member of the Computer Poker Research Group at the University of Alberta. His research focuses on developing techniques for online modeling of dynamic agents in poker games. As a member of the Computer Poker Research Group, he has participated in the Annual Computer Poker Competition since its inception in 2006.

John Hawkin chaired the Annual Computer Poker Competition in 2009. He is in the process of completing his Ph.D. from the University of Alberta, working with the Computer Poker Research Group. His Ph.D. research focuses on action abstraction in no-limit poker games. Hawkin currently works at Verafin, a company that provides fraud and money laundering detection software to financial institutions.

Jonathan Rubin cochaired the Annual Computer Poker Competition in 2011 and 2012. His Ph.D. research was on the use of case-based reasoning within the domain of computer poker. In 2011, his agent, Sartre, won the bankroll division of the three-player, limit Texas Hold'em AAAI competition. Rubin has recently completed a postdoc at PARC, a Xerox Company within the Intelligent Systems Laboratory.

Martin Zinkevich received his Ph.D. from Carnegie Mellon in 2004 in multiagent theory. While a postdoc at the University of Alberta with the Alberta Ingenuity Centre for Machine Learning, he was the lead programmer for the first Annual Computer Poker Competition in 2006 and chair of the second competition in 2007. His work on competition design has continued with the Lemonade Stand Game competition, a competition focusing on equilibrium selection. Currently, Zinkevich is a research scientist at Google.

Honoring AI pioneer David Waltz

Brandeis University has established an endowed fellowship to honor David Waltz, a former Brandeis professor (1984-93) who died of brain cancer in 2012. By recruiting a new PhD student every four years to study AI as the Waltz Fellow, Brandeis will honor his name and his career.

You can make a tax-deductible gift online at davidwaltz.org or by sending a check payable to Brandeis University with a memo noting the Waltz Fellowship to:

Advancement Services
415 South St., MS 126
Brandeis University
Waltham, MA 02454

AAAI Annual Business Meeting

The annual business meeting of the Association for the Advancement of Artificial Intelligence will be held at 12:45 PM, Monday, July 15, 2013 in the Hyatt Regency Bellevue Hotel during AAAI-13. All AAAI members are welcome.

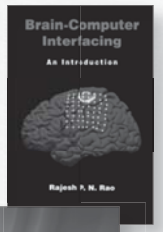
CAMBRIDGE

E-books Available for most titles!

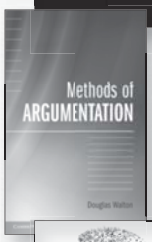
Hot New Titles in AI *from* Cambridge University Press

Forthcoming…

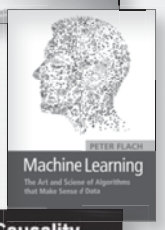
Brain-Computer Interfacing
An Introduction
Rajesh P. N. Rao
$80.00: Hb: 978-0-521-76941-9: 356 pp.



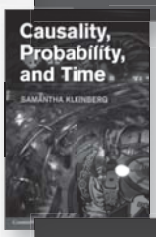
Methods of Argumentation
Douglas Walton
$95.00: Hb: 978-1-107-03930-8: 322 pp.
$32.99: Pb: 978-1-107-67733-3



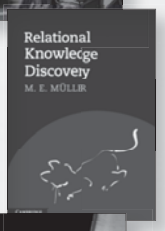
Machine Learning
The Art and Science of Algorithms that Make Sense of Data
Peter Flach
$120.00: Hb: 978-1-107-09639-4: 409 pp.
$60.00: Pb: 978-1-107-42222-3



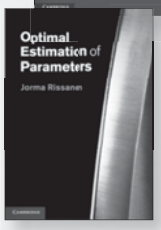
Causality, Probability, and Time
Samantha Kleinberg
$99.00: Hb: 978-1-107-02648-3: 265 pp.



Relational Knowledge Discovery
M. E. Müller
$99.00: Hb: 978-0-521-19021-3: 278 pp.
$47.00: Pb: 978-0-521-12204-7



Optimal Estimation of Parameters
Jorma Rissanen
$90.00: Hb: 978-1-107-00474-0: 170 pp.



Prices subject to change.

CAMBRIDGE UNIVERSITY PRESS
www.cambridge.org/us/computerscience
800.872.7423
@cambUP_maths

The AAAI Fall Symposium Series

Friday through Sunday, November 15–17

The Westin Arlington Gateway

Arlington, Virginia

The AAAI Symposium Series brings together a set of two and one-half day symposia at a common site, providing a unique and intimate forum for colleagues in a given discipline. The series also provides an important gathering point for the AI Community as a whole.

Please join us as we bring together communities of researchers in a variety of disciplines for conversation, discussion, and scientific discovery . . .

2013 AAAI Fall Symposium Series

www.aaai.org/Symposia/Fall/fss13.php

Final Chance to Register for ICWSM-13!

The Seventh International AAAI Conference on Weblogs and Social Media will be held at the Massachusetts Institute of Technology and the Microsoft New England Research and Development Center in Cambridge, Massachusetts, July 8–11. This unique forum brings together researchers working at the nexus of computer science and the social sciences, with work drawing upon network science, machine learning, computational linguistics, sociology and communication. The broad goal of ICWSM is to increase understanding of social media in all its incarnations.

Onsite registration will be located in the foyer of Kresge Auditorium at MIT, 77 Massachusetts Avenue, Cambridge. For full details about the conference program, please visit the ICWSM-13 website or write to icwsm13@aaai.org.

www.icwsm.org

Forthcoming Titles from AAAI Press

Proceedings of the Twenty-Seventh AAAI Conference on Artificial Intelligence and the Twenty-Fifth Innovative Applications of Artificial Intelligence Conference
ISBN 978-1-57735-615-8

Proceedings of the Twenty-Sixth International Florida Artificial Intelligence Research Society Conference
ISBN 978-1-57735-605-9

Proceedings of the Sixth European Conference on Planning
978-1-57735-629-5

Proceedings of the Seventh International AAAI Conference on Weblogs and Social Media
978-1-57735-610-3

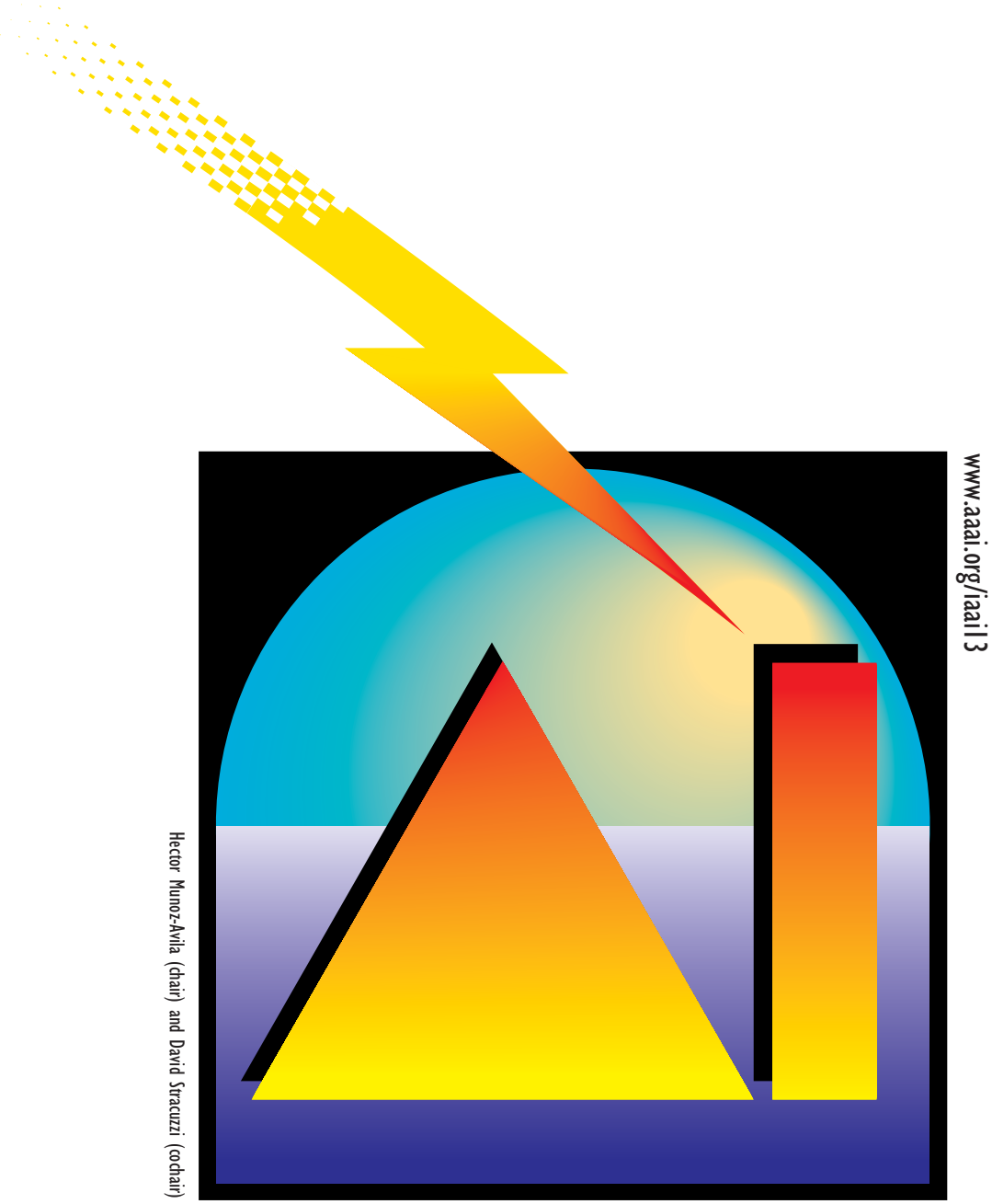
Proceedings of the Tenth Symposium on Abstraction, Reformulation and Approximation
978-1-57735-630-1

Proceedings of the Twenty-Second International Joint Conference on Artificial Intelligence Conference
978-1-57735-631-8

Proceedings of the Sixth International Symposium on Combinatorial Search
978-1-57735-632-5

Journal of Artificial Intelligence Research 2012

AAAI Press
2275 East Bayshore Road, Suite 160 Palo Alto, California 94303 USA
650-328-3123 www.aaai.org/Press/



To learn about the latest, state of the art AI Applications ...

Please Join Us for

IAAI–14 in Bellevue, Washington USA