House Committee on Oversight and Government Reform
Subcommittee on Information Technology
February 14, 2018

"Game Changers: Artificial Intelligence Part I"

Witness: Charles Isbell, Georgia Institute of Technology

Chairman Hurd, Ranking Member Kelly, and distinguished members of the subcommittee, my name is Dr. Charles Isbell and I am a Professor and Executive Associate Dean for the College of Computing at Georgia Tech. Thank you for the opportunity to appear before this Subcommittee to discuss the development, uses, barriers to adoption, and potential challenges and advantages of government use of artificial intelligence.

By way of explaining my background, let me note that while I tend to focus on statistical machine learning, my research passion is actually artificial intelligence. I like to build large integrated systems, so I also tend to spend a great deal of my time doing research on autonomous agents, interactive entertainment, some aspects of human-computer interaction, software engineering, and even programming languages

I think of my field as interactive artificial intelligence. My fundamental research goal is to understand how to build autonomous agents that must live and interact with large numbers of other intelligent agents, some of whom may be human. Progress towards this goal means that we can build artificial systems that work with humans to accomplish tasks more effectively; can respond more robustly to changes in environment, relationships, and goals; and can better co-exist with humans as long-lived partners.

As requested by the Subcommittee, my testimony today will focus on the potential for artificial intelligence and machine learning to transform the world around us. I will:

1. Situate recent developments in AI in the larger context of developments in computing more generally;
2. Explore the potential uses and misuses of this technology by focusing on the human-machine loop; and
3. Discuss the gaps in education and training that threaten to minimize participation in the field.

As the members of this Subcommittee well know, there has been an explosion in the development and deployment of what we might call AI technology. With that explosion has come a corresponding explosion in interest in AI.

In any discussion—particularly technical ones—it helps to define our terms. There are many potential definitions of AI. My favorite one is that it is "the art and science of making computers act like they do in the movies." In the movies, computers are often semi-magical and anthropomorphic; they do things that, if humans did them, we would say they required intelligence. This definition is borne out in our use of AI in the everyday world. We use the infrastructure of AI to search billions upon billions of documents to find the answers to a staggering variety of questions—often expressed literally as questions. We use automatically tagged images to organize our photos, and we use that same infrastructure to plan optimal routes for trips—even altering our routes on-the-fly in the face of changes in traffic. We are able to detect automatically the presence of tumors from x-rays, even those trained doctors find difficult to see. We let computers finish our sentences as we type texts and use search engines, sometimes facilitating a subtle shift from prediction of our behavior to influence over our behavior. Often we take advantage of these services by using our phones (our phones!) to interpret a wide variety of spoken commands.

This basic definition, of course, ignores what is going on underneath the hood. Perhaps a somewhat better way of grappling with AI is to understand that it is a set of computing techniques and approaches that attempt to solve exponentially hard problems in reasonable time by cheating in clever ways. In other words, at bottom, AI is about *computing methods* for automated understanding and reasoning, especially ones that *leverage data* to adapt their behavior over time.

That AI is really about computing is important. What has enabled many of the advances in AI over the last decade is the stunning increase of computational power combined with the ubiquity of that computing. That AI also leverages data is equally important. The advances in AI over the last decade are also due in large part to the even more stunning increase in the availability of data, again made possible by the ubiquity of the internet, social media, and relatively inexpensive sensors (including cameras, GPS, and the computer itself) that track our every move.

Consider the problems above: Google leverages arrays of server farms to index and search documents now available digitally; neural networks use millions of examples of pictures of human faces to perform the hundreds of millions of calculations necessary to do face-tagging in the same way that we can do phoneme and word detection from audio; our navigation apps like Waze use both the digital expression of maps to sort through millions or even billions of possible paths from one place to another, as well as the ubiquity of GPS in other vehicles to detect changes in traffic; medical prediction software can build tumor detectors by leveraging decades of data on x-rays and ground-truth labels of cancer; and the same techniques are used to crowd-source likely completions to search queries.

Consider the technology behind them: Deep learning is an update on an algorithm whose modern expression was known about the time of my birth. It uses layers of

artificial "neurons" to map from a set of features (*e.g.,* pixels, sounds, financial information, and so on) to more abstract concepts (*e.g.,* names of objects, words, credit-worthiness, and so on). As recently as twenty years ago, computational power was such that one could only build one or two layers. Performance required highly trained humans hand-tuning both network structure and the form of features themselves. Now, with both cheap, fast computing power and an abundance of data, the structure and features can also be learned, freeing computing professionals to develop better techniques that take advantage of this newfound power. Accordingly, the new systems work far better than we had available even a few years ago.

So, in some very important sense, AI already exists. It is not the AI of science fiction, neither benevolent intelligences working with humans as we traverse the galaxy, nor malevolent AI that seeks humanity's destruction. Nonetheless, we are living every day with machines that make decisions that, if humans made them, we would attribute to intelligence. And the machines often make those decisions faster and better than humans would.

Importantly, each of the examples we consider above is a distinctly human-centered problem. It is human-centered both in the sense that these systems are trying to solve problems that humans deal with every day—question answering, symptom evaluation, navigation—but also human-centered in the sense that humans have or currently perform some of those tasks. Presumably, these developments are all to the good. We are living up to the promise of technology that allows us to automate away work that is dirty, dangerous, or dull, freeing up human capital to be more productive, and, hopefully, for humans to be more fulfilled. The social and economic benefits are potentially immense.

There are also some reasons for concern. Those concerns also have social and economic components. I will focus briefly on two potential issues: the opaqueness of our intelligent machines and the potential impact on jobs.

We are increasingly using our AI systems to make real decisions, and we do not necessarily understand those decisions. In particular, these decisions can have severe impacts. For example, according to the Marshall Project, almost every state uses some form of "risk assessment" at some stage in the criminal justice system.

> Risk assessments have existed in various forms for a century, but over the past two decades, they have spread through the American justice system, driven by advances in social science. The tools try to predict recidivism — repeat offending or breaking the rules of probation or parole — using statistical probabilities based on factors such as age, employment history, and prior criminal record. They are now used at some stage of the criminal justice process in nearly every state. Many court systems use the tools to guide decisions about which prisoners to release on parole, for example, and risk as-

sessments are becoming increasingly popular as a way to help set bail for inmates awaiting trial.

Consider the automation of this process, relying on an algorithm in lieu of a judge's discretion. As noted by Cathy O'Neil, author of *Weapons of Math Destruction*, the data used by these algorithms to build models are sometimes suspect. Worse, we treat the output as "objective" without understanding that the data are themselves not objective. In this particular case, we set out to predict recidivism as if that means *the chance of committing a crime again* when in fact we are predicting *the chance of being arrested and convicted again.* It does not take much imagination to see how being from a heavily policed area raises the chances of being arrested again, being convicted again, and in aggregate leads to even more policing of the same areas, creating a feedback loop. One can imagine similar issues with determining fit for a job, or credit-worthiness, or even face recognition and automated driving. In computing, we call this garbage-in-garbage-out: an algorithm is only as good as its data. This saying is certainly true, and especially relevant for AI algorithms that learn based on the data they are given.

Luckily, one way to address these issues is straightforward: to increase transparency. An AI algorithm should inspectable. The kind of data the algorithm uses to build its model should be available. The decisions that such algorithms make should be inspectable. In other words, as we deploy these algorithms, each algorithm should be able to explain its output. "This applicant was assigned high risk because…" is more useful than, "This applicant was assigned high risk."

Of course, as we make our AI better and easier to understand, it is difficult not to imagine that AI will do more and more for us. In today's climate, we are imagining not only robots that assemble our cars, but that those cars will drive themselves. We can see a world where we will not only have algorithms that allow us to watch the stock market but will do a faster, better job buying and selling stocks than stockbrokers do. We may soon trust the x-ray machine itself to tell us if we have a tumor more than we trust a doctor. I am skeptical that we will create such AI machines in the near future, but it does seem that we are making inexorable progress toward that end. We may not replace all truck drivers and taxi cab drivers, but we may replace many of them. We may not replace all cashiers, but we may replace many of them. In a country where there are nearly 3 million truck drivers and more than 3 million cashiers, one can imagine what a significant impact such automation will have on the economy and on the job force.

Luckily again technology and automation does not simply destroy jobs, it creates them. In this particular case, it creates jobs that require technological sophistication and understanding. Here, it is important to return to our definitions. AI is about computing methods for automated understanding and reasoning, especially ones that leverage data to adapt their behavior over time. Thus, the future belongs to those who are not simply highly literate but compurate; that is, those who under-

stand computing and how it fits into problem solving will be most productive and impactful in the future.

We can see in the current data that our fellow citizens understand this reality. At Georgia Tech, we launched an affordable online master's degree in Computer Science four years ago. We are currently enrolling 6,365 students, 70% of whom are US citizens or permanent residents. Across the country, undergraduate computer science enrollments are at an all-time high at Research I universities, growing 113% between 2009 and 2015. From 2006 to 2015, the average number of CS majors increased for large departments (10+ faculty) from 320 to 970 and for small departments from 160 to 500 majors. The overall numbers are significantly higher than at the height of the dot-com boom.

At the same time, non-majors are increasingly taking upper-division computing courses for use in their own fields. According to Generation CS, the number of non-majors in courses intended for majors is increasing at a rate equal to or higher than that of majors. We are also seeing increasing interest in AI. For example, at Georgia Tech, 43% of our CS minors are focused on Artificial Intelligence. This year, our peers are reporting record numbers of graduate student applicants in machine learning and artificial intelligence.

Even more telling, institutions have been forced to cap the number of students who major in a program. This throttling of support suggests that demand may be even higher than it seems, but it also suggests that we are not capable of responding to this demand even as we need to educate more and more students in the area. The number of Ph.D. graduates in computer science going into higher education is dropping significantly. Further, this issue is not limited to those seeking undergraduate and advanced degrees. We are seeing an increasing need to educate students at the high school level as well and a corresponding lack of teachers available who are qualified to teach foundational computer science in K-12. Given the slow pace of production and the lack of an incentive structure for graduates in computer science to become teachers, the country will not be able to produce enough CS teachers quickly enough to meet demand.

In Georgia, for example, there are approximately 519,000 high school students. Only 29,000 of them are enrolled in computing of any kind—less than 6 percent. According to the Professional Standards Commission, the governing body over teacher certification in the state, there were only 93 credentialed teachers in 2017. The majority of the computing courses in the state are being taught by approximately 400-500 engaged and committed teachers who are not certified to do so. The state is in its nascent stages of offering a framework to guide what "high school-level CS" actually means. For now, the curricula and quality of the CS courses vary tremendously. The College Board's Advanced Placement Computer Science A exam is more formalized and demonstrates the magnitude of the problem for rigorous computing. Data from the College Board suggest that, in 2017, only 125 of the 500 high schools in the state

offered AP Computer Science. In Atlanta Public Schools, which is in the heart of Georgia's technology hub, there are only two high schools that offer Advanced Placement Computer Science.

Under these circumstances, possibly the only way to deploy this subject broadly is to offer blended learning courses. The core content of computational courses will ultimately have to be delivered through online platforms in close conjunction with classroom teachers who can be present and facilitate the actual process of learning.

In conclusion, I am excited by these hearings. Advances in AI are central to our economic and social future. The issues are being raised here can be addressed with thoughtful support for robust funding in basic research in artificial intelligence—including research in how to engage in education; support for that education throughout the pipeline; and in developing standards for the proper use of intelligent systems.

I thank you very much for your time and attention today, and I look forward to working with you in your efforts to understand how we can best develop these technologies to create a future where we are partners with intelligent machines.

Thank you. This concludes my testimony.

Committee on Oversight and Government Reform
Witness Disclosure Requirement — "Truth in Testimony"

Pursuant to House Rule XI, clause 2(g)(5) and Committee Rule 16(a), non-governmental witnesses are required to provide the Committee with the information requested below in advance of testifying before the Committee. You may attach additional sheets if you need more space.

Name:

1. Please list any entity you are representing in your testimony before the Committee and briefly describe your relationship with each entity.	
Name of Entity	**Your relationship with the entity**
Georgia Tech	Professor

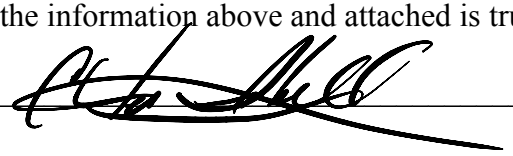
2. Please list any federal grants or contracts (including subgrants or subcontracts) you or the entity or entities listed above have received since January 1, 2015, that are related to the subject of the hearing.

Recipient of the grant or contact (you or entity above)	Grant or Contract Name	Agency	Program	Source	Amount
See CV					

3. Please list any payments or contracts (including subcontracts) you or the entity or entities listed above have received since January 1, 2015 from a foreign government, that are related to the subject of the hearing.

Recipient of the grant or contact (you or entity above)	Grant or Contract Name	Agency	Program	Source	Amount
N/A					

I certify that the information above and attached is true and correct to the best of my knowledge.

Signature  Date: _____

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Earned Degrees

Ph.D.	1998	Massachusetts Institute of Technology	*Electrical Engineering and Computer Science*
S.M.	1993	Massachusetts Institute of Technology	*Electrical Engineering and Computer Science*
B.S.	1990	Georgia Institute of Technology	*Information and Computer Science*

Employment History

Executive Associate Dean	College of Computing Georgia Institute of Technology	*2017-present*
Faculty Athletic Representative	Georgia Institute of Technology	*2017-present*
Senior Associate Dean	College of Computing Georgia Institute of Technology	*2012-2017*
Professor	School of Interactive Computing College of Computing Georgia Institute of Technology	*2012-present*
Associate Dean	College of Computing Georgia Institute of Technology	*2008-2012*
Associate Professor	School of Interactive Computing College of Computing Georgia Institute of Technology	*2008-2012*
Assistant Professor	College of Computing Georgia Institute of Technology	*2002-2008*
Visiting Scholar	Department of Computer and Information Science University of Pennsylvania	*2002*
Research Scientist	AT&T Labs-Research	*1998-2002*

Current Fields of Interest

Academic Scholarship. My research passion is artificial intelligence with an emphasis on statistical machine learning. I think of my particular field of study as *interactive artificial intelligence* and focus on problems involving *statistical modeling of agent interactions*; that is, I care about the application of machine learning techniques to building autonomous agents and environments that must live with large numbers of other intelligent agents, some of whom may be human.

Academic Administration. I also have a strong passion for educational reform, as organizational and curricular matters, and believe that both are necessary to improve the research and academic enterprises. I split my time among my research and administrative selves because I think such administrative efforts deserve as much intellectual energy and thought as any of our other academic efforts and often can have a profound impact on those efforts.

I. Research, Scholarship, and Creative Scholarship

Ph.D. Thesis

Title: *Sparse Multi-Level Representations for Text Retrieval*
Date Completed: *May 1998*
Advisors: *Paul Viola and Rodney Brooks*
University: *Massachusetts Institute of Technology*

S.M. Thesis

Title: *Explorations of the Practical Issues of Using Temporal Difference Learning Methods for Prediction-Control Tasks*
Date Completed: *December 1992*
Advisor: *Tomaso Poggio*
University: *Massachusetts Institute of Technology*

A. Refereed Publications and Submitted Articles

A.1. Published and Accepted Journal Articles

[1] Sam Krening, Brent Harrison, Karen Feigh, Charles L. Isbell, Mark Riedl, and Andrea Thomaz. Learning from Explanations Using Sentiment and Advice in RL. *IEEE Transactions on Cognitive and Developmental Systems*, 9(1):44–55, 2016.

[2] Luis Carlos Cobo Rus, Kaushik Subramanian, Charles L. Isbell, Aaron Lanterman, and Andrea Thomaz. Abstraction from Demonstration for Efficient Reinforcement Learning in High-Dimensional Domains. *Artificial Intelligence*, 216(0):103–128, 2014.

[3] David Roberts and Charles L. Isbell. Lessons on Using Computationally Generated Influence for Shaping Narrative Experiences. *Transactions on Computational Intelligence and AI in Games*, 6(2):1–15, 2014.

[4] Michael Holmes, Alexander Gray, and Charles L. Isbell. Fast Kernel Conditional Density Estimation: A Dual Tree Monte Carlo Approach. *Computational Statistics and Data Analysis*, 54(7):1707–1718, 2010.

[5] Charles L. Isbell, Lynn Stein, Robb Cutler, Jeffrey Forbes, Linda Fraser, John Impagliazzo, Viera Prolux, Steve Russ, Richard Thomas, and Yan Xu. (Re)Defining Computing Curricula by (Re)Defining Computing. *ACM SIGCSE Bulletin*, 41(4):195–207, 2009.

[6] Olufisayo Omojokun, Charles L. Isbell, and Prasun Dewan. Towards Automatic Personalization of Device Controls. *IEEE Transactions on Consumer Electronics*, 55(1):269–276, 2009.

[7] Raffay Hamid, Siddhartha Maddi, Amos Johnson, Aaron Bobick, Irfan Essa, and Charles L. Isbell. A Novel Sequence Representation for Unsupervised Analysis of Human Activities. *Artificial Intelligence*, 173(14), 2009.

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[9] David L. Roberts, Charles L. Isbell, and Michael L. Littman. Optimization Problems Involving Collections of Dependent Objects. *Annals of Operations Research*, 163(1):255–270, 2008.

[10] Charles L. Isbell, Michael Kearns, Satinder Singh, Christian R. Shelton, Peter Stone, and Dave Kormann. Cobot in LambdaMOO: An Adaptive Social Statistics Agent. *Journal of Autonomous Agents and Multi-Agent Systems*, 13(3):327–354, 2006.

[11] Mark J. Nelson, Michael Mateas, David L. Roberts, and Charles L. Isbell. Declarative Optimization-Based Drama Management in Interactive Fiction. *IEEE Computer Graphics & Applications*, 26(3):32–41, 2006.

[12] Tucker Balch, Frank Dellaert, Adam Feldman, Andrew Guillory, Charles L. Isbell, Zia Kahn, Andrew Stein, and Hank Wilde. How AI and Multi-Robot Systems Research Will Accelerate Our Understanding of Social Animal Behavior. *Proceedings of the IEEE*, 94(7):1445–1463, 2006.

[13] Olufisayo Omojokun, Jeffrey Pierce, Charles L. Isbell, and Prasun Dewan. Comparing End-User and Intelligent Remote Control Interface Generation. *Personal and Ubiquitous Computing*, 10(2-3):136–143, 2006.

[14] Charles L. Isbell, Olufisayo Omojokun, and Jeffrey Pierce. From Devices to Tasks: Automatic Task Prediction for Personalized Appliance Control. *Personal and Ubiquitous Computing*, 8(3):146–153, 2004.

[15] Brian Landry, Jeffrey Pierce, and Charles L. Isbell. Supporting Routine Decision-Making with a Next-Generation Alarm Clock. *Personal and Ubiquitous Computing*, 8(3):154–160, 2004.

A.2. Conference Presentations with Proceedings

Refereed and Archival

[1] Yannick Schroecker and Charles L. Isbell. State Aware Imitation Learning. In *Advances in Neural Information Processing Systems (NIPS) 31*, 2017.

[2] Jonathan Scholz, Jindal Nehchal, Martin Levihn, and Charles L. Isbell. Navigation Among Movable Obstacles with Learned Dynamic Constraints. In *Proceedings of the the 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2016.

[3] Kaushik Subramanian, Charles L. Isbell, and Andrea Thomaz. Exploration from Demonstration for Interactive Reinforcement Learning. In *Proceedings of the 15th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2016.

[4] Samantha Krening, Brent Harrison, Karen Feigh, Charles L. Isbell, and Andrea Thomaz. Object-Focused Advice in Reinforcement Learning. In *Proceedings of the 15th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2016.

[5] Himanshu Sahni, Brent Harrison, Kaushik Subramanian, Thomas Cederborg, Charles L. Isbell, and Andrea Thomaz. Policy Shaping in Domains with Multiple Optimal Policies. In *Proceedings of the 15th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2016.

[6] Thomas Cederborg, Ishaan Grover, Charles L. Isbell, and Andrea L Thomaz. Policy Shaping With Human Teachers. In *Proceedings of the Twenty-Fourth International Joint Conference on Artificial Intelligence (IJCAI)*, 2015.

[7] Jesse Rosalia, Guliz Tokadli, Charles L. Isbell, Andrea Thomaz, and Karen Feigh. Discovery, Evaluation, and Exploration of Human Supplied Options and Constraints. In *Proceedings of the 14th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2015.

[8] Jonathan Scholz, Martin Levihn, Charles L. Isbell, Henrik Christensen, and Mike Stilman. Learning Non-Holonomic Object Models for Mobile Manipulation. In *Proceedings of the the 2015 IEEE International Conference on Robotics and Automation (ICRA)*, 2015.

[9] Jonathan Scholz, Martin Levihn, Charles L. Isbell, and David Wingate. A Physics-Based Model Prior for Object-Oriented MDPs. In *Proceedings of the 31st International Conference on Machine Learning (ICML)*, 2014.

[10] Joshua Jones and Charles L. Isbell. Story Similarity Measures for Drama Management with TTD-MDPs. In *Proceedings of the 13th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2014.

[11] Shane Griffith, Kaushik Subramanian, Jonathan Scholz, Charles L. Isbell, and Andrea Thomaz. Policy Shaping: Integrating Human Feedback with Reinforcement Learning. In *Advances in Neural Information Processing Systems (NIPS) 26*, 2013.

[12] Liam Mac Dermed and Charles L. Isbell. Point Based Value Iteration with Optimal Belief Compression for Dec-POMDPs. In *Advances in Neural Information Processing Systems (NIPS) 26*, 2013.

[13] Ryan Curtin, William March, Parikshit Ram, David Anderson, Alexander Gray, and Charles L. Isbell. Tree-Independent Dual-Tree Algorithms. In *Proceedings of the Thirtieth International Conference on Machine Learning (ICML)*, 2013.

[14] Luis Carlos Cobo Rus, Charles L. Isbell, and Andrea Thomaz. Object Focused Q-learning for Autonomous Agents. In *Proceedings of the Twelfth International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2013.

[15] Joshua Letchford, Liam Mac Dermed, Vincent Conitzer, Ronald Parr, and Charles L. Isbell. Computing Optimal Strategies to Commit to in Stochastic Games. In *Proceedings of the Twenty-Sixth National Conference on Artificial Intelligence (AAAI)*, 2012.

[16] Luis Carlos Cobo Rus, Charles L. Isbell, and Andrea Thomaz. Automatic Decomposition and State Abstraction from Demonstration. In *Proceedings of the Eleventh International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2012.

[17] Karthik Narayan, Charles L. Isbell, and David Roberts. DEXTOR: Reduced Effort Authoring for Template-Based Natural Language Generation. In *Proceedings of the Seventh Artificial Intelligence and Interactive Digital Entertainment (AIIDE)*, 2011.

[18] Liam Mac Dermed, Karthik Narayan, Charles L. Isbell, and Lora Weiss. Quick Polytope Approximation of All Correlated Equilibria in Stochastic Games. In *Proceedings of the Twenty-Sixth National Conference on Artificial Intelligence (AAAI)*, 2011.

[19] Luis Carlos Cobo Rus, Peng Zang, Charles L. Isbell, and Andrea Thomaz. Automatic State Abstraction from Demonstration. In *Proceedings of the Twenty-Second International Joint Conference on Artificial Intelligence (IJCAI)*, 2011.

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[21] Peng Zang, Runhe Tian, Charles L. Isbell, and Andrea Thomaz. Batch versus interactive learning by demonstration. In *Proceedings of the Ninth International Conference on Development and Learning (ICDL)*, 2010.

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[30] Christopher Simpkins, Sooraj Bhat, Charles L. Isbell, and Michael Mateas. Adaptive Programming: Integrating Reinforcement Learning into a Programming Language. In *Proceedings of the Twenty-Third ACM SIGPLAN International Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA)*, 2008.

[31] Rudolph Mappus, David Minnen, and Charles L. Isbell. Dimensionality Reduction for Improved Source Separation in fMRI Data. In *Proceedings of theInternational Conference on Bio-inspired Systems and Signal Processing (BIOSIGNALS)*, 2008.

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[33] David Minnen, Thad Starner, Charles L. Isbell, and Irfan Essa. Detecting Subdimensional Motifs: An Efficient Algorithm for Generalized Multivariate Pattern Discovery. In *Proceedings of the Seventh IEEE International Conference on Data Mining (ICDM)*, 2007.

[34] Michael Holmes, Alex Gray, and Charles L. Isbell. Fast Nonparametric Conditional Density Estimation. In *Proceedings of the Twenty-Third Conference on Uncertainty in Artificial Intelligence (UAI)*, 2007.

[35] David Minnen, Charles L. Isbell, Irfan Essa, and Thad Starner. Discovering Multivariate Motifs using Subsequence Density Estimation. In *Proceedings of the Twenty-Second National Conference on Artificial Intelligence (AAAI)*, 2007.

[36] David L. Roberts, Sooraj Bhat, Kenneth St. Clair, and Charles L. Isbell. Authorial Idioms for Target Distributions in TTD-MDPs. In *Proceedings of the Twenty-Second National Conference on Artificial Intelligence (AAAI)*, 2007.

[37] David L. Roberts, Andrew Cantino, and Charles L. Isbell. Player Autonomy versus Designer Intent: A Case Study of Interactive Tour Guides. In *Proceedings of the Third Artificial Intelligence and Interactive Digital Entertainment (AIIDE)*, 2007.

[38] Sooraj Bhat, David L. Roberts, Mark Nelson, Charles L. Isbell, and Michael Mateas. A Globally Optimal Online Algorithm for TTD-MDPs. In *Proceedings of the Sixth International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2007.

[39] David L. Roberts, Andrew Cantino, and Charles L. Isbell. Improving Quality of Experience Using TTD-MDP-Based Tour Guides. In *Proceedings of the Sixth International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2007.

[40] Merrick Furst, Charles L. Isbell, and Mark Guzdial. Threads: How to Restructure a Computer Science Curriculum for a Flat World. In *Proceedings of the Thirty-Eighth ACM Technical Symposium on Computer Science Education (SIGCSE)*, 2007.

[41] Peng Zang and Charles L. Isbell. Managing Domain Knowledge and Multiple Models with Boosting. In *Proceedings of the Twentieth International Joint Conference on Artificial Intelligence (IJCAI)*, 2007.

[42] David Minnen, Thad Starner, Irfan Essa, and Charles L. Isbell. Improving Activity Discovery with Automatic Neighborhood Estimation. In *Proceedings of the Twentieth International Joint Conference on Artificial Intelligence (IJCAI)*, 2007.

[43] Manu Sharma, Michael Holmes, Juan Santamaria, Arya Irani, Charles L. Isbell, and Ashwin Ram. Transfer Learning in Real-Time Strategy Games Using Hybrid CBR/RL. In *Proceedings of the Twentieth International Joint Conference on Artificial Intelligence (IJCAI)*, 2007.

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[45] Sooraj Bhat, Charles L. Isbell, and Michael Mateas. On the Difficulty of Modular Reinforcement Learning for Real-World Partial Programming. In *Proceedings of the Twenty-First National Conference on Artificial Intelligence (AAAI)*, 2006.

[46] David L. Roberts, Mark Nelson, Charles L. Isbell, Michael Mateas, and Michael L. Littman. Targeting Specific Distributions of Trajectories in MDPs. In *Proceedings of the Twenty-First National Conference on Artificial Intelligence (AAAI)*, 2006.

[47] Michael Holmes and Charles L. Isbell. Looping Suffix Tree-Based Inference of Partially Observable Hidden State. In *Proceedings of the Twenty-Third International Conference on Machine Learning (ICML)*, 2006.

[48] Mark Nelson, David L. Roberts, Charles L. Isbell, and Michael Mateas. Reinforcement Learning in Declarative Optimization-Based Drama Management. In *Proceedings of the Fifth International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2006.

[49] Andrew Guillory, Tucker Balch, and Charles L. Isbell. Learning Executable Models of Behavior from Observations and Low Level Knowledge. In *Proceedings of the Fifth International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2006.

[50] David L. Roberts, Sooraj Bhat, Charles L. Isbell, Brian Cooper, and Jeffrey Pierce. A Decision-Theoretic Approach to File Consistency in Constrained Peer-to-Peer Device Networks. In *Proceedings of the Fifth International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2006.

[51] Raffay Hamid, S. Maddi, Amos Johnson, S. Batta, Aaron Bobick, Irfan Essa, and Charles L. Isbell. Unsupervised Activity Discovery and Characterization from Event-Streams. In *Proceedings of the Twenty-First Conference on Uncertainty in Artificial Intelligence (UAI)*, 2005.

[52] Raffay Hamid, Amos Johnson, S. Batta, Aaron Bobick, Charles L. Isbell, and G. Coleman. Detection and Explanation of Anomalous Activities: Representing Activities as Bags of Event n-Grams. In *Proceedings of the Twenty-Third IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pages 1031–1038, 2005.

[53] Michael Holmes and Charles L. Isbell. Schema Learning: Experience-based Construction of Predictive Action Models. In *Advances in Neural Information Processing Systems (NIPS) 17*, pages 585–562, 2005.

[54] Charles L. Isbell and Jeff Pierce. An IP Continuum for Adaptive Interface Design. In *Proceedings of the 11th International Conference on Human-Computer Interaction (HCII)*, 2005.

[55] Lawrence Saul, Daniel Lee, Charles L. Isbell, and Yaun LeCun. Real time voice processing with audiovisual feedback: toward autonomous agents with perfect pitch. In *Advances in Neural Information Processing Systems (NIPS) 15*, pages 1205–1212, 2003.

[56] Michael Kearns, Charles L. Isbell, Satinder Singh, Diane Litman, and Jessica Howe. CobotDS: A Spoken Dialogue System for Chat. In *Proceedings of the Nineteenth National Conference on Artificial Intelligence (AAAI)*, pages 435–440, 2002.

[57] Charles Isbell, Christian Shelton, Michael Kearns, Satinder Singh, and Peter Stone. Cobot: A Social Reinforcement Learning Agent. In *Advances in Neural Information Processing Systems (NIPS) 14*, pages 1393–1400, 2002.

[58] Charles L. Isbell, Christian Shelton, Michael Kearns, Satinder Singh, and Peter Stone. A Social Reinforcement Learning Agent. In *Proceedings of the Fifth International Conference on Autonomous Agents*, pages 377–384, 2001.

[59] Charles L. Isbell, Michael Kearns, Dave Kormann, Satinder Singh, and Peter Stone. Cobot in LambdaMOO: A Social Statistics Agent. In *Proceedings of the Seventeenth National Conference on Artificial Intelligence (AAAI)*, pages 36–41, 2000.

[60] Charles L. Isbell and Parry Husbands. The Parallel Problems Server: An Interactive Tool for Large-Scale Machine Learning. In *Advances in Neural Information Processing Systems (NIPS) 12*, pages 703–709, 2000.

[61] Parry Husbands and Charles L. Isbell. MITMatlab: A Tool for Interactive Supercomputing. In *Proceedings of the Ninth SIAM Conference on Parallel Processing for Scientific Computing.*, 1999.

[62] Charles L. Isbell and Paul Viola. Restructuring Sparse High Dimensional Data for Effective Information Retrieval. In *Advances in Neural Information Processing Systems (NIPS) 11*, pages 480–486, 1999.

[63] Parry Husbands and Charles L. Isbell. Interactive Supercomputing with MITMatlab. In *The Second IMA Conference on Parallel Computation*, 1998.

[64] Deborah McGuiness, Charles L. Isbell, M. Parker, Peter Patel-Schneider, Lori Resnick, and Chris Welty. A Description Logic-Based Configurator for the Web. In *Proceedings of the Fifteenth National Conference on Artificial Intelligence (AAAI)*, 1998.

[65] Parry Husbands and Charles L. Isbell. The Parallel Problems Server: A Client-Server Model for Large Scale Scientific Computation. In *Proceedings of the Third International Conference on Vector and Parallel Processing (VECPAR)*, pages 156–169, 1998.

[66] Jeremy De Bonet, Charles L. Isbell, and Paul Viola. MIMIC: Finding Optima by Estimating Probability Densities. In *Advances in Neural Information Processing Systems (NIPS) 9*, pages 424–430, 1997.

[67] Deborah McGuiness, Lori Resnick, and Charles L. Isbell. Description Logic in Practice: A CLASSIC Application. In *Proceedings of the Fourteenth International Joint Conference on Artificial Intelligence (IJCAI)*, 1995.

Refereed

[1] Yannick Schroecker and Charles Isbell. SAIL: A Temporal Difference Approach to State Aware Imitation Learning. In *The 3rd Multidisciplinary Conference on Reinforcement Learning and Decision Making*, 2017.

[2] Ashley Edwards, Srijan Sood, and Charles Isbell. Cross-Domain Perceptual Rewards for Reinforcement Learning. In *The 3rd Multidisciplinary Conference on Reinforcement Learning and Decision Making*, 2017.

[3] Saurabh Kumar, Himanshu Sahni, Farhan Tejani, Yannick Schroecker, and Charles Isbell. State Space Decomposition and Subgoal Creation for Transfer in Deep Reinforcement Learning. In *The 3rd Multidisciplinary Conference on Reinforcement Learning and Decision Making*, 2017.

[4] Pushkar Kolhe, Michael Littman, and Charles Isbell. Peer Reviewing Short Answers using Comparative Judgement. In *The Third ACM Conference on Learning @ Scale*, 2016.

[5] Ashley Edwards, Charles Isbell, and Michael Littman. Expressing Tasks Robustly via Multiple Discount Factors. In *The 2nd Multidisciplinary Conference on Reinforcement Learning and Decision Making*, 2015.

[6] Jonathan Scholz, Martin Levihn, and Charles Isbell. What Does Physics Bias: A Comparison of Model Priors for Robot Manipulation. In *The 1st Multidisciplinary Conference on Reinforcement Learning and Decision Making*, 2013.

[7] Shane Griffith, Kaushik Subramanian, Jonathan Scholz, Charles Isbell, and Andrea Thomaz. Policy Shaping: Integrating Human Feedback with Reinforcement Learning. In *The 1st Multidisciplinary Conference on Reinforcement Learning and Decision Making*, 2013.

[8] Kaushik Subramanian, Charles Isbell, and Andrea Thomaz. Learning Options through Human Interaction. In *Workshop on Agents Learning Interactively from Human Teachers at IJCAI*, 2011.

[9] David L. Roberts, Harikrishna Narayanan, and Charles Isbell. Learning to influence emotional responses for interactive storytelling. In *Proceedings of the AAAI 2009 Spring Symposium on Intelligent Narrative Technologies II*, 2009.

[10] Peng Zang, Charles Isbell, and Andrea Thomaz. Exploiting Training Regimens to Improve Learning. In *Multidisciplinary Symposium on Reinforcement Learning at ICML*, 2009.

[11] David Minnen, Peng Zang, Charles Isbell, and Thad Starner. Boosting Diverse Learners for Domain Agnostic Time Series Classification. In *Workshop and Challenge on Time Series Classification at SIGKDD*, 2007.

[12] David Roberts, Christina Strong, and Charles Isbell. Using Feature Value Distributions to Estimate Player Satisfaction Through an Author's Eyes. In *AAAI 2007 Fall Symposium on Intelligent Narrative Technologies*, 2007.

[13] David Roberts and Charles Isbell. Desiderata for Managers of Interactive Experiences: A Survey of Recent Advances in Drama Management. In *The Agent Based Systems for Human Learning and Entertainment Workshop (ABSHLE) at AAMAS*, 2007.

[14] Peng Zang and Charles Isbell. Similarity in Reinforcement Learning. In *Workshop on Knowledge Discovery and Similarity in Case-Based Reasoning at ICCBR*, 2007.

[15] David Roberts, Christina Strong, and Charles Isbell. Estimating Player Satisfaction Through the Author's Eyes. In *Workshop on Optimizing Player Satisfaction at AIIDE*, 2007.

[16] Olufisayo Omojokun and Charles Isbell. User Modelling for Personalized Universal Appliance Application Interaction. In *Proceedings of the Richard Tapia Celebration of Diversity in Computing Conference*, pages 65–68, 2003.

[17] Olufisayo Omojokun and Charles Isbell. Supporting Personalized Agents in Universal Appliance Interaction. In *Proceedings of the Forty-First Annual ACM Southeast Conference*, 2003.

[18] Olufisayo Omojokun, Charles Isbell, and Prasun Dewan. An architecture for Supporting Personalized Agents in Appliance Interaction. In *AAAI Fall Symposium on Personalized Agents*, 2002.

[19] Charles Isbell, Gavin Bell, Brian Amento, Steve Whittaker, and Jonathan Helfman. IshMail: Designing Advanced Email Systems. In *Proceedings of the CSCW Workshop on Redesigning Email for the 21st century*, 2002.

[20] Charles Isbell, Michael Kearns, Dave Kormann, Satinder Singh, and Peter Stone. Cobot in LambdaMOO: A Social Statistics Agent. In *Proceedings of the Workshop on Interactive Robotics and Entertainment (WIRE)*, 2000.

[21] Parry Husbands and Charles Isbell. The Parallel Problems Server. In *Proceedings of the 1998 MIT Workshop on High Performance Computing in Science and Engineering*, 1998.

[22] Alex Borgida, Charles Isbell, and Deborah McGuiness. Reasoning with Black Boxes: Handling Test Concepts in CLASSIC. In *Proceedings of the Workshop on Description Logics*, 1996.

Abstract Refereed

[1] David Roberts, Mark Riedl, and Charles Isbell. Opportunities for Machine Learning to Impact Interactive Narrative. In *Workshop on Machine Learning and Games at NIPS*, 2007.

[2] Michael Holmes, Alexander Gray, and Charles Isbell. Fast SVD for Large-Scale Matrices. In *Workshop on Efficient Machine Learning at NIPS*, 2007.

[3] David Minnen, Thad Starner, Irfan Essa, and Charles Isbell. Pattern Discovery for Locating Motifs in Multivariate, Real-valued Time-series Data. In *The Learning Workshop (SNOWBIRD)*, 2007.

[4] Michael Holmes, Alex Gray, and Charles Isbell. Fast Nonparametric Conditional Density Estimation. In *The Learning Workshop (SNOWBIRD)*, 2007.

[5] Kevin Quennesson, Elias Ioup, and Charles Isbell. Wavelet statistics for human motion classification. In *National Conference on Artificial Intelligence (AAAI) Special Track*, 2006.

[6] David Minnen, Thad Starner, Irfan Essa, and Charles Isbell. Activity Discovery: Sparse Motifs from Multivariate Time Series. In *The Learning Workshop (SNOWBIRD)*, 2006.

[7] Michael Holmes and Charles Isbell. Looping Suffix Trees for Inference of Partially Observable Hidden State. In *The Learning Workshop (SNOWBIRD)*, 2006.

[8] Raffay Hamid, S. Maddi, Amos Johnson, S. Batta, Aaron Bobick, Irfan Essa, and Charles Isbell. Unsupervised Activity Discovery and Characterization from Event-Streams. In *The Learning Workshop (SNOWBIRD)*, 2005.

[9] Michael Kearns, Charles Isbell, Satinder Singh, Diane Litman, and Jessica Howe. CobotDS: A Spoken Dialogue System for Chat. In *The Learning Workshop (SNOWBIRD)*, 2001.

A.3. Other Refereed Material

Refereed Demos

[1] Charles Isbell, Gavin Bell, Brian Amento, Steve Whittaker, and Jonathan Helfman. IshMail. In *Proceedings of the the Fifteenth Annual ACM Symposium on User Interface Software and Technology (Demo)*, 2002.

Magazines and Other Media

[1] Douglas H. Fisher, Charles L. Isbell, Michael L. Littman, Michael Wollowski, Todd Neller, and James Boerkoel. Ask Me Anything About MOOCs. *AI Magazine*, 38(2):7–12, 2017.

[2] Eric Eaton, Tom Dietterich, Maria Gini, Barbara J. Grosz, Charles L. Isbell, Subbarao Kambhampati, Michael Littman, Francesca Rossi, Stuart Russell, Peter Stone, Tony Walsh, and Michael Wooldridge. Who Speaks for AI? *AI Matters*, 2(2):4–14, Dec 2015.

[3] Michael Littman, Charles Isbell, and Aaron Gross. Overfitting: Machine Learning Video. In *AAAI Video Competition*, 2014.

[4] Yukio Ohsawa, Peter McBurney, Simon Parsons, Christopher A. Miller, Alan Schultz, Jean Scholtz, Michael A. Goodrich, Eugene Santos Jr, Benjamin Bell, Charles L. Isbell, and Michael L. Littman. AAAI-2002 Fall Symposium Series. *AI Magazine*, 24(1):95–98, 2003.

A.4. Software

A.4.1 *Association Environment*, co-developed and designed with Brian Amento. A system for capturing, indexing and retrieving users document and data use.

A.4.2 *Parallel Problems Server* and associated toolkits, co-developed and designed with Parry Husbands. A server-based computation engine for doing high-performance linear algebra with any PPS-compliant client, such as Matlab*P.

A.4.3 *Ishmail*, java version 1.0, co-developed and designed with Gavin Bell; emacs version 2.0, co-developed and designed with Jonathan Helfman. A full-featured email client and server system for power email users. Has been used by independent researchers as an machine learning test platform.

A.4.4 *CoAgent*, a C++ and java system for developing behavior-based virtual agents. Both the cobot and Ishmail systems use this design.

A.5. Patents

[1] Jonathan Helfman and Charles Isbell. Electronic Message Sorting and Notification System. *6,396,513*, 2002.

B. Presentations

B.1. Invited Talks

B.1.1 Invited Speaker, 2018. *AAAI 2018*, “Interactive Machine Learning: How to Best Learn from Human”

B.1.2 Keynote Speaker, 2017. *New Faculty Workshop, UCSD*, "Teaching Matters Even More than You Think"

B.1.3 Invited Speaker, 2017. *UPCEA Summit for Online Leadership*, "Building a Scalable, Accessible, and Community Oriented Online Degree"

B.1.4 Invited Speaker, 2017. *Deluxe Corp*

B.1.5 Invited Panelist, 2017. *American Academy of Arts and Sciences Commission on the Future of Undergraduate Education*

B.1.6 Invited Panelist, 2016. *Online Education 2.0: The Future of Learning in the 21st Century Economy*

B.1.7 Invited Speaker and Panelist, 2016. *ITHAKA: The Next Wave 2016; The Bigger Picture: How Macro Changes in Higher Education Should Shape Your Strategy*, "Trends that Matter"

B.1.8 Invited Speaker, 2016. *AI-HRI, 2016 AAAI Fall Symposium*, "Learning from Humans by Meeting Them Where They Are"

B.1.9 Invited Panelist, 2016. *New America*, "Most Innovative People in Higher Ed"

B.1.10 Invited Panelist, 2015. *Rockefeller Institite of Government*, "Higher Education and Employability: New Models for Integrating Study and Work"

B.1.11 Invited Speaker, 2015. *Second Multidisciplinary Conference on Reinforcement Learning and Decision Making*, "Reinforcement Learning as Software Engineering."

B.1.12 Invited Speaker, 2015. *Workshop on Mathematical sciences for understanding real world problems in Africa*, "Joint Opportunities Using a MOOC-Based Masters of Science."

B.1.13 Keynote Speaker, 2015. *Strategic Integration of MOOCs in Research Universities Workshop, University of Illinois*. "Some Lessons Learned while Creating a Real MOOC-based Masters of Science."

B.1.14 Panelist, 2015. *Harvard-MIT Online Learning Summit*.

B.1.15 Invited Speaker, 2014. *University of Cape Town*, "Interactive Machine Learning for Interactive Experiences."

B.1.16 Keynote Speaker, 2014. *LearnLabs 3rd Annual Learning Science Workshop*, "Interactive Machine Learning... for Learning."

B.1.17 Plenary Speaker, 2014. *36th International Conference on Software Engineering*, "Some Lessons Learned while Creating a Real MOOC-based Masters of Science."

B.1.18 Invited Speaker, MAC50 Anniversary Symposium, 2014. *Massachusetts Institute of Technology*, "Some Lessons Learned while Creating a Real MOOC-based Masters of Science."

B.1.19 Panelist, Seminar on MOOCs, 2014. *Postsecondary National Policy Institute*, "A Masters of Science in CS Online."

B.1.20 Plenary Speaker, Workshop on Online Learning, 2014. *American Society for Engineering Education Engieering Deans Institute*, "A Masters of Science in CS Online."

B.1.21 Panelist and Plenary Speaker, Workshop on Online Learning, 2014. *ECE Department Heads Association Meeting*, "A Masters of Science in CS Online."

B.1.22 Distinctive Voices @ The Beckman Center, 2011. *National Academy of Sciences*, "Interactive Artificial Intelligence and Machine Learning."

B.1.23 AI Colloquium, *University of Texas at Austin*, 2011. "Adaptive Drama Management: Bringing Machine Learning to Interactive Entertainment."

B.1.24 CS Colloquium and CRA-W/CDC Distinguished Lecture Series, *University of Southern California*, 2010. "Adaptive Drama Management: Bringing Machine Learning to Interactive Entertainment."

B.1.25 Computer Science Colloquium, *Cornell University*, 2010. "Adaptive Drama Management: Bringing Machine Learning to Interactive Entertainment." *(updated talk)*

B.1.26 Computer Science Colloquium, *Dartmouth College*, 2010. "Implementing Threads: Practical Issues in Restructuring a Computing Curriculum."

B.1.27 Plenary Speaker, *Richard Tapia Celebration of Diversity in Computing*, 2009. "Adaptive Drama Management."

B.1.28 Panelist, *Global Information Technology Management Association (GITMA)*, 2008. "Changing Computing Curricula via Implementing Threads Model at University System of Georgia Universities Consortium."

B.1.29 *Massachusetts Institute of Technology*, 2007. "Creating and Assessing a Structuring Principle for Undergraduate Curricula."

B.1.30 Panelist, MSR Faculty Summit *Microsoft Research Labs*, 2007. "CS1: Where's It Going and What Should We Be Thinking About."

B.1.31 School of Computing Colloquium *University of Utah*, 2007. "Threads: An Undergraduate Degree Curriculum for the New Face of Computing."

B.1.32 CS Distinguished Lecturer Series *University of Maryland*, 2007. "Threads: An Undergraduate Degree Curriculum for the New Face of Computing."

B.1.33 *Brooklyn College*, 2006. "Threads: An Undergraduate Degree Curriculum for the New Face of Computing."

B.1.34 Rutgers Computer Science Colloquium *Rutgers University*, 2006. "Threads: An Undergraduate Degree Curriculum for the New Face of Computing."

B.1.35 The CDC Distinguished Lecturer Series, *Florida International University*, 2004. "Building Socially-Aware Adaptive Agents."

B.1.36 *Workshop on Activity Recognition and Discovery at NIPS 17*, 2004. "Reinforcement Learning and Human Activity Discovery."

B.1.37 AI Colloquim, *Rutgers University*, 2003. "Applying Reinforcement Learning to Social Relationships".

B.1.38 AI Colloquim, *University of Georgia*, 2003. "Building Adaptive Social Agents"

B.1.39 AI Colloquium, *University of Michigan*, 2002. "Building Adaptive Social Agents"

B.1.40 Plenary Speaker, *First Annual Richard Tapia Celebration of Diversity in Computing Conference*, 2001. "Social Reinforcement Learning."

B.1.41 *Conference for African-American Researchers in the Mathematical Sciences*, 1998. "Finding Optima by Estimation of Probability Densities."

B.2. Testimony

[1] Charles Isbell. Keeping college within reach: Improving access and affordability through innovative partnerships. *House Committee on Education and the Workforce, Subcommittee on Higher Education and Workforce Training*, September 18, 2013.

C. Grants and Contracts

C.1.1 **Interactive Machine Learning for Machine Training**
Sponsor: ONR
Investigator(s): Andrea Thomaz (PI), Charles Isbell, Karen Feigh, Mark Reidl (co-PIs)

C.1.2 **30th International Conference on Machine Learning (ICML 2013)**
Sponsor: NSF
Investigator(s): Charles Isbell (PI)

C.1.3 **Advancing Interactive Machine Learning**
Sponsor: ONR
Investigator(s): Charles Isbell (co-PI) and Andrea Thomaz (co-PI)

C.1.4 **Computer Science Study Panel Phase III**
Sponsor: DARPA
Investigator(s): Charles Isbell (PI)

C.1.5 **Pilot Program for Computer Science Principles Course**
Sponsor: The College Board
Investigator(s): Charles Isbell (PI)

C.1.6 **Intelligent Tutoring Agents in Adaptive Training Environments**
Sponsor: Army Research
Investigator(s): Charles Isbell (PI)

C.1.7 **Integrated Cognitive-Neuroscience Architectures for Understanding Sensemaking (ICArUS)**
Sponsor: IARPA
Investigator(s): Charles Isbell (co-PI) with GTRI and Lockheed Martin (lead integrator)

C.1.8 **Collaborative Research: EArly-concept Grants for Exploratory Research: Computational Thinking Olympiad**
Sponsor: NSF
Investigator(s): Charles Isbell (PI)

C.1.9 **International Travel: Working Group on (Re)Defining Computing**
Sponsor: NSF
Investigator(s): Charles Isbell (PI)

C.1.10 **Integrating Android into CS courses**
Sponsor: Google
Investigator(s): Russ Clark, Charles Isbell and Kristin Vadas Marsicano

C.1.11 **HCC: Web Games to Advance Interactive Learning Agents**
Sponsor: NSF
Investigator(s): Charles Isbell (co-PI) and Andrea Thomaz (co-PI)

C.1.12 **Learning for Home Heartbeat**
Sponsor: Eaton, Corp
Investigator(s): Charles Isbell and Olufisayo Omojokun

C.1.13 **Persistent, Adaptive, Collaborative Agents**
Sponsor: RIM
Investigator(s): Charles Isbell and Irfan Essa

C.1.14 **RoboCamp**
Sponsor: Microsoft
Investigator(s): Tucker Balch, Charles Isbell and Cedric Stallworth (co-PIs)

C.1.15 **SGER: Collaborative Research: Persistent, Adaptive, Collaborative Synthespians**
Sponsor: NSF
Investigator(s): Charles Isbell (PI), Ifran Essa (co-PI), Michael Mateas (co-PI)

C.1.16 **CPATH EAE: Extending Contextualized Computing in Multiple Institutions Using Threads**
Sponsor: NSF
Investigator(s): Charles Isbell (PI), Maureen Biggers (co-PI), Merrick Furst (co-PI), Cedric Stallworth (co-PI)

C.1.17 **Computer Science Study Panel Phase II**
Sponsor: DARPA
Investigator(s): Charles Isbell (PI)

C.1.18 **Signals to Symbols**
Sponsor: AFRL
Investigator(s): Charles Isbell (PI), subcontract with GTRI

C.1.19 **CAREER: Activity Discovery for Programmable & Adaptive Personalized Environments**
Sponsor: NSF
Investigator(s): Charles Isbell (PI)

C.1.20 **Computer Science Study Panel**
Sponsor: DARPA
Investigator(s): Charles Isbell (PI)

C.1.21 **GILA: Integrated Learning**
Sponsor: DARPA IPTO Integrated Learning
Investigator(s): Ashwin Ram (PI at Georgia Tech) with Charles Isbell and Michael Mateas (co-PIs at Georgia Tech) and GTRI, UMD, and Lockheed (integrator and lead institute)

C.1.22 **Asynchronous Reasoning and Learning**
Sponsor: DARPA IPTO seedling grant
Investigator(s): Charles Isbell (PI), Ashwin Ram (co-PI)

C.1.23 **Modeling Environment for Atmospheric Discovery, Data Mining and Machine Learning Working Group**
Sponsor: NSF, as part of the NCSA Expedition
Investigator(s): Bryant York (PI), Charles Isbell and Parry Husbands (co-PIs)

C.2. As Senior Personnel or Contributor

C.1.1 **GroupWear**
Sponsor: DARPA IPTO ASSIST
Investigator(s): Thad Starner (PI) with A. Pentland, I. Essa, G. Abowd, C. Isbell, E. Price, S. Intille, and H. Lieberman

D. Other Professional Activities

D.1. Consulting

- *Womble Carlyle Sandridge & Rice*. Software expertise, 2007-2010.
- *iAAec*. Software architecture for applying reinforcement learning to culturally-aware tutorial systems, 2003

E. Individual Student Guidance

E.1. Ph.D. Students

Ph.D. Students: Graduated

Michael P. Holmes (CoC, co-advised with Alex Gray) *2003-2008*
Research Trader, RGM Advisors
Dissertation: Multi-tree Monte Carlo methods for fast, scalable machine learning
Awards: Distinguished Student Paper Award, ICML 2006

Chip Mappus (CoC) *2003-2009*
Research Scientist, Georgia Tech Research Institute
Dissertation: Estimating the Discriminative Power of Time Varying Features for EEG BMI

David Roberts (CoC) *2004-2010*
Assistant Professor, Department of Computer Science, NC State University
Dissertation: Computational techniques for reasoning about and shaping player experiences in interactive narratives
Awards: Georgia Tech President's Fellow; Department of Homeland Security Graduate Research Fellowship

Peng Zang (CoC) *2005-2011*
Analyst, Operations Strategy Group, Goldman Sachs
Dissertation: Scaling Solutions to Markov Decision Problems

Sooraj Bhat (CoC, co-advised with Alex Gray) *2004-2013*
Research Scientist, Microsoft Research
Dissertation: Syntactic Foundations for Machine Learning

Luis C. Cobo Rus (ECE) *2010-2013*
Research Scientist, Google
Dissertation: Leveraging Attention Focus for Effective Reinforcement Learning in Complex Domains
Awards: la Caixa fellowship; Google Engineering Intern Scholarship; Georgia Tech Research and Innovation Conference Best Poster Prize

Liam Mac Dermed (CoC) *2007-2013*
Research Scientist, Google
Dissertation: Value Methods for Efficiently Solving Stochastic Games of Complete and Incomplete Information
Awards: Shackleford Fellowship

Arya Irani (CoC, GTRI research scientist) *2006-2015*
Research Scientist, GTRI
Utilizing Negative Policy Information to Accelerate Reinforcement Learning

Mark Nelson (CoC, co-advised with Michael Mateas) *2004-2015*
Assistant Professor, ITU Copenhagen
Dissertation: Representing and Reasoning about Videogame Mechanics for Automated Design Support

Jon Scholz (CoC) *2010-2015*
Research Scientist, Google Deep Mind
Dissertation: Physics-Based Reinforcement Learning for Autonomous Manipulation
Awards: Best paper award, Humanoid Robotics 2010 (with Mike Stilman)

Ryan Curtin (CoE, co-advised with Rich Vuduc) *2012-2015*
Research Scientist
Dissertation: Improving Dual-Tree Algorithms

Ph.D. Students: Current

Chris Simpkins (CoC, GTRI research scientist) *2007-present*
Integration of machine learning with software development systems

Kaushik Subramanian (CoC, co-advised with Andrea Thomaz) *2010-present*
Interactive Reinforcement Learning

Ashley Edwards (CoC, co-advised with Andrea Thomaz) *2011-present*
Robotics and interactive machine learning
Awards: National Science Foundation Graduate Research Fellowship 2012-2015

Himanshu Sahni (CoC, co-advised with Thad Starner) *2014-present*
Scalable machine learning

E.2. Mentorship of Postdoctoral Fellows or Visiting Scholars

Thomas Cederborg (CoC, co-advised with Andrea Thomaz) *2014-present*
ineractive machine lerning

Josh Jones (CoC) *2011-2013*
Neurologically consistent machine lerning

Olufisayo Omojokun (CoC) *2006-2009*
Adaptive task modeling

II. Honors and Awards

A. Research Honors and Awards

- **National Academy of Sciences Kavli Fellow**, distinguished young scientists, 2010-2012
- **Outstanding Junior Faculty Research Award**, Georgia Tech College of Computing, 2007
- **NSF CAREER Award**, 2007
- **Computer Science Study Group**, A DoD Young Investigator award, 2006
- **Distinguished Student Paper Award**, Michael Holmes and Charles Isbell (2006). Looping Suffix Tree-Based Inference of Partially Observable Hidden State. Proceedings of the Twenty-Third International Conference on Machine Learning.
- **Best Paper Award**, Charles Isbell, Christian Shelton, Michael Kearns, Satinder Singh and Peter Stone (2001). A Social Reinforcement Learning Agent. Proceedings of Fifth International Conference on Autonomous Agents, pages 377-384.

B. Teaching and Curriculum Honors and Awards

- University Professional and Continuing Education Association Program of Excellence [Credit] Award, Georgia Institute of Technology and the online Master of Science in Computer Science, 2016
- The Regents Teaching Excellence Award for an Outstanding Department, College of Computing's Threads Program, 2013
- Georgia Tech, CETL. Thanks for Being a Great Teacher!, 2008-2014
- Georgia Tech. Parents of President's Scholars. Recognition of Exceptional Commitment to Excellence in Teaching, 2007
- Georgia Tech. College of Computing. William A. "gus" Baird Award for Excellence in Teaching, 2006

C. Service Honors and Awards

- Dean's Award for Singular Service to the College of Computing, OMSCS Pioneers, 2014
- Dean's Award for Singular Service to the College of Computing, Threads Leadership Team, 2006

D. Other Honors and Awards

- Sixteen Most Innovative People in Higher Education, Washington Monthly, 2016
- Scholar, Academy for Innovative Higher Education Leadership, 2015-2016
- Scholar, University System of Georgia Executive Leadership Institute, 2010-2011
- Participant, Georgia Tech Institute for Leadership and Entrepreneurship Leadership Roundtable, 2010
- Modern Day Technology Leader Award, Black Engineer of the Year Awards, 2009

- 50 Most Important African American Technologists, “Soul of Technology” eAccess Corp, 2009
- Participant, Georgia Tech University Leadership Program, 2008-2009
- Scholar of Note, Black Issues in Higher Education, 2004
- AT&T Cooperative Research Fellowship, 1990-1998
- National Science Foundation Fellowship, 1990-1994
- Student representative (most outstanding student) of Georgia Institute of Technology, Academic Recognition Day, State of Georgia, 1990
- INROADS/Atlanta Intern of the Year, 1989, 1990

III. Service

A. Professional Contributions

A.1. Memberships and Activities in Professional Societies

- Member, Association for Computing Machinery

A.2. Journal Reviewing Activities

- **Editor**, Journal of Autonomous Agents and Multi-Agent Systems
- **Reviewer**, Foundations and Trends in Robotics
- **Reviewer**, ACM Transactions on Computer-Human Interaction
- **Reviewer**, Artificial Intelligence Journal
- **Reviewer**, International Journal of Social Robotics
- **Reviewer**, Journal of Artificial Intelligence Research
- **Reviewer**, Journal of Machine Learning Research
- **Reviewer**, Journal of Autonomous Agents and Multi-Agent Systems
- **Reviewer**, Machine Learning

A.3. Conference Committee Activities

- **Video Competition Co-Chair**, AAAI 2016
- **General Chair**, Tapia 2015
- **Fundraising Co-Chair**, ICML 2013-2014
- **Local Co-Chair**, ICML 2013
- **Program Committee**, ICIDS 2012
- **Program Committee**, AIIDE 2012
- **Program Committee**, Doctoral Consortium, AAAI 2012
- **Program Committee**, Doctoral Consortium, FDG 2012
- **Program Committee**, ICML 2012
- **Program Co-chair and Co-organizer**, AIIDE Workshop on Taking Non-Player Characters to the Next Level, 2011
- **Program Committee**, NIPS 2012
- **Program Committee**, ICIDS 2011
- **Senior Program Committee**, AIIDE 2011
- **Program Committee**, Doctoral Consortium, AAAI 2011
- **Chair, Organizing Committee**, National Academy of Sciences Kavli Frontiers of Science Symposium, 2011-2012

- **Organizing Committee**, National Academy of Sciences Kavli Frontiers of Science Symposium, 2010-2011
- **Co-chair and co-organizer**, *(Re)defining Computing Curricula by (Re)defining Computing* Working Group, ACM-SIGCSE Annual Conference on Innovation and Technology in Computer Science Education, 2009
- **Co-chair and co-organizer**, Doctoral Consortium, TAPIA 2009
- **Program Committee**, RSS 2009
- **Program Committee**, AAMAS 2009
- **Organizing Committee**, AAAI Spring Symposium on Intelligent Narrative Technologies II, 2009.
- **Organizing Committee**, AAAI Spring Symposium on Agents that Learn from Human Teachers, 2009.
- **Program Committee**, AAAI 2008
- **Program Committee**, ICML 2008
- **Organizing Committee**, AAAI Fall Symposium on Computational Approaches to Representation Change During Learning and Development, 2007.
- **Program Committee**, AAAI 2007
- **Reviewer**, SIGGRAPH 2007
- **Senior Program Committee**, AIIDE 2007
- **Local Co-Chair**, RoboCup Junior 2007
- **Program Co-chair and Co-organizer**, AAMAS Workshop on Agent-Based Systems for Human Learning and Entertainment, 2007.
- **Program Committee**, AAMAS 2007
- **Reviewer**, CHI 2007
- **Program Committee**, AAAI 2006
- **Co-Chair**, Workshop Committee, NIPS 2007
- **Senior Co-Chair**, Workshop Committee, NIPS 2006
- **Co-Chair**, Workshop Committee, NIPS 2005
- **Program Committee**, AAMAS 2005
- **Program Committee**, CHI 2005
- **Program Committee**, AAAI 2004
- **Program Committee** IJCAI 2003
- **Program Co-chair and Co-organizer**, Ubicomp 2003 Workshop: Multi-Device Interfaces for Ubiquitous Peripheral Interaction, 2003.
- **Program Chair and Organizer**, AAAI Fall Symposium on Personalized Learning Agents, 2002.
- **Program Committee**, AAMAS 2002
- **Program Committee**, AAAI 2000

A.4. Other Reviewing Activities

- **External Reviewer**, National Research Council report: "Autonomy Research for Civil Aviation: Towards a New Era of Flight", 2014
- **Member**, NSF Site Visit Team for Pittsburgh Science of Learning Center, 2011
- **Member**, NSF Site Visit Team for Pittsburgh Science of Learning Center, 2010
- **Member**, Committee of Visitors for the Information and Intelligent Systems Division in the Directorate for Computer and Information Science and Engineering at the National Science Foundation (NSF), 2009
- **Member**, NSF Site Visit Team for Pittsburgh Science of Learning Center, 2008

B. Public and Community Service

- Member, National Academies Data Science Post-Secondary Education Roundtable, 2016 - present
- Member, National Academies Committee on the Growth of Computer Science Undergraduate Enrollment, 2016 - 2017
- Member CMDiT Board of Advisors, 2016 - present
- Member, ABET Subcommittee on Diversity and Inclusion, 2015 - present
- Member, AAAI Executive Council, 2015 - present
- Member, National Academies NASA Technology Roadmaps Committee, 2015 - present
- Member, Google Online Education Advisory Board, 2015 - present
- Co-Chair, Executive Committee, *Coalition to Diversify Computing*, sponsored by the Computing Research Association, the Association for Computing Machinery, and The Association of Computer and Information Science and Engineering Departments at Minority Institutions, 2015 - 2016
- Member, Advisory Board for the MIT/Harvard Center for Brains, Minds and Machines, 2014 - present
- Member, Advisory Board for National Science Foundation, AC/ERE, 2014 - present
- Member, Search Committee for the Assistant Director, CISE, 2014
- Member, ABET Academic Advisory Council, 2013 - present
- Member, DARPA Information Science and Technology (ISAT) study group, 2012 - present
- Member, National Science Foundation Committee on Equal Opportunities in Science and Engineering (CEOSE), 2012 - present
- Member, Advisory Board, Pittsburgh Science of Learning Center, 2012-2015
- Member, Board of Visitors, School of Information Sciences, University of Pittsburgh, 2013-present
- Co-Chair, Computing Research Association Education Committee (CRA-E), 2011 - 2013
- Member, Computing Research Association Education Committee (CRA-E), 2010 - present

- Member, Executive Committee, *Coalition to Diversify Computing*, sponsored by the Computing Research Association, the Association for Computing Machinery, and The Association of Computer and Information Science and Engineering Departments at Minority Institutions, 1995 - 2002, 2011 - present
- Member, Advisory Board for National Science Foundation, CISE, 2009 - present
- Member, Advisory Board for the Alliance for the Advancement of African American Researchers in Computing, 2008 - 2012
- Member of the Governing Board, *The Institute for African American e-Culture*, 2002 - 2007
- Panelist, *Workshop on Increasing the Participation of Minorities in the Computing Disciplines*, sponsored by the National Science Foundation, 1995

C. Institute Contributions

Georgia Tech Committees

- Member, Executive Committee, Creating Next in Education, 2015-present
- Member, Workforce of the Future Task Force, 2015-present
- Member, Search Committee for the Associate Dean of Learning Systems, Professional Education, 2015
- Chair, Search Committee for the Chair of the School of Architecture, 2015
- Member, Executive Council of the Strategic Technology Investment Committee, Georgia Tech, 2015 - present
- Member, Dual Degree Engineering Program Task Force, 2014-present
- Member, GTNeuro Minor Committee, 2013
- Member, Strategic Technology Investment Committee, Georgia Tech, 2012 - present
- Member, Talks@Tech Planning Committee, Georgia Tech, 2012
- Member, President's Strategic Plan Steering Committee, Georgia Tech, 2011 - 2012
- Member, Human Resources Diversity Council Steering Committee, Georgia Tech, 2011 - present
- Member, Information Technology Implementation Committee, Georgia Tech, 2011 - 2012
- Member, CoC Staff Advisory Committee, 2011 - present
- Member, Search Committee for the Chair of the School of Architecture, 2010
- Member, Institute Honorary Degree and Commencement Speaker Committee, 2010 - present
- Member, President's Strategic Planning Steering Committee, 2009 - 2010
- Co-Chair, Subcommittee for the President's Strategic Planning Steering Committee, 2010
- Member, Institute Honorary Degree Committee, 2009 - 2010
- Member, College of Computing Implemention Team for CoC Staff Recommendations, 2009 - 2010
- Member, Search Committee for the Dean of the College of Computing, 2008 - 2010

- Member, GT Council on Accreditation, 2008 - 2010
- Chair, Provost's Taskforce on Modularity for the Undergraduate Curriculum, 2008
- Chair, College of Computing Undergraduate Curriculum Committee, 2007 - present
- Member, Provost's Taskforce on Undergraduate Curriculum: Broadening, 2007 - 2009
- Member, Institute Undergraduate Curriculum Committee, 2007 - 2013
- Ph.D. Review Co-ordinator, Interactive Computing, 2006 - 2007
- Member, College of Computing Undergraduate Curriculum Committee, 2003 - 2004, 2006 - 2007
- Area Co-ordinator, Intelligent Systems, 2005 - 2010
- Co-chair, College of Computing IIC Task Force for Threads Implementation, 2005
- Member, College of Computing TSO Advisory Committee, 2006 - 2009
- Member, College of Computing CNS Steering Committee, 2004 - 2005
- Chair, College of Computing ICD Task Force on reviewing the CoC undergraduate curriculum, 2004.
- Member, College of Comptuing CNS Task Force, 2004
- Member, College of Computing IIC Faculty Recruiting Committee, 2004 - 2006

IV. Other National and International Recognition

A. Selected Articles, Appearances, and Publications by the Popular Media

[1] Hari Sreenivasan. How Online Graduate Programs Offer Degrees at Significant Savings. *PBS NewsHour*, September 2017.

[2] Ian Bogost. Artificial Intelligence Has Become Meaningless. *The Atlantic*, March 2017.

[3] Charles Isbell. Reading List for a New World Order. *Chronicle of Higher Education*, 63(12), April 2017.

[4] Ben Mulroney and Michael Hiscock. Online or Classroom Learning: What's Better for Students? *CTV's Your Morning*, October 2016.

[5] Evan Ackerman. You Can't Stop Robots With Furniture Barricades Anymore. *IEEE Spectrum*, October 2016.

[6] Kevin Carey. Georgia Tech's $7,000 Online Master's Degree Could Start a Revolution. *New York Times*, page A15, October 2016.

[7] Tom Ashbrook. New Frontiers in Online Higher Education. *On Point with Tom Ashbrook*, October 3, 2016.

[8] Sam Charrington. Talk 4: Charles Isbell - Interactive AI, Plus Improving ML Education. *This Week in Machine Learning and AI*, September 9, 2016.

[9] Gilad Edelman. The Sixteen Most Innovative People in Higher Education. *Washington Monthly*, September 2016.

[10] Emily Bazelon and John Dickerson and David Plotz. Which Candidate Is the Best Sweet Talker? *Slate Political Gabfest*, May 6, 2016.

[11] Rose. Episode 10: Rude Bot Rises. *Flash Forward*, April 5, 2016.

[12] Melissa Korn. Online Degree Hits Learning Curve. *Wall Street Journal*, December 13, 2015.

[13] Peter Stokes. *Higher Education and Employability: New Models for Integrating Study and Work*. Harvard Education Press, 2015.

[14] Jeremy Campbell. Marty McFly's next gadgets from Georgia Tech. *11 Alive News*, October 21, 2015.

[15] Tasnim Shamma. Experts Predict Next 25 Years of Digital Life at Ga Tech. *WABE Radio*, October 23, 2015.

[16] David Markiewicz. Hacker Schools Offer Students a Different Path to Tech Jobs. *Atlanta Journal-Constitution*, March 7, 2014.

[17] Carl Straumsheim. The First Cohort. *Inside Higher Ed*, December 13, 2013.

[18] Paul Fain. Helpful or Hindrance? *Inside Higher Ed*, September 19, 2013.

[19] Ry Rivard. The Fine Print. *Inside Higher Ed*, May 28, 2013.

[20] Chip Rogers. Secrets to Lower College Costs. *GPB Radio*, August 1, 2013.

[21] Van Jensen. Into the Unknown. *Georgia Tech Alumni Magazine*, 88(3):48–57, 2012.

[22] Kelsey Sheey. Computer Science Transitions From Elective to Requirement. *US News and World Report*, April 3, 2012.
Also reprinted in the Chicago Tribune, April 4, 2012.

[23] Ryan Lytle. Learn to Code in College Without Breaking the Bank. *US News and World Report*, February 16, 2012.
Also reprinted in the Chicago Tribune, February 17, 2012.

[24] Amar Toor. New Program Makes it Easier to Turn Your Computer into a Conversational Chatterbox. *Engadget*, September 5, 2011.

[25] Staff. Leaders in Computing: The Interviews from the 2009 Richard Tapia Celebration of Diversity in Computing Conference. *A4RC YouTube Channel*, July 22, 2010.
Recorded April 4, 2009.

[26] Scott Leith. iPhone Gets Kudos, a Needs-Improvement List. *The Atlanta Journal Constitution*, July 13, 2007.

[27] Staff. RoboCup. *WABE Radio*, June 3, 2007.

[28] Staff. RoboCup Junior. *Good Day Atlanta, FOX 5*, June 3, 2007.

[29] Ronald Roach. Threads Computer Science Curriculum Debuts at Georgia Tech. *Diverse Issues in Higher Education*, 23:29, November 2, 2006.

[30] Ronald Roach. Making Things Smart, part of the Emerging Scholars of Note Series. *Black Issues in Higher Education*, page 29, 2004.

[31] Clark Howard. Clark Howard's Advice on Home Warranties. *WSBTV Atlanta*, 2003.

[32] Gerrit Gohlke. Cybermaps: More Beautiful than Art. *European Photography*, 2003.

[33] Steve Carney. Database is Black History in the Making. *Los Angeles Times*, 2001.

[34] Martin Dodge and Rob Kitchin. *Mapping Cyberspace*. Routledge Press, 2001.

[35] Arianna Cha. Lost in Cyberspace? Try a Bot... *Washington Post*, 2000.

[36] John Murrell. We Will Have Countless Friends. *Time Magazine/Digital*, 2000.

[37] Anne Eisenberg. Find Me a File, Catch Me a Cache. *New York Times*, 2000.