

# Curriculum Vitae

Jacob Beal  
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## Education:

MIT	PhD (EECS)	2007
MIT	M.Eng. (EECS)	2002
MIT	S.B. (Mathematics)	2000
MIT	S.B. (EECS)	2000

## Appointments:

Scientist, BBN Technologies	Sept. 2008 -
Research Affiliate, MIT CSAIL	Sept. 2008 -
Fellow, Science Commons	Sept. 2008 -
Postdoctoral Associate in MIT Project MAC	Sept. 2007 - Aug. 2008
Teaching Assistant for MIT course 6.034, "Artificial Intelligence"	Four terms, 2000-2003
Research Assistant in MIT Project MAC	Ten terms, seven summers, 2001-2007

## Grants:

- **MIT Energy Initiative Seed Fund PACEM: Cooperative Control for Citywide Energy Management**, Jacob Beal, Hal Abelson (PI), 2008-2010, \$90,000.
- **NSF Biology and Information Technology Grant *Biologically-Inspired Robust Space/Time Programming of Sensor/Actuator Ensembles***, Jacob Beal, Jonathan Bachrach, Thomas Knight Jr. (PI), Gerald Jay Sussman (co-PI), Sept. 2006-2009, \$600,000.
- **NSF Robust Intelligence Grant *Robustness from Non-Stop Collaboration***, Jacob Beal, Keith Bonawitz, Patrick Winston (PI), Gerald Jay Sussman (co-PI), Nov. 2005-2008, \$500,000.

## Patents:

- Jacob Beal and Jonathan Bachrach, U.S. Patent Application No. 12/394,011, *Methods and Apparatus for Energy Demand Management*, pending, filed February, 2009.

## Supervised Theses:

Vinayak Ranade	M.Eng.	MIT	June 2010	Incentives and Control for PACEM
Dany M. Qumsiyeh	M.Eng.	MIT	June 2008	A Distributed Building Evacuation System

## Other Teaching/Mentoring Experience:

- Taught a one-week course consisting of five two-hour lectures, *Spatial Computing: From global to local and back again*, at the Third French Complex Systems Summer School in August 2009, to an international group of approximately 30 students with backgrounds varying from undergraduate to experienced researchers in a variety of fields.

- Teaching assistant for MIT course 6.034, “Artificial Intelligence,” four terms, 2000 to 2003. Responsibilities included teaching weekly tutorials to 40-75 students organized into 5-15 student sessions, and design of problem sets and examinations.
- Created and taught the Intensive program within MIT course 6.034, “Artificial Intelligence,” beginning in 2001. Students in the Intensive program work on projects addressing real problems in AI research and applications.
- As a graduate student and postdoc at MIT, I supervised approximately 17 undergraduates through MIT’s Undergraduate Research Opportunities Program (UROP). Of the students who worked for me, at least 5 have already gone on to pursue graduate degrees.
- Conference tutorials are listed below.

## Professional Service

### *Journals*

- Guest Editor, *Special Issue on Spatial Computing*, ACM Transactions on Autonomous and Adaptive Systems, scheduled for publication in mid-2011.
- Guest Editor, *Special Issue on Human-Level Intelligence*, IEEE Intelligent Systems, July 2009.
- Recent reviewing includes the journals “Autonomous Agents and Multi-Agent Systems”, “Artificial Life”, “IEEE Transactions on Systems, Man, and Cybernetics”, “International Journal of Distributed Sensor Networks”, “Swarm Intelligence”, “The Computer Journal”, and the Cognitive Science Conference and the International Symposium on Stability, Safety, and Security of Distributed Systems.

### *Conferences, Seminar Series and Workshops*

- Organizer, Engineered Self-Organization Seminar Series, ongoing at BBN Technologies.
- Publications Chair, 3rd International Workshop on Bio-Design Automation, June 2011.
- Workshop Chair, IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO 2010), September 2010.
- Organizer, *Spatial Computing Workshop 2010*, attached to IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO), September 2010. Also organized SCW in 2009 and 2008.
- Track Chair, *Swarm, Amorphous, Spatial, and Complex Systems Track* of 12th International Symposium on Stabilization, Safety, and Security of Distributed Systems (SSS 2010), September 2010.
- Organizer, Workshop on *Agents Learning Interactively from Human Teachers (ALIHT)* at 9th International Conference on Autonomous Agents and Multi-agent Systems (AAMAS 2010), May 2010.
- Poster Co-chair, IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO 2009), September 2009.
- Organizer, *Naturally-Inspired Artificial Intelligence* symposium, in AAAI 2008 Fall Symposium Series, November 2008.
- Organizer, *Genesis Workshop*, internal MIT workshop, September 2003.
- Program committee of:

- Self-organizing Complex Systems track for ACM Symposium on Applied Computing, March 2011 (previously on 2010 PC).
- 5th International ICST Conference on Bio-Inspired Models of Network, Information, and Computing Systems (Bionetics 2010), December 2010.
- 10th International Symposium on Distributed Autonomous Robotic Systems (DARS 2010), November 2010.
- Special session on Morphogenetic Engineering at 7th International Conference on Swarm Intelligence (ANTS 2010), September 2010.
- IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO 2010), September 2010.
- 2nd International Workshop on Bio-Design Automation, June, 2010.
- Symposium on AI-Inspired Biology, March 2010.
- Self-Organized Systems track for 11th International Symposium on Stabilization, Safety, and Security of Distributed Systems (SSS 2009), November 2009.

#### *Other Organization*

- Founding organizer of the Dangerous Ideas Seminar, a regular series at MIT CSAIL designed to spur cross-pollination of ideas within the lab and to foster creativity by challenging students, faculty, and research staff with each others’ ideas. The Dangerous Ideas Seminar ran from 2001 through 2005.

## **Publications**

### **Journal articles**

1. Jonathan Bachrach, Jacob Beal, and James McLurkin, *Composable Continuous Space Programs for Robotic Swarms*, Neural Computing and Applications, Special Issue on Swarms, Volume 19, Issue 6 (2010), pages 825–847.
2. Sagar Indurkha and Jacob Beal, *Reaction Factoring and Bipartite Update Graphs Accelerate the Gillespie Algorithm for Large-Scale Biochemical Systems*, in PLoS ONE 5(1): e8125. doi:10.1371/journal.pone.0008125, January 2010
3. Jacob Beal and Jonathan Bachrach, *Infrastructure for Engineered Emergence on Sensor/Actuator Networks*, IEEE Intelligent Systems, (Vol. 21, No. 2) pp. 10-19, March/April 2006.

### **Book Chapters & Theses**

1. Hal Abelson, Jacob Beal, and Gerald Jay Sussman, *Amorphous Computing*, article in “Encyclopedia of Complexity and System Science,” Springer-Verlag, March 2009.
2. Jacob Beal, *Learning by Learning to Communicate*, PhD Thesis, August 2007.
3. Jacob Beal, *Programming an Amorphous Computational Medium*, in Unconventional Programming Paradigms, Lecture Notes in Computer Science Vol. 3566, August 2005.
4. Jacob Beal, *Generating Communications Systems Through Shared Context*, Master’s Thesis, January 2002.

### **Conference articles:**

1. Nelson Elhage and Jacob Beal *Laplacian-Based Consensus on Spatial Computers*, 9th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2010), May 2010.

2. Jacob Beal and Jennifer Roberts, *Enhancing Methodological Rigor for Computational Cognitive Science: Complexity Analysis*, Cognitive Science Conference, July 2009.
3. Jennifer Roberts and Jacob Beal, *Enhancing Methodological Rigor for Computational Cognitive Science: Core Tenets and Ad Hoc Residuals*, Cognitive Science Conference, July 2009.
4. Jacob Beal, *Self-Managing Associative Memory for Dynamic Acquisition of Expertise in High-Level Domains*, International Joint Conference on Artificial Intelligence (IJCAI) 2009, July 2009.
5. Jacob Beal, Jonathan Bachrach, Dan Vickery, and Mark Tobenkin, *Fast Self-Stabilization for Gradients*, 2009 IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS), June 2009.
6. Jacob Beal, Nikolaus Correll, Leonardo Urbina, and Jonathan Bachrach, *Behavior Modes for Randomized Robotic Coverage*, Second International Conference on Robot Communication and Coordination, April 2009.
7. Jacob Beal, *Flexible Self-Healing Gradients*, ACM Symposium on Applied Computing 2009, March 2009.
8. Jonathan Bachrach, Jacob Beal, Joshua Horowitz, and Dany Qumsiyeh, *Empirical Characterization of Discretization Error in Gradient-based Algorithms*, IEEE SASO 2008, October 2008.
9. Jacob Beal and Thomas F. Knight, Jr, *Analyzing Composability in a Sparse Encoding Model of Memorization and Association*, IEEE 7th International Conference on Development and Learning (ICDL 2008), August 2008.
10. Jacob Beal, *Learning Composable Signals for a Cognitive Substrate*, Cognitive Science Conference, July 2008.
11. Jacob Beal, *Shared Focus of Attention for Heterogeneous Agents*, Short Paper, 7th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2008), May 2008.
12. Jacob Beal, Jonathan Bachrach, Dan Vickery, and Mark Tobenkin, *Fast Self-Healing Gradients*, ACM Symposium on Applied Computing 2008, March 2008. *Received Best Paper Award (Artificial Intelligence & Agents Theme)*.
13. Jonathan Bachrach, Jacob Beal, and Takeshi Fujiwara, *Continuous Space-Time Semantics Allow Adaptive Program Execution*, IEEE SASO 2007, July 2007.
14. Jonathan Bachrach and Jacob Beal, *Programming a Sensor Network as an Amorphous Medium*, extended abstract for poster at IEEE DCOSS 2006, June 2006.
15. Jacob Beal, *What the Assassins' Guild Taught Me About Distributed Computing*, International Conference on Complex Systems (ICCS) 2006, June 2006.
16. Jacob Beal and Sara Bennett, *Predictive Modelling for Fisheries Management in the Colombian Amazon*, International Conference on Complex Systems (ICCS) 2004, June 2004.
17. Jacob Beal, *An Algorithm for Bootstrapping Communications*, International Conference on Complex Systems (ICCS), June 2002.

#### Conference abstracts

1. Jacob Beal, Ting Lu, and Ron Weiss, *Automatic Compilation from High-Level Languages to Genetic Regulatory Networks*, 2nd International Workshop on Bio-Design Automation (IWBDA), June 2010.

2. Jacob Beal, Ting Lu, and Ron Weiss, *Automatic Compilation from High-Level Languages to Genetic Regulatory Networks*, Institute of Biological Engineering annual conference, March 2010.
3. Jacob Beal, *Functional blueprints: a means of adaptive integration?*, First International Workshop on Morphogenetic Engineering, June 2009.
4. Jacob Beal and Seth Gilbert, *Analyzing Failures as Noise*, LIDS Student Conference, MIT, January 2004.

### Workshops, Symposia, and Seminars

1. Jacob Beal, Alice Leung, and Robert Laddaga, *Spectrum Curricula for Measuring Teachability*, Workshop on *Agents Learning Interactively from Human Teachers (ALIHT)* at 9th International Conference on Autonomous Agents and Multi-agent Systems (AAMAS 2010), May 2010.
2. Mark Burstein, Robert P. Goldman, Drew V. McDermott, David McDonald, Jacob Beal, and John Maraist, *LTML - A Language for Representing Semantic Web Service Workflow Procedures*, workshop on “Semantics for the Rest of Us – Variants of Semantic Web Languages in the Real World”, at 8th International Semantic Web Conference, October 2009
3. Jacob Beal, *Dynamically Defined Processes for Spatial Computers*, Spatial Computing Workshop 2009, September 2009.
4. Richard Schantz, Jacob Beal, Joe Loyall, Partha Pal, Kurt Rohloff, and A. Bestavros, Research Challenges in Information Systems for the Next Generation Electric Grid, Proceedings of the National Workshop on New Research Directions for Future Cyber-Physical Energy Systems, June 2009.
5. Jacob Beal, Paul Robertson, and Robert Laddaga, *Curricula and Metrics to Investigate Human-Like Learning*, AAAI 2009 Spring Symposium “Agents that Learn from Human Teachers”, March, 2009.
6. Jacob Beal and Gerald Jay Sussman, *Engineered Robustness by Controlled Hallucination*, AAAI 2008 Fall Symposium “Naturally-Inspired Artificial Intelligence”, November 2008.
7. Jacob Beal and Jonathan Bachrach, *Cells Are Plausible Targets for High-Level Spatial Languages*, Spatial Computing Workshop, October 2008.
8. Rachel Greenstadt and Jacob Beal, *Cognitive Security for Personal Devices*, First ACM workshop on AISec, October 2008.
9. Jonathan Bachrach and Jacob Beal, *Autonomy in Spatial Computing*, Third Workshop on Hot Topics in Autonomic Computing, June 2008.
10. Jacob Beal, *Developmental Cost for Models of Intelligence*, AAAI 2007 Workshop on Evaluating Architectures for Intelligence, July 2007.
11. Jacob Beal and Jonathan Bachrach, *Programming Manifolds*, Dagstuhl Seminar 06361: Computing Media and Languages for Space-Oriented Computation, Andre DeHon, Jean-Louis Giavitto, and Fredric Gruau eds, December 2006.
12. Jacob Beal, *Sidestepping Impossibility: Combat Consensus in the Assassins’ Guild*, MIT CSAIL Student Workshop 2006, September 2006.
13. Jacob Beal and Gerald Jay Sussman, *CogSci to AI: It’s the Brainware, Stupid!*, AAAI 2006 Spring Symposium “Between a Rock and a Hard Place: Cognitive Science Principles Meet AI-Hard Problems”, Stanford, March 2006.
14. Jacob Beal, *Amorphous Medium Language*, Large-Scale Multi-Agent Systems Workshop at AAMAS, July 2005.

15. Jacob Beal and Seth Gilbert, *RamboNodes for the Metropolitan Ad Hoc Network*, Workshop on Dependability in Wireless Ad Hoc Networks and Sensor Networks, part of the International Conference on Dependable Systems and Networks, June 2004.
16. Jacob Beal, Carl Blaurock, Keith Bonawitz, Kyrilian Dyer, Paul Elliott, Paul Eremenko, Eric Feron, Emilio Frazzoli, Benjamin Ingram, Michael Lester, Manway Liu, Stefan Marti, Joshua Napoli, Kailas Narendran, and Scott Rasmussen, *The Development of a Small Autonomous Helicopter Robot for Search and Rescue in Hostile Environments*, Proceedings of the AUVERSI Annual Symposium, July 1999.

**Published Whitepapers and Technical Reports:**

1. Jacob Beal and Hal Abelson, *PACEM: Cooperative Control for Citywide Energy Management*, whitepaper, August 2008.
2. Jacob Beal, Jonathan Bachrach, and Mark Tobenkin, *Constraint and Restoring Force*, MIT CSAIL Tech Report 2007-044, August 2007.
3. Jonathan Bachrach and Jacob Beal, *Building Spatial Computers*, MIT CSAIL Tech Report 2007-017, March 2007.
4. Jacob Beal, *What the Assassins' Guild Taught Me About Distributed Computing*, MIT CSAIL Technical Report MIT-CSAIL-TR-2006-038, June 2006.
5. Jacob Beal, *Learning From Snapshot Examples*, MIT AI Memo 2005-012, April 2005.
6. Jacob Beal, Tim Shepard, *Shrinking the Leap of Faith*, publicly available report, March 2005.
7. Jacob Beal and Gerald Jay Sussman, *Biologically-Inspired Robust Spatial Programming*, MIT AI Memo 2005-001, January 2005.
8. Jacob Beal and Tim Shepard, *Deamplification of DoS Attacks via Puzzles*, publicly available report, October 2004.
9. Jacob Beal, *Near-Optimal Distributed Failure Circumscription*, AI Memo 2003-017, August 2003.
10. Jacob Beal, *A Robust Amorphous Hierarchy from Persistent Nodes*, AI Memo 2003-012, May 2003.
11. Jacob Beal, *Persistent Nodes for Reliable Memory in Geographically Local Networks*, AI Memo 2003-011, April 2003.
12. Jacob Beal, *Leaderless Distributed Hierarchy Formation*, AI Memo 2002-021, December 2002.
13. Ryan Newton and Jacob Beal, *Amorphous Infrastructure for Language Implementation*, MIT CSAIL Tech Report 2006-015, December 2002.

**Tutorials:**

1. *Spatial Computing for Networked Collaboration*, International Symposium on Collaborative Technologies and Systems (CTS 2010), May 2010.
2. *Spatial Computing for Swarms*, 2009 IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO), September 2009.
3. *Spatial Computing: From global to local and back again*, five-lecture series at Third French Complex Systems Summer School, August, 2009.

4. *Introduction to Spatial Computing*, Second International Conference on Robot Communication and Coordination (RoboComm), April 2009.
5. *Spatial Approaches to Pervasive Computing*, with Marco Mamei and Christian Borcea, 2008 IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO), October 2008.

**Plenary Talks:**

1. *Spatial Computing: From Manifold Geometry to Biology*, AMORPH Conference (Amorphous Computing and Complex Biological Networks), Sheffield, U.K., August 2010.

**Other Invited Presentations:**

1. *Spatial Computing and Proto*, Lecture for Harvard course CS 266 “Bio-inspired Distributed and Multi-Agent Systems,” Harvard, April 2010.
2. *Composable Continuous-Space Programs for Robotic Swarms*, Seminar lecture at Harvard, March 2010.
3. *Composable Continuous-Space Programs for Robotic Swarms*, iRobot, July 2009.
4. *PACEM: Cooperative Control for Citywide Energy Management*, Massachusetts Technology Transfer Offices Day, June 2009.
5. *Spatial Computing*, presented on “Grand Challenges” panel at IEEE SASO 2008, October 2008.
6. *BioBricks & High-Level Programming*, MIT Synthetic Biology Lunch seminar series, April 2008.
7. *Spatial Computing and the Challenge of Engineered Emergence*, Harvard CRCS Privacy and Security Lunch Seminar, April 2008.
8. *Programming Cell Aggregates*, MIT Synthetic Biology Lunch seminar series, January 2008.
9. *Learning by Learning to Communicate*, Dartmouth College, October 2007.
10. *Principles for Engineered Emergence*, Unconventional Computation: Quo Vadis?, March 2007.
11. *Programming Manifolds*, Dagstuhl Seminar 06361, “Computing Media and Languages for Space-Oriented Computation,” September 2006.
12. *Integration by Coincidence: Status and Speculation*, MIT Biologically Inspired Cognitive Architectures (BICA) workshop, January 2006.
13. *Programming an Amorphous Medium*, Unconventional Programming Paradigms workshop, September 2004.

**Graduate Advisors:**

Gerald J. Sussman	MIT
Patrick H. Winston	MIT
Tom Knight	MIT
Joel Moses	MIT

**Awards and Honors:**

2008 Best Paper Award (Artificial Intelligence & Agents Theme), ACM SAC 2008  
 2000 Tau Beta Pi, Engineering Honor Society

**Other Relevant Experience:**

1. Grandmaster of the MIT Assassin’s Guild, 2001-2002, a live-action role-playing student group. Ran more than 20 games (starting in 1998) under the auspices of the Guild, with games ranging up to 10 days in length and over 60 participants playing.