

## Dr. Joshua Clifford Bongard, BSc, MSc, PhD

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Votey Hall 329  
Department of Computer Science  
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**Nationality:** Canadian  
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### Employment

**Fall 2006-present** Assistant Professor, Department of Computer Science, University of Vermont

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### Education

**2003-2006** Cornell University, Ithaca, USA  
Computational Synthesis Laboratory  
Sibley School of Mechanical and Aerospace Engineering and  
Faculty of Computing and Information Science  
Postdoctoral Associate

**1999-2003** University of Zürich, Zürich, Switzerland  
Department of Information Technology  
Artificial Intelligence Laboratory (Prof. Dr. R. Pfeifer)  
Software Engineering Group (Prof. Dr. H. Schauer)  
Combined Doctoral appointment  
**PhD Thesis:**  
"Incremental Approaches to the Combined Evolution of a Robot's Body and Brain"

**1998-1999** University of Sussex, Brighton, United Kingdom  
Cognitive and Computing Sciences Graduate Research Centre  
MSc, Evolutionary and Adaptive Systems  
Graduated with Distinction  
**MSc Thesis:**  
"Evolving Heterogeneity: Implications for Agent-Based Systems and Collective Problem Solving"

**1993-1997** McMaster University, Hamilton, Canada  
Department of Computer Science and Systems  
BSc Honours, Computer Science *Summa Cum Laude*

**August 1994** Oxford University, Oxford, United Kingdom  
Corpus Christi College / Detroit Mercy study abroad programme  
Equivalent of 4.0 GPA in British Literature

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### Publications

#### Books

1. Pfeifer, R. and J. Bongard (2006) ***How the Body Shapes the Way We Think: A New View of Intelligence***, Boston, MA: MIT Press. Times Cited: 183

#### Miscellaneous

2. Bongard, J. (2009). Biologically inspired computing. ***IEEE Computer***, 42(4): 95-98.
3. Bongard, J. (2008). Probabilistic Robotics Book Review. ***Artificial Life***, 14(2): 227-229.
4. Conduit, R., Adami, C., Lipson, H., Zykov, V. and Bongard, J. (2007). To sleep, perchance to dream. ***Science***, 315: 1219-1220.

## Journal Articles

5. Kaipa, K., Bongard, J., Meltzoff, A. (2010). A social robot that can imitate kinematically similar but visually different teachers. **Neural Networks**, in preparation. [Invited submission]  
ISI Impact Factor: 2.838
6. Bongard, J. C. (2010). Innocent until proven guilty: Reducing robot shaping from polynomial to linear time. **IEEE Transactions on Evolutionary Computation**, in review.  
ISI Impact Factor: 6.612
7. Bongard, J. C. (2010). The utility of evolving simulated robot morphology increases with task complexity for object manipulation. **Artificial Life**, in press.  
ISI Impact Factor: 1.9
8. Rughani, A., Dumont, T. M., Lu, Z., Bongard, J., Horgan, M. A., Penar, P. L., Tranmer, B. I. (2010). Use of an artificial neural network to predict head injury outcome. **Journal of Neurosurgery**, in press.  
ISI Impact Factor: 2.877
9. Bongard J. C. (2009). Accelerating self-modeling in cooperative robot teams. **IEEE Transactions on Evolutionary Computation**, 13(2): 321-332.  
ISI Impact Factor: 6.612
10. Bongard, J. and H. Lipson (2007) Automated reverse engineering of nonlinear dynamical systems, **Proceedings of the National Academy of Sciences**, 104(24): 9943-9948.  
ISI Impact Factor: 9.38                      Times Cited: 25
11. Bongard, J., V. Zykov and H. Lipson (2006) Resilient machines through continuous self-modeling, **Science**, 314: 1118-1121.  
ISI Impact Factor: 30.268                      Times Cited: 83
12. Kouchmeshky, B., W. Aquino, H. Lipson and J. Bongard (2006) Co-evolutionary strategy for structural damage identification using minimal physical testing, **International Journal for Numerical Methods in Engineering**, 69(5): 1085-1107.  
ISI Impact Factor: 2.303                      Times Cited: 8
13. Bongard, J. and H. Lipson (2005) Active coevolutionary learning of deterministic finite automata, **Journal of Machine Learning Research**, 6(Oct): 1651-1678.  
ISI Impact Factor: 5.881                      Times Cited: 27
14. Bongard, J. and H. Lipson (2005) Nonlinear system identification using coevolution of models and tests, **IEEE Transactions on Evolutionary Computation**, 9(4): 361-384.  
ISI Impact Factor: 6.612                      Times Cited: 43
15. Pfeifer, R., F. Iida and J. Bongard (2005) New robotics: design principles for intelligent systems, **Artificial Life, Special Issue on New Robotics, Evolution and Embodied Cognition**, 11(1-2): 99-120.  
ISI Impact Factor: 1.9                      Times Cited: 28

## Book Chapters

16. Bongard, J. C. (2010) Why morphology matters. **Horizons of Evolutionary Robotics**, in press.
17. Bongard, J. and R. Pfeifer (2003) Evolving complete agents using artificial ontogeny, in Hara, F. & R. Pfeifer, (eds.), **Morpho-functional Machines: The New Species (Designing Embodied Intelligence)**, Springer-Verlag, pp. 237-258.

## Peer-Reviewed Conference Publications

18. Lu, Z., Wu, X., Bongard, J. C. (2009) "Active Learning with Adaptive Heterogeneous Ensembles", to appear in *Proceedings of the International Conference on Data Mining*, Miami, FL.
19. Kaipa, K., Bongard, J. C., Meltzoff A. N. (2009) "Combined Structure and Motion Extraction from Visual Data Using Evolutionary Active Learning", *Proceedings of the 2009 Genetic and Evolutionary Computation Conference*, Montreal Canada.

20. Auerbach, J., Bongard, J. C. (2009) "Evolution of Functional Specialization in a Morphologically Homogeneous Robot", *Proceedings of the 2009 Genetic and Evolutionary Computation Conference*, Montreal Canada.
21. Auerbach, J., Bongard, J. C. (2009) "How Robot Morphology and Training Order Affect the Learning of Multiple Behaviors", *2009 IEEE Congress on Evolutionary Computation (IEEE CEC 2009)*, Trondheim, Norway.
22. Bongard, J. (2008) "Behavior Chaining: Incremental Behavior Integration for Evolutionary Robotics", *Artificial Life XI*, MIT Press, Cambridge, MA.
23. Bongard, J. (2007) "Synthesizing Physically-Realistic Environmental Models from Robot Exploration", *Advances in Artificial Life: 9th European Conference*, Springer-Verlag, Berlin, pp. 806-815.
24. Bongard, J. (2007) "Action-Selection and Crossover Strategies for Self-Modeling Machines", *Proceedings of the 9th Annual Conference on Genetic and Evolutionary Computation*, ACM Press, New York, NY, pp. 198-205.
25. Bongard, J. (2007) "Exploiting Multiple Robots to Accelerate Self-Modeling", *Proceedings of the 9th Annual Conference on Genetic and Evolutionary Computation*, ACM Press, New York, NY, pp. 214-221.
26. Lipson, H., J. Bongard, V. Zykov and E. Malone (2006) "Evolutionary Robotics for Legged Machines: From Simulation to Physical Reality", Arai, T. et al. (eds.), *Intelligent Autonomous Systems 9 (IAS-9)*, 11-18.
27. Bongard, J., V. Zykov and H. Lipson (2006) "Automated Synthesis of Body Schema using Multiple Sensor Modalities", *The Tenth International Conference on the Simulation and Synthesis of Living Systems (ALIFE10)*, 220-226.
28. Bongard, J. and H. Lipson (2005) "Automatic Synthesis of Multiple Internal Models Through Active Exploration", *AAAI Fall Symposium on Reactive to Anticipatory Cognitive Embodied Systems*, Arlington, VA, November 2005.
29. Bongard, J. and H. Lipson (2005) "'Managed Challenge' Alleviates Disengagement in Co-evolutionary System Identification", in *Proceedings of the 2005 Genetic and Evolutionary Computation Conference (GECCO)*, ACM, pp. 531-538.
30. White, P., V. Zykov and J. Bongard (2005) "Three Dimensional Stochastic Reconfiguration of Modular Robots", *Robotics: Science and Systems*, Cambridge, MA.
31. Bongard J. and Lipson H. (2005) "Reinventing the Wheel: Experiments in Evolutionary Geometry", *Late Breaking Papers of the 2005 Genetic and Evolutionary Computation Conference*, June, Washington DC.
32. Zykov, V., J. Bongard and H. Lipson (2005) "Co-evolutionary Variance Can Guide Physical Testing in Evolutionary System Identification", *The 2005 NASA/DoD Conference on Evolvable Hardware*, June, Washington DC, pp. 213-220.
33. Lipson, H. and J. Bongard (2004) "An Exploration-Estimation Algorithm for Synthesis and Analysis of Engineering Systems Using Minimal Physical Testing", in *Proceedings of the 2004 ASME Design Engineering Technical Conferences and Computer and Information in Engineering Conference*, Salt Lake City, UT.
34. Zykov, V., J. Bongard and H. Lipson (2004) "Evolving Dynamic Gaits on a Physical Robot", in *Late Breaking Papers for the 2004 Genetic and Evolutionary Computation Conference (GECCO)*, Seattle, WA.
35. Bongard, J. and H. Lipson (2004) "Once More Unto the Breach: Co-evolving a Robot and its Simulator", in *Proceedings of the Ninth International Conference on the Simulation and Synthesis of Living Systems (ALIFE9)*, pp. 57-62.
36. Bongard, J. and H. Lipson (2004) "Automated Robot Function Recovery after Unanticipated Failure or Environmental Change using a Minimum of Hardware Trials", in *Proceedings of the NASA/DoD Conference on Evolvable Hardware*, IEEE Computer Society, pp. 169-176.

37. Bongard, J. and H. Lipson (2004) "Automating Genetic Network Inference with Minimal Physical Experimentation Using Coevolution", in *Proceedings of the 2004 Genetic and Evolutionary Computation Conference (GECCO)*, Springer, pp. 333-345.
38. Bongard, J. and H. Lipson (2004) "Automated Damage Diagnosis and Recovery for Remote Robotics", in *Proceedings of the 2004 International Conference on Robotics and Automation (ICRA)*, Omnipress, pp. 3545-3550.
39. Bongard, J. (2002) "Evolved Sensor Fusion and Dissociation in an Embodied Agent", in *Proceedings of the EPSRC/BBSRC International Workshop on Biologically-Inspired Robotics: The Legacy of W. Grey Walter*, pp. 102-109.
40. Frutiger, D. R., Bongard, J. and F. Iida (2002) "Iterative Product Engineering: Evolutionary Robot Design", in Bidaud, P. & F. B. Amar (eds.), *Proceedings of the Fifth International Conference on Climbing and Walking Robots*, Professional Engineering Publishing, pp. 619-629.
41. Bongard, J. and R. Pfeifer (2002) "A Method for Isolating Morphological Effects on Evolved Behaviour", in Hallam, B., Floreano, D. et al (eds.), *Proceedings of the Seventh International Conference on the Simulation of Adaptive Behaviour (SAB2002)*, MIT Press, pp. 305-311.
42. Bongard, J. and R. Pfeifer (2002) "Relating Neural Network Performance to Morphological Differences in Embodied Agents", in *Proceedings of the Sixth International Conference on Cognitive and Neural Systems*, Boston, USA.
43. Bongard, J. (2002) "Evolving Modular Genetic Regulatory Networks", in *Proceedings of the IEEE 2002 Congress on Evolutionary Computation (CEC2002)*, IEEE Press, pp. 1872-1877.
44. Paul, C. and J. Bongard (2001) "The Road Less Travelled: Morphology in the Optimization of Biped Robot Locomotion", in *Proceedings of The IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS2001)*, Hawaii, USA.
45. Bongard, J. and C. Paul (2001) "Making Evolution an Offer It Can't Refuse: Morphology and the Extradimensional Bypass", in J. Keleman & P. Sosik (eds.), *Proceedings of the Sixth European Conference on Artificial Life*, (Springer-Verlag), pp. 401-412.
46. Bongard, J. and R. Pfeifer (2001) "Repeated Structure and Dissociation of Genotypic and Phenotypic Complexity in Artificial Ontogeny", in *Proceedings of the 2001 Genetic and Evolutionary Computation Conference*. San Francisco, CA: Morgan Kaufmann, pp. 829-836.
47. Bongard, J. and C. Paul (2000) "Investigating Morphological Symmetry and Locomotive Efficiency using Virtual Embodied Evolution", in *From Animals to Animats: The Sixth International Conference on the Simulation of Adaptive Behaviour*. (MIT Press) pp. 420-429.
48. Bongard, J. (2000) "Reducing Collective Behavioural Complexity through Heterogeneity", in *Artificial Life VII: Proceedings of the Seventh International Conference*. (MIT Press), pp. 327-336.
49. Bongard, J. (2000) "The Legion System: A Novel Approach to Evolving Heterogeneity for Collective Problem Solving", in R. Poli, W. Banzhaf et al (eds.), *Genetic Programming: Third European Conference*. (Springer-Verlag) pp. 25-37.
50. Bongard, J. (1999) "Coevolutionary Dynamics of a Multi-Population Genetic Programming System", in Floreano, D., J.-D. Nicoud & F. Mondada (eds.), *Proceedings of the Fifth European Conference on Artificial Life*. (Springer-Verlag) pp. 316-321.

### **Workshop Publications**

51. Lu, Z., Bongard, J. C. (2009) Exploiting Multiple Classifier Types with Active Learning *2009 Genetic and Evolutionary Computation Conference (GECCO 2009)*, Montreal Canada.
52. Bongard, J. C. (2009) The Impact of Jointly Evolving Robot Morphology and Control on Adaptation Rate. *2009 Genetic and Evolutionary Computation Conference (GECCO 2009)*, Montreal Canada.
53. Bongard, J. (2008) Embodied cognition: the other morphology. *The Neuromorphic Engineer*, DOI: 10.2417/1200812.1420.

54. Lungarella, M., Iida, F., Bongard, J. and Pfeifer, R. (2008) AI in the 21st century -- with historical reflections, Proceedings of the 50th Anniversary Summit of Artificial Intelligence, pp. 1-8.
55. Lu, Z., Rughani, A. I., Tranmer, B. I., Bongard, J. (2008) "Informative Sampling for Large Unbalanced Data Sets", 4th Workshop on Medical Applications of Genetic and Evolutionary Computation at GECCO 2008.

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#### Grants and Awards

Bongard J. (2007) New Faculty Fellowship, Microsoft Award, \$200,000, 2007—  
Bongard J. (2007) "Exploiting 'Like Me' Hypotheses for Learning Robots", NSF, \$192,391, 2007-2009  
Rizzo, D., Eppstein, M., Bongard, J., Goodnight, C., Stevens, L., Hoffman, J. Molofsky, J. (2007) "Complex Systems Modeling for Environmental Problem Solving", NSF, \$6,750,000, 2007-2010.

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#### Experience

**External reviewer:** The Austrian Science Fund (FWF), Austria's national scientific funding body

**Member, Editorial Board:** Evolutionary Computation Journal (MIT Press)

**Ad hoc reviewer:** Journal of Machine Learning Research, IEEE Transactions on Evolutionary Computation, IEEE Transactions on Robotics, Artificial Life, Adaptive Behavior, IEEE Transactions on Systems, Man, and Cybernetics, Journal of Neurorobotics, Neural Computation, PLoS ONE

**Co-organizer:** "The 50th Anniversary Summit of Artificial Intelligence: Trends and Challenges in the 21st Century", Monte Verita, Switzerland, summer 2006

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#### Teaching

**Instructor:**

Fall, 2006/07/08: *Software Engineering*, University of Vermont Computer Science Department

Spring, 2007/08/09: Human Computer Interaction, University of Vermont CS Department

Fall 2009: Embodied Cognition, University of Vermont Honors College

**Primary Graduate Advisor:** Zhenyu Lu, (PhD student, Jan 2007-present);  
Joshua Auerbach (PhD student, Jan 2008-present)

**Postdoctoral Advisor:** Kaipa Krishnanand (postdoctoral associate, Jan 2008-present)

**Mentor:** Over 50 undergraduate and graduate student projects, 2003-present.

**Leader:** Student workshop on embodied Artificial Intelligence, University of Ilmenau, 2002.

**Organizer and Instructor:**

(July, 2009) **Invited organizer**, Telluride Neuromorphic Cognition Engineering Workshop. Duties included: supervising PhD students and postdoctoral students interested in working with my research software. Providing a formal lecture and a series of informal tutorials on evolutionary robotics and embodied cognition.

(July, 2002) MIGROS Summer Course on Robotics and Artificial Intelligence, Zurich.

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#### Selected Invited Talks

(2002) **Invited lecture**, Center for Research in Cognitive Science, University of Sussex, UK

(2002) **Invited lecture**, Woods Hole Marine Biological Laboratory (host: [Jelle Atema](#))

(2002) **Invited lecture**, Artificial Intelligence Laboratory, Massachusetts Institute of Technology (host: [Rodney A. Brooks](#))

(2002) **Invited lecture**, Division of Cell Biology, Biozentrum, University of Basel, Switzerland. (Host: [Walter Gehrig](#))

(2003) **Keynote presentation**, EPSRC Network on Evolvability in Biological and Software Systems Symposium, Hertfordshire, UK

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(2004) **Invited lecture**, Department of Information Technology, University of Zurich, Switzerland

(August, 2007) **Invited lecture**, National Science Foundation's *Future Challenges for the Science of Learning* workshop

(October 12, 2007) **Invited lecture** at the IBM T. J. Watson Research Center.  
(October 26, 2007) **Invited lecture** for the Elder Education Enrichment group of Vermont.

(January 25, 2008) **Invited lecture** at Boston University as part of the NSF Science of Learning seminar series. (host: [Steve Grossberg](#))

(April, 2008) **Invited lecture**, The Capo Caccia Workshop toward Cognitive Engineering. (host: [Rodney Douglas](#))

(May, 2008) **Invited keynote address**, Genetic Programming Theory and Practice (GPTP)

(June, 2008) **Invited lecture**, Woods Hole Workshop on Computational Neuroscience (host: [Terrence Sejnowski](#))

(June, 2008) **Invited lecture**, Telluride Neuromorphic Engineering Workshop

(September, 2008) **Invited attendance**, National Academy of Engineering's U.S. Frontiers of Engineering Symposium

(October, 2008) **Invited attendance**, Workshop on the Fundamentals of Cognitive Dynamic Systems (host: [Simon Haykin](#))

(October, 2008) **Invited lecture**, Dartmouth Computer Science Colloquium (host: [Tanzeem Choudhury](#))

(February, 2009) **Invited lecture**, Pragyan technical festival, National Institute of Technology, Trichy, India. Lecture presented by video conference to ~100 undergraduate students. Past presenters included **Noam Chomsky**; co-presenters included **Nobel Laureate John C. Mather**.

(February, 2009) **Invited lecture**, Hughes Research Laboratories (Malibu, CA)

(March, 2009) **Invited lecture**, The Salk Institute (San Diego, CA) (host: [Terrence Sejnowski](#))

(March, 2009) **Invited lecture**, Rockwood Annual Memorial Lecture, University of California, San Diego (host: [Terrence Sejnowski](#))

(September, 2009) **Invited lecture**, Union College (Schenectady, New York)

(October, 2009) **Invited attendance**, Workshop on the State of Agent-Based Modeling in the Social Sciences (host: Scott Page, University of Michigan). Declined.

(October, 2009) **Invited lecture**, Workshop: Exploring New Horizons in Evolutionary Design of Robots, part of the IEEE-Intelligent Robotics and Systems Conference (host: Stephane Doncieux, Universite de Pierre et Marie Curie, France).

(October, 2009) **Invited lecture**, University of Massachusetts, Amherst.

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#### Selected Global Media Coverage

**Discover Magazine (cover article):** "When Robots Live Among Us" (June, 2008)  
**New Scientist:** "Self-aware' space rovers would be speedy explorers" (Sept. 21, 2007)  
**Esquire:** "Six Ideas that Will Change the World" (November 2007)  
**Nature News:** "Injured Robot Learns to Limp" (November 2006)  
**Science News:** "New Robot Shrugs Off Injury" (November 2006)  
**MIT Technology Review:** "Robotic Recovery" (November 2006)  
**Discovery Channel:** "Self-Aware Robots" (November 2006)  
**Forbes:** "New Robot Can Sense Damage, Recover" (November 2006)  
**USA Today:** "New Robot Can Sense Damage and Compensate" (November 2006)  
**Scientific American:** "Resilient Robot Hobbles Along, Even if Injured" (November 2006)  
**Die Zeit:** "The GOLEM in the machine" (January 2007)  
**New Scientist:** "Animals' grown from an artificial embryo" (August 2002)

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### Scholarships and Prizes

- 2008** Recipient of the UVM College of Engineering and Mathematical Sciences  
Milt Silveira Junior Faculty Award (\$2K prize)  
**2007** One of *MIT Technology Review's* TR35: The Top 35 Young Innovators under 35  
**2007** Microsoft New Faculty Fellowship (\$200K prize)  
**2002** Best Paper Award, Seventh Intl. Conf. on the Simulation of Adaptive Behaviour (SAB-2002)  
**1999** Santa Fe Institute Complex Systems Summer School alumnus  
**1993-1997** McMaster University Dean's Honour List

### Professional References

**1. Prof. Dr. Hod Lipson**

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**2. Prof. Dr. Rolf Pfeifer**

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Director, Artificial Intelligence Laboratory  
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Andreasstrasse 15  
8050 Zurich  
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**3. Andrew N. Meltzoff**

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Co-Director,  
UW Institute for Learning and Brain Sciences  
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**4. Prof. Dr. Phil Husbands**

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Professor of Computer Science and Artificial  
Intelligence  
Department of Informatics  
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**5. Prof. Dr. Wilkins Aquino**

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**6. Dr. Inman Harvey**

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Senior Lecturer in CS and AI  
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