

Curriculum Vitae

EDUARDO J. IZQUIERDO

PERSONAL DATA

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POSITIONS HELD

Aug. 2015 - present Assistant Professor
Cognitive Science Program
School of Informatics, Computing, and Engineering
Program in Neuroscience
Member, Indiana University Network Science Institute
Member, Center for Complex Networks and Systems Research
Indiana University Bloomington

2013 - 2015 Research Scholar
Cognitive Science Program, Indiana University. Bloomington, IN.

2012 - 2013 Visiting Assistant Professor
Cognitive Science Program, Indiana University. Bloomington, IN.

2010 - 2012 Research Scholar
Cognitive Science Program, Indiana University. Bloomington, IN.

2009 - 2010 Research Scholar
Institute of Neuroscience, University of Oregon. Eugene, OR.

2008 - 2009 Research Scholar
Centre for Systems Biology, University of Birmingham. Birmingham, UK.

EDUCATION

November, 2008 Ph.D. Computer Science and AI
Centre for Computational Neuroscience and Robotics
University of Sussex, Brighton, UK.
Dissertation title: *The dynamics of learning behavior: A situated, embodied, and dynamical systems approach.*

August, 2004 M.Sc. Intelligent Systems
University of Sussex, Brighton, UK.
Thesis title: *Evolving dynamical systems: Nearly neutral regions in continuous fitness landscapes.*
(Graduated with distinction)

August, 2002 B.S. Computer Engineering
Universidad Simon Bolivar
(graduated with honors)

AS EDITOR

1. Siqueiros JM, Froese T, Gerhenson C, Aguilar W, Sayama H, Izquierdo EJ (In Press) Special Issue: Artificial Life Conference. *Artificial Life* 24(1). MIT Press.
2. Gerhenson C, Froese T, Siqueiros JM, Aguilar W, Izquierdo EJ, Sayama H. (2016) Proceedings of the Artificial Life Conference. MIT Press. ISBN: 9780262339360.
3. Izquierdo, E.J. and Almeida e Costa, F. (2006) Special Issue on the dynamical systems approach to cognition. *Adaptive Behavior* 14(2).

JOURNAL AND PEER-REVIEWED CONFERENCE PROCEEDINGS

4. Rodriguez, N., Izquierdo, E.J., and Ahn, Y.Y. (Submitted) Optimal modularity arbitrates memory capacity of reservoir computers. *Nature Communications*.
5. Siqueiros JM, Froese T, Gerhenson C, Aguilar W, Sayama H, Izquierdo EJ (In Press) ALife and Society: Editorial Introduction to the Artificial Life Conference 2016 Special Issue. *Artificial Life* 24(1). MIT Press.
6. Olivares, E., Izquierdo, E.J., and Beer, R.D. (2017) Potential role of a ventral nerve cord central pattern generator in forward and backward locomotion in *Caenorhabditis elegans*. *Network Neuroscience*. Advance publication 10.1162/netn_a_00036.
7. Aguilera, M., Alquezar, C., and Izquierdo, E.J. (2017) Signatures of criticality in a maximum entropy model of the *C. elegans* brain during free behaviour. Proceedings of the 14th European Conference of Artificial Life. Lyon, France.
8. Candadai M.V., and Izquierdo, E.J. (2017) Information Bottleneck in Control Tasks with Recurrent Spiking Neural Networks. Proceedings of the 26th International Conference on Artificial Neural Networks. Sardinia, Italy.
9. Setzler M., and Izquierdo, E.J. (2017) Adaptability and Neural Reuse in Minimally Cognitive Agents. Proceedings of the 39th Annual Conference of the Cognitive Science Society. London, UK: Cognitive Science Society.
10. Candadai M.V., and Izquierdo, E.J. (2017) Evolution and Analysis of Embodied Spiking Neural Networks Reveals Task-Specific Clusters of Effective Networks. Proceedings of The Genetic and Evolutionary Computation Conference. Berlin, Germany: ACM.
11. Izquierdo, E.J., and Beer, R.D. (2016) The whole worm: brain–body–environment models of *C. elegans*. *Current Opinion in Neurobiology* 40:23–30. doi:10.1016/j.conb.2016.06.005.
12. Roberts WM, Augustine SB, Lawton KJ, Lindsay TH, Thiele TR, Izquierdo EJ, Faumont S, Lindsay RA, Britton MC, Pokala N, Bargmann CI, Lockery SR (2016) A stochastic neuronal model predicts random search behaviors at multiple spatial scales in *C. elegans*. *eLife* 2016;10.7554/eLife.12572.
13. Chen P, Evans T, Frisby M, Izquierdo EJ, Plale B. (2016). A Hybrid Approach to Population Construction For Agricultural Agent-Based Simulation. IEEE 12th International Conference on eScience. Baltimore, Maryland.
14. Izquierdo, E.J., Williams, P. and Beer, R.D. (2015) Information flow through the *C. elegans* klinotaxis circuit. *PLoS ONE* 10(10):e0140397. doi:10.1371/journal.pone.0140397.
15. Izquierdo, E.J. and Beer, R.D. (2015). An integrated neuromechanical model of steering in *C. elegans*. In the Proceedings of ECAL 2015 (pp. 199-206). MIT Press.
16. Izquierdo, E.J., Aguilera, M. and Beer, R.D. (2013). Analysis of ultrastability in small dynamical recurrent neural networks. In P. Lio, O. Miglino, G. Nicosia, S. Nolfi & M. Pavone (Eds.), *Advances in Artificial Life: ECAL 2013* (pp. 51-58).
17. Izquierdo, E.J., and Beer, R.D. (2013) Connecting a connectome to behavior: An ensemble of neuroanatomical models of *C. elegans* klinotaxis. *PLOS Computational Biology*.

18. Izquierdo, E.J., and Lockery, S.R. (2010) Evolution and analysis of minimal neural circuits for klinotaxis in *C. elegans*. *Journal of Neuroscience* 30:12908-12817.
19. Izquierdo, E.J., Harvey, I. and Beer, R.D. (2008) Associative learning on a continuum in evolved dynamical neural networks. *Journal of Adaptive Behavior*. Adaptive Behavior 16, 361-384.
20. Izquierdo, E.J. and Buhmann, T. (2008) Analysis of a dynamical recurrent neural network evolved for two qualitatively different tasks: Walking and chemotaxis. In S. Bullock, J. Noble, R. A. Watson, and M. A. Bedau (Eds.) *Proc. of the 11th Int. Conf. on Artificial Life*. MIT Press, Cambridge, MA. **Best student paper award.**
21. Izquierdo, E.J. and Fernando, C. (2008) The evolution of evolvability in gene transcription networks. In S. Bullock, J. Noble, R. A. Watson, and M. A. Bedau (Eds.) In S. Bullock, J. Noble, R. A. Watson, and M. A. Bedau (Eds.) *Proc. of the 11th Int. Conf. on Artificial Life*. MIT Press, Cambridge, MA.
22. Izquierdo, E.J. and Harvey, I. (2007) The dynamics of associative learning in an evolved situated agent. In Proc. of the 9th *European Conference on Artificial Life*. Springer-Verlag.
23. Fine, P., Di Paolo, E., and Izquierdo, E.J. (2007) Adapting to your body. In F. Almeida e Costa et al. (Eds.), *Advances in Artificial Life: Proceedings of the Ninth European Conference on Artificial Life* (pp. 203-211). Springer.
24. Froese, T., Virgo, N., and Izquierdo, E.J. (2007) Autonomy: a review and reappraisal. In F. Almeida e Costa et al. (Eds.), *Advances in Artificial Life: Proceedings of the Ninth European Conference on Artificial Life* (pp. 455-464). Springer.
25. Izquierdo, E.J. and Harvey, I. (2007) Hebbian learning using fixed weight evolved dynamical 'neural' networks. In H.A. Abbass et al (Eds.) *Proc. of the First IEEE Symposium on Artificial Life*. pp394-401. IEEE Press.
26. Izquierdo, E.J., and Harvey, I. (2006) Learning on a Continuum in Evolved Dynamical Node Networks. In L. Rocha et al. (Eds.) *Proceedings of the Tenth International Conference on the Simulation and Synthesis of Living Systems* (pp. 507-512). MIT Press.
27. Izquierdo, E.J., and Di Paolo, E. (2005) Is an embodied system ever purely reactive? In M. Capcarrere et al. (Eds.) *Advances in Artificial Life: Proceedings of the Eight European Conference on Artificial Life* (pp. 252-261). Springer-Verlag.
28. Izquierdo, E.J. (2004) The Role of Nearly Neutral Networks in the Evolution of Dynamical Neural Networks. In J. Pollack et al. (Eds.) *Proceedings of the Ninth International Conference on the Simulation and Synthesis of Living Systems* (pp. 322-327). MIT Press.

PEER-REVIEWED ABSTRACTS

1. Olivares, E.I., Izquierdo, E.J., and Beer, R.D. (2017). A CPG-driven neuromechanical model of forward locomotion in *C. elegans*. Society for Neuroscience Conference, 2017. Washington D.C.
2. Izquierdo, E.J., and Beer, R.D. (2017). Integrated neuromechanical model shows stretch-reception can generate and propagate wave responsible for forward locomotion. Society for Neuroscience Conference, 2017. Washington D.C.
3. Olivares, E.I., Izquierdo, E.J., and Beer, R.D. (2017). Connectome analysis shows the feasibility of ventral cord central pattern generators driving locomotion in *C. elegans*. 21st International *C. elegans* Conference. Los Angeles.
4. Izquierdo, E.J., and Beer, R.D. (2017). Integrated neuro-mechanical model shows stretch-reception can generate and propagate wave responsible for forward locomotion. 21st International *C. elegans* Conference. Los Angeles.
5. Olivares, E.I., Izquierdo, E.J., and Beer, R.D. (2017). From Connectome to Behavior: Circuit motifs that generate oscillations to drive forward and backward locomotion in *C. elegans*. NetSci 2017. Indianapolis.

6. Izquierdo, E.J., and Beer, R.D. (2017). From Connectome to Behavior: An Integrated Neuromechanical Model of Forward Locomotion in *C. elegans*. NetSci 2017. Indianapolis.
7. Izquierdo, E.J., and Beer, R.D. (2016). Propagation of rhythmic dorsoventral wave in a neuromechanical model of locomotion in *Caenorhabditis elegans*. Proceedings of the Artificial Life Conference 2016, Cancun, Mexico.
8. Setzler M, and Izquierdo, E.J. (2016). Evolvability of Minimally Cognitive Agents. Proceedings of the Artificial Life Conference 2016, Cancun, Mexico.
9. Izquierdo EJ, Beer RD (2015). Evolution and analysis of an integrated neuromechanical model of forward locomotion in *C. elegans*. 2015 Meeting Planner. Society for Neuroscience. Chicago.
10. Izquierdo, E.J., and Beer, R.D. (2014). Steering in *C. elegans*: An integrated neuromechanical model of klinotaxis. ESF-EMBO Flies, worms and robots: combining perspectives on minibrains and behaviors. Sant Feliu, Spain.
11. Izquierdo, E.J., and Beer, R.D. (2014). Information flow through a sensorimotor circuit: Spatial orientation in *C. elegans*. Computational and Systems Neuroscience Conference (COSYNE) 2014. Salt Lake City, Utah.
12. Izquierdo, E.J. and Lockery, S.R. (2009). A minimal neural network model of klinotaxis behavior in *C. elegans*. 17th International *C. elegans* meeting. University of California, Los Angeles.
13. Izquierdo, E.J., and Harvey, I. (2006). A situated, embodied and dynamical systems approach to understanding learning and memory. 50th Anniversary Summit of Artificial Intelligence. Switzerland, 9-14 July, 2006.
14. Izquierdo, E.J. and Harvey, I. (2005) Learning to discriminate between multiple possible environments: an imprinting scenario. In Workshop on *Memory and Learning Mechanisms in Autonomous Robotics* (ECAL 2005). Canterbury, UK.

OTHER

1. Izquierdo, E.J. (2012). Connectome of *Caenorhabditis elegans*. Standalone figure in Eric Kandel's *Principles of Neural Science*. Fifth edition. pp 1523-1524. McGraw-Hill.

SOFTWARE

C. elegans Connectome Explorer (work in collaboration with Thomas Buhrmann). First online tool that allows researchers in the community to explore the *C. elegans* connectome: <http://elegans.herokuapp.com>.

FUNDING

1. In Preparation: NSF CAREER Award. Due July 2018.
2. Pending:
 1. PI: "Optimizing Dynamical Recurrent Neural Networks for Multi-task Learning" Google Faculty Research Award. \$150,000. August 2018 - July 2019.
 2. PI: "RI: Small: Modulating Behavioral Building Blocks: Neuromechanical Model of the Forward/Backward Locomotion Switch in *C. elegans*" NSF/IIS, \$497,790.00, August 2018 - July 2021.
3. Rejected: PI: Mathematical Modeling of Living Systems Program from Simons Foundation. 5-year grant, \$100,000 per year. Applied Fall 2015.
4. Obtained:
 1. Co-PI: "RI: Small: An Ensemble of Neuromechanical Models of *C. elegans* Forward Locomotion", NSF/IIS, \$492,189. Sept. 2015 - 2018.
 2. Participated as a lead contributor: "RI: Small: BCSP: The Whole Worm: A Brain-Body-Environment Model of Nematode Chemotaxis", NSF/IIS, \$489,440. Oct. 2012 - 2015.

PROFESSIONAL ACTIVITIES

1. Reviewer for *Nature*, *Journal of Neuroscience*, *Frontiers Neurocience*, *Frontiers Physics*, *Frontiers Robotics and AI*, *Biological Cybernetics*, *Adaptive Behavior*, *Cognitive Systems Research*, *PLOS ONE*, *Journal of Neural Engineering*, *Symmetry*, *Entropy*, *Complexity Journal*.
2. On the Program Committee for *European Conference on Artificial Life 2017, 2015, 2007*; *Conference on Complex Systems 2017*; *Cognitive Science Conference 2017, 2016*; *Artificial Life 2018, 2016, 2014*; Worm's Neural Information Processing Workshop as part of the *Natural Information Processing Conference 2017* *Biologically Inspired Cognitive Architectures 2015*; *IEEE Congress on Evolutionary Computation 2009*.
3. On the Editorial Board of *Adaptive Behavior Journal* and *Frontiers in Robotics and AI Journal*.
4. Member of panel discussions at OpenWorm meetings. Dec, 2015. Jan, 2016.
5. Co-organizer for the International Conference of Artificial Life. ALife 2016. Cancun, Mexico. July 2016.
6. Co-Organizer of Dynamics of Learning Behavior and Neuromodulation Workshop. ECAL 2007. September 2007.
7. Organizer of the workshop Active Agents and their Environments as Dynamical Systems. ECAL 2005. September 2005.
8. Organizer of the workshop *Dynamical Systems approach to Life and Cognition* with the visit of Prof. Randall Beer to the University of Sussex, 8-9 March 2005.
9. Co-founder and organizer of the seminar groups: *activate.d* and *Life and Mind seminar group* as part of the Centre for Computational Neuroscience and Robotics in the University of Sussex.

TEACHING

1. Indiana University
 1. C105: Brains & Minds, Robots & Computers. Spring 2016, Fall 2016, Fall 2017.
 2. Q260/Q320: Computation in the Cognitive and Information Science. Spring 2013, Spring 2016, Spring 2017.
 3. Q530: Programming for Cognitive Sciences. Fall 2012, Fall 2016.
 4. Q700: Modeling Evolutionary, Adaptive, Cognitive Systems course. Fall 2015.
 5. Q230: Math and Logic for Cognitive Science. Fall 2012.
2. University of Oregon
 1. Teacher assistant for a Techniques in Computational Neuroscience course organized by Shawn Lockery. Spring 2009.
3. University of Sussex
 1. Teacher assistant for the Artificial Life course organized by Inman Harvey as part of the Master in Science Program in Evolutionary and Adaptive Systems. University of Sussex, U.K. Fall 2005, 2006, 2007.
 2. Teacher assistant for the Non-Symbolic Artificial Intelligence second year undergraduate course at the University of Sussex, U.K. Spring 2005, 2006, 2007.
 3. Teacher assistant for the Foundations of Computation first year undergraduate course at the University of Sussex, U.K. Fall 2007, 2008.

4. Voluntary teaching in the Homework Club. UNICEF program. Brighton, U.K. Fall 2007.

MENTORING

1. Current:

1. Erick Olivares. Postdoc in Cognitive Science Program. Spring 2016 - Current.
2. Madhavun Candadai Vasu. Graduate student in Cognitive Science Program. Advisor. Spring 2016-current.
3. Matt Setzler. Graduate student in Cognitive Science Program. Co-advisor. Research committee. Spring 2016-current.
4. Nathaniel Rodriguez. Graduate student in Complex Systems Program. Research committee. Spring 2016-current.
5. Derek Whitley. Graduate student in Complex Systems Program. Research committee. Summer 2017-current.
6. Jason Yoder. Graduate student in Complex Systems Program. Research committee. Summer 2017-current.
7. Zach Tosi. Graduate student in Informatics and Cognitive Science Program. Lab rotation. Research committee. Spring 2017.
8. Chelsea Campbell. Undergraduate student in Informatics and Cognitive Science. Cox Research Scholar. Research Project. Fall 2017-.
9. Alex DeCourcy. Undergraduate student in Informatics and Cognitive Science. Independent Research. Fall 2017.

2. Past:

1. Daniel Simpson (grad student in Bioinformatics program), lab rotation. Fall 2015. Research Assistant, Spring 2016.
2. Saber Sheybani. Graduate student in Intelligent Systems Engineering. Independent study. Spring 2017.
3. Miguel Aguilera (Visiting Research Scholar, Cognitive Science, Indiana University. Summer 2013). Supervising a project on analyzing ultrastability.
4. Marc Dillon (Undergraduate, Cognitive Science, Indiana University. Summer, 2012). Teaching to evolve and analyze dynamical neural networks.
5. Marc Dillon (Undergraduate, Cognitive Science, Indiana University. Fall, 2012). Supervising a project modeling klinokinesis in *Caenorhabditis elegans*.
6. Margaret Antonik (SPUR Undergraduate, Institute of Neuroscience, University of Oregon. Summer 2009). Teaching to build mathematical models of biological organisms.
7. Thomas Baker (M.Sc. dissertation. Evolutionary and Adaptive Systems. University of Sussex. 2006-2007) Dynamics of small recurrent neural networks with non-monotonic activation functions.

REFERENCES

1. Prof. Randall D. Beer. Cognitive Science, Indiana University.
2. Prof. Shawn Lockery. Institute of Neuroscience, Oregon University.
3. Prof. Ezequiel Di Paolo. Ikerbasque, Spain.
4. Prof. Inman Harvey. University of Sussex, UK.