

# Madhavun Candadai Vasu

Doctoral Candidate, Cognitive Science (Minor in Computer Science)  
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<https://github.com/madvn>

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## EDUCATION

- Indiana University, Bloomington** – GPA 4.0/4.0 Aug 2015 – May 2020  
Doctoral candidate, Ph.D. in Cognitive Science, minor in Computer Science  
Advisor: Dr. Eduardo J. Izquierdo  
Awarded Cognitive Science Research Award for dissertation research
- University of Cincinnati** – GPA 3.98/4.0 Aug 2012 – Mar 2015  
Master of Science, Electrical Engineering  
Advisor: Dr. Ali A. Minai
- Amrita School of Engineering, India** – GPA 8.16/10.0 Jul 2007 – Aug 2011  
Bachelor of Technology, Electronics and Communication Engineering

## CORE SKILLS

- Python (Tensorflow)
- C++
- MATLAB
- Scientific Writing
- Artificial Neural Networks
- Deep (Reinforcement) Learning
- ROS
- Evolutionary Algorithms
- Multivariate data analysis
- Information Theory
- Dynamical Systems Theory
- Time-series analysis

## RESEARCH AND WORK EXPERIENCE

**Artificial Intelligence Research Scientist** Jun 2020 – Present  
PATH ROBOTICS, COLUMBUS, OH

- Responsible for expanding the company's machine perception and machine learning capabilities for robotic automation of welding and other manufacturing processes.
- Designing and implementing neural and non-neural algorithms, including deep and reinforcement learning algorithms for robotic perception and control.
- Working hands-on on entire pipeline from research to testing in simulation to implementation on robots.

**Doctoral Candidate, Advisor: Dr. Eduardo J. Izquierdo** Aug 2015 – May 2020  
INDIANA UNIVERSITY, BLOOMINGTON

- Doctoral research topic: Bits from Behaviors: Understanding Function Using Information in Embedded, Embodied, and Dynamical Neural Networks
- Optimized neural networks (deep, recurrent and dynamical) to perform a variety of tasks using evolutionary and reinforcement learning algorithms
  - Analyzed optimized networks using statistical and information theoretic tools to develop an understanding of how they operate.
  - Demonstrated that the same neural network can manifest itself as distinct yet overlapping functional networks during the course of performing different tasks (Candadai & Izquierdo, 2017)
  - Demonstrated that neural resources can be reused among multiple tasks down to the level of transient neural dynamics i.e. same neural activity can produce different behaviors (Candadai & Izquierdo, 2018)
  - Extended existing methods to identify the source of information encoded in neural networks: externally provided by the environment versus generated internally (Candadai & Izquierdo, 2020)

## Other research activities:

- Initiated a cross-functional collaboration with Dr. Tom Froese on a project that demonstrated the significant impact of social interaction on neural network dynamics (Candadai et. al., 2019)
- Co-advised two undergraduate students that led to two research papers in international conferences (Abe et. al., 2020 & Todd et. al., 2020)
- Co-advised a summer research student on a data analytics project that won the Wells-Fargo data science contest, and the people's choice best poster prize at the School of Informatics spring 2019 symposium
- Associate instructor to "Introduction to Python", "Math and Logic", "Neural networks and the brain" and "Computational modeling for Cognitive Scientists".

## Summer Research Intern

May 2018 – Aug 2018

### INTEL A.I. LABS

- Investigated information theoretic properties of unsupervised learning of disentangled representations using beta-variational auto-encoders for camera inputs to robotic applications
- Identified impediments to hierarchical reinforcement learning by systematically studying learning outcomes under different goal space designs (Dwiel, Candadai et. al., 2019, ICLR)
- Contributed to the team that participated in the WUR Autonomous Greenhouse Challenge
- Demonstrated the ability of DDPG to train flexible robots and characterized its informational requirements (Dwiel, Candadai et. al., 2019, IROS)

## Graduate Research Assistant, Advisor: Dr. Ali A. Minai

Aug 2014 – Mar 2015

### UNIVERSITY OF CINCINNATI

- Developed a recurrent neural network attractor model that outperformed other benchmarks for unsupervised keyword detection in text-corpora (Candadai et. al., 2015, IJCNN)
- Utilized Python NLTK to parse corpora and custom implementations of Hopfield networks to build the networks
- Teaching assistant to "Software engineering", "Intelligent systems" and "Probability and random processes".

## Student Researcher

Aug 2014 – Mar 2015

### CINCINNATI CHILDREN'S HOSPITAL MEDICAL CENTER

- Constructed structural and functional brain networks from DTI data using FSL, and Diffusion Toolkit
- Modeled developmental changes in the functional network to construct age appropriate human brain atlases

## Associate System Engineer

Jul 2011 – Jul 2012

### IBM

- Designed and development of a Web Portal for an international insurance firm as part of the GBS team
- Utilized HTML/JSP for front end, Java for business layer and Web Services over SOAP to interact between them

## AWARDS & FUNDING

- Cognitive Science Research Award 2020
- NSF Research Traineeship affiliate, Complex Networks and Systems 2019
- Supplemental Research Fellowship, Indiana University 2017 & 2018
- Outstanding Graduate Teaching Award 2017 – 18
- ACM Graduate student travel grant to present at GECCO'17 2017
- Graduate Fellowship, Indiana University 2015 – 16
- University Graduate Scholarship, University of Cincinnati 2012 – 14
- RevolutionUC Hackathon – 2<sup>nd</sup> place – Quick Pick: intelligent restaurant recommendations 2014

## TALKS

1. (2019, May) Disentangling sources of predictive coding in embodied agents. Midwestern Cognitive Science Conference, Cognitive Science Society.
2. (2018, April) Information theoretic exploration of the neural basis of behavior. Intelligent and Interactive Systems Seminar, School of Informatics, Computing and Engineering, Indiana University, Bloomington.

## PUBLICATIONS

### Computational Neuroscience / Cognitive Science

1. **Candadai, M.**, Izquierdo, E.J. Sources of predictive information in dynamical neural networks. *Nature, Scientific Reports* 10, 16901 (2020). [[pdf](#)]
2. **Candadai, M.**, Setzler, M., Izquierdo, E. J., & Froese, T. (2019). Embodied dyadic interaction increases complexity of neural dynamics: A minimal agent-based simulation model. *Frontiers in Psychology*. [[pdf](#)]
3. **Candadai, M.**, & Izquierdo, E. J. (2018, May) Multifunctionality in embodied agents: Three levels of neural reuse. 40<sup>th</sup> *Cognitive Science Conference*. (Oral presentation) [[pdf](#)]
4. **Vasu, M. C.**, & Izquierdo, E. J. (2017, September). Information Bottleneck in Control Tasks with Recurrent Spiking Neural Networks. In *International Conference on Artificial Neural Networks (ICANN)* (pp. 236-244). Springer, Cham. (Oral presentation) [[pdf](#)]
5. **Vasu, M. C.**, & Izquierdo, E. J. (2017, July). Evolution and analysis of embodied spiking neural networks reveals task-specific clusters of effective networks. In *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO)* (pp. 75-82). ACM. (Oral presentation) [[pdf](#)]  
*Nominated for Best Student Paper, 2017 by International Society of Artificial Life – Student chapter.*

### Machine Learning / Artificial Intelligence

6. Leite, A., **Candadai, M.**, & Izquierdo, E. J. (2020, July). Reinforcement learning beyond the Bellman equation: Exploring critic objectives using evolution. In *Artificial Life Conference Proceedings* (pp. 441-449). [[pdf](#)]
7. Todd, G., **Candadai, M.**, & Izquierdo, E. J. (2020, July). Interaction between evolution and learning in nk fitness landscapes. In *Artificial Life Conference Proceedings* (pp. 761-767). [[pdf](#)]
8. Dwiell, Z.\*, **Candadai, M.\***, Phielipp, M. (2019, November). On Training Flexible Robots using Deep Reinforcement Learning. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. [[pdf](#)] (\* Equal contribution)
9. Dwiell, Z., **Candadai, M.**, Phielipp, M., Bansal, A. (2019, May) Hierarchical Policy Learning is sensitive to goal space design. *Task-Agnostic Reinforcement Learning (TARL) workshop, International Conference on Learning Representations (ICLR)*. [[pdf](#)]
10. **Candadai, M.**, Vanarase, A., Mei, M., & Minai, A. A. (2015, July). ANSWER: An unsupervised attractor network method for detecting salient words in text corpora. In *Neural Networks (IJCNN)*, 2015 (pp. 1-8). IEEE. [[pdf](#)]

### Tools

11. **Candadai, M.**, & Izquierdo, E. J., (2020). infotheory: A C++/Python package for multivariate information theoretic analysis. *Journal of Open Source Software (JOSS)*, 5(47), 1609. [[repo/site](#)]

## ABSTRACTS & POSTERS

1. **Candadai, M.**, Izquierdo, E. J. (2019, October) Information dynamics in embodied multifunctional recurrent neural networks. *Society for Neuroscience Annual Meeting (SfN)*.
2. **Candadai, M.**, & Izquierdo, E. J. (2019, March) On the Role of Predictive Coding in Adaptive Behavior. *Greater Indiana, Society for Neuroscience Meeting*.
3. **Vasu, M. C.**, & Izquierdo, E. J. (2018, March) Multifunctionality from Brain-Body-Environment Interaction: An Information and Dynamical Systems Theoretic Account. *Greater Indiana, Society for Neuroscience Meeting*.

## OUTREACH AND VOLUNTEERING

### Indiana University Science Fest

Built robotic models of animal behavior to nurture interest in STEM education among middle schoolers. 2019

### Association for India's Development (AID), Secretary, Cincinnati chapter

Raised ~\$16000 towards children's education, women's health and vaccination in India. 2015