

# Nicholas Waytowich

## Curriculum Vitae

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## Professional Experience

- 2022–Present **Lead Scientist, Human-Guided Machine Learning Branch, Human Research and Engineering Directorate (HRED), U.S. Army Research Laboratory, Maryland.**  
Researching human-guided AI/ML algorithms to improve deep-reinforcement learning.
- 2023–Present **Adjunct Professor, Anne Arundel Community College, Maryland.**  
Teaching various engineering classes
- 2017–2022 **Machine Learning Research Scientist, Human Research and Engineering Directorate (HRED), U.S. Army Research Laboratory, Maryland.**  
Researching machine learning, human-agent teaming, multi-agent systems and deep-reinforcement learning.
- 2019–2020 **CEO and Co-Founder, AIMS-Technologies, LLC.**  
CEO and co-founder of a start-up company (Aerial Interception of Multirotor Systems (AIMS) Technologies) to research and develop new capabilities to detect and counter non-cooperative, small unmanned aerial systems (sUAS)
- 2017–2020 **Adjunct Associate Research Scientist, Columbia University, New York.**  
Researching novel AI/ML methods for Brain-Computer Interfaces
- 2015–2017 **Postdoctoral Research Fellow, Laboratory for Intelligent Imaging and Neural Computing (LIINC), Columbia University, New York.**  
Researched the neural correlates of adaptation during longitudinal feedback from brain-computer interfaces and designing novel transfer learning algorithms for real-world neuro-imaging paradigms.
- 2015–2017 **Postdoctoral Research Fellow, Human Research and Engineering Directorate (HRED), U.S. Army Research Laboratory, Maryland.**  
Focused on the design and implementation of heterogeneous, multi-agent systems of human and computer agents for collaborative machine learning.
- 2010–2015 **Graduate Research Assistant, Advanced Signal Processing in Engineering and Neuroscience Lab - ODU, Norfolk.**  
Developed novel signal processing and machine learning algorithms for non-invasive and visual based brain-computer interfaces to aid individuals with severe neuromuscular disorders.
- 2008–2010 **Research Assistant, Brain-Computer Interface Lab, University of North Florida, Jacksonville.**  
Developed novel brain-computer interface applications to control anthropomorphic manipulator arms for neuroprosthetic control.

## Education

- 2013-2015 **Ph.D. Biomedical Engineering, Old Dominion University, Norfolk VA.**  
Specialization in Brain-Computer Interfaces and Machine Learning
- 2011–2013 **Masters in Electrical and Computer Engineering, Old Dominion University, VA.**  
Specialization in Signal Processing and Machine Learning
- 2006–2010 **B.S. Mechanical Engineering, University of North Florida, Jacksonville FL.**  
Specialization in Robotics

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## Research and Teaching Interests

- Human-Guided Machine Learning
- Human-in-the-loop Reinforcement Learning
- Brain-Computer Interfaces
- Human-Agent Teaming
- Machine Learning & Artificial Intelligence
- Deep Learning
- Robotics
- Multi-Agent Systems

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## Ph.D. Dissertation

Title *Development of a Practical Visual Evoked Potential Based Brain-Computer Interface*

Advisor Dean J. Krusienski

Description Optimized visual stimulus design and developed novel paradigmatic approaches to create a practical visual evoked potential based brain-computer interface. Additionally, a custom BCI software platform was developed and implemented with the Google Glass (HMD device) for ergonomic deployment.

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## Teaching and Mentoring Experience

2023–Present **ORAU Student Mentor/Advisor**, *Army Research Laboratory*.

Currently mentor several undergraduate, and graduate students each year through OakRidge Associated Universities (ORAU) on various projects related to machine learning, reinforcement learning, robotics and human-in-the-loop AI

2018–Present **ORAU Student Mentor/Advisor**, *Army Research Laboratory*.

Currently mentor several undergraduate, and graduate students each year through OakRidge Associated Universities (ORAU) on various projects related to machine learning, reinforcement learning, robotics and human-in-the-loop AI

2008–2010 **Teaching Assistant/Laboratory Instructor**, *Robotics Laboratory, University of North Florida*.

Managed UNF's Robotics and Manufacturing laboratory and taught the Robotics lab for the Introduction to Robotics course at UNF. Responsibilities included the development, preparation and teaching of weekly lectures and laboratory exercises

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## Peer-Reviewed Publications

2023 César-Tondreau, Brian and Warnell, Garrett and Kochersberger, Kevin and **Waytowich, Nicholas**. "Negative Obstacle Traversal of Physical Ground Robots via Imitation Learning Based Control". In: *Robotics and Autonomous Systems*, 2023

2022 **Waytowich, Nicholas** and Hare, James and Goecks, Vinicius G and Mittrick, Mark and Richardson, John and Basak, Anjon and Asher, Derrick E. "Learning to guide multiple heterogeneous actors from a single human demonstration via automatic curriculum learning in StarCraft II". In: *SPIE: Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications IV*, 2022

Khatwani, Mohit and Rashid, Hasib-Al and Paneliya, Hirenkumar and Horton, Mark and Homayoun, Houman and **Waytowich, Nicholas** and Hairston, W David and Mohsenin, Tinoosh. "A Flexible Software-Hardware Framework for Brain EEG Multiple Artifact Identification". In: *Handbook of Biochips*, 2022

Watkins-Valls, David and Allen, Peter K and Maia, Henrique and Seshadri, Madhavan and Sanabria, Jonathan and **Waytowich, Nicholas** and Varley, Jacob. "Mobile manipulation leveraging multiple views". In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*

Goecks, Vinicius G and **Waytowich, Nicholas** and Asher, Derrik E and Jun Park, Song and Mittrick, Mark and Richardson, John and Vindiola, Manuel and Logie, Anne and Dennison, Mark and Trout, Theron and others. "On games and simulators as a platform for development of artificial intelligence for command and control". In: *The Journal of Defense Modeling and Simulation*, 2022

Shiri, Aidin and Kallakuri, Uttej and Rashid, Hasib-Al and Prakash, Bharat and **Waytowich, Nicholas R** and Oates, Tim and Mohsenin, Tinoosh. "E2hrl: An energy-efficient hardware accelerator for hierarchical deep reinforcement learning". In: *ACM Transactions on Design Automation of Electronic Systems (TODAES)*, 2022

Shah, Rohin and Wang, Steven H and Wild, Cody and Milani, Stephanie and Kanervisto, Anssi and Goecks, Vinicius G and **Waytowich, Nicholas** and Watkins-Valls, David and Prakash, Bharat and Mills, Edmund and others. "Retrospective on the 2021 BASALT Competition on Learning from Human Feedback". In: *Proceedings of Machine Learning Research (PLMR), NeurIPS 2021 Competitions and Demonstrations Track*, 2022

Basak, Anjon and Zaroukian, Erin G and Corder, Kevin and Fernandez, Rolando and Hsu, Christopher D and Sharma, Piyush K and **Waytowich, Nicholas R** and Asher, Derrik E. "Utility of doctrine with multi-agent RL for military engagements". In: *SPIE: Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications IV*, 2022

César-Tondreau, Brian and Warnell, Garrett and Kochersberger, Kevin and **Waytowich, Nicholas**. "Towards fully autonomous negative obstacle traversal via imitation learning based control". In: *MDPI: Robotics*, 2022

Jayarajah, Kasthuri and Gangopadhyay, Aryya and **Waytowich, Nicholas**. "TagTeam: Towards wearable-assisted, implicit guidance for human-drone teams". In: *Proceedings of the 1st ACM Workshop on Smart Wearable Systems and Applications*, 2022

Navardi, Mozghan and Shiri, Aidin and Humes, Edward and **Waytowich, Nicholas R** and Mohsenin, Tinoosh. "An optimization framework for efficient vision-based autonomous drone navigation". In: *IEEE 4th International Conference on Artificial Intelligence Circuits and Systems (AICAS)*, 2022

Shiri, Aidin and Navardi, Mozghan and Manjunath, Tejaswini and **Waytowich, Nicholas R** and Mohsenin, Tinoosh. "Efficient Language-Guided Reinforcement Learning for Resource-Constrained Autonomous Systems". In: *IEEE Micro*, 2022

Prakash, Bharat and **Waytowich, Nicholas** and Oates, Tim and Mohsenin, Tinoosh. "Towards an interpretable hierarchical agent framework using semantic goals". In: *NeurIPS Workshop on Language and Reinforcement Learning (LaReL)*, 2022

2021 Goecks, Vinicius G and **Waytowich, Nicholas** and Watkins, David and Prakash, Bharat. "Combining learning from human feedback and knowledge engineering to solve hierarchical tasks in minecraft". In: *AAAI MAKE*, 2021

Schaefer, Kristin E and Perelman, Brandon and Rexwinkle, Joe and Canady, Jonroy and Neubauer, Catherine and **Waytowich, Nicholas** and Larkin, Gabriella and Cox, Katherine and Geuss, Michael and Gremillion, Gregory. "Human-autonomy teaming for the tactical edge: the importance of humans in artificial intelligence research and development". In: *Systems Engineering and Artificial Intelligence*, 2021

- Shiri, Aidin and Prakash, Bharat and Mazumder, Arnab Neelim and **Waytowich, Nicholas R** and Oates, Tim and Mohsenin, Tinoosh. "An energy-efficient hardware accelerator for hierarchical deep reinforcement learning". In: *2021 IEEE 3rd International Conference on Artificial Intelligence Circuits and Systems (AICAS)*, 2021
- Shiri, Aidin and Mazumder, Arnab Neelim and Prakash, Bharat and Homayoun, Houman and **Waytowich, Nicholas R** and Mohsenin, Tinoosh. "A Hardware Accelerator for Language-Guided Reinforcement Learning". In: *IEEE Design & Test*, 2021
- Khatwani, Mohit and Rashid, Hasib-Al and Paneliya, Hirenkumar and Horton, Mark and **Waytowich, Nicholas** and Hairston, W David and Mohsenin, Tinoosh. "A flexible multichannel eeg artifact identification processor using depthwise-separable convolutional neural networks". In: *ACM Journal on Emerging Technologies in Computing Systems (JETC)*, 2021
- Manjunath, Nitheesh Kumar and Shiri, Aidin and Hosseini, Morteza and Prakash, Bharat and **Waytowich, Nicholas R** and Mohsenin, Tinoosh. "An Energy Efficient EdgeAI Autoencoder Accelerator for Reinforcement Learning". In: *IEEE Open Journal of Circuits and Systems*, 2021
- 2020 Aidin Shiri, Arnab Neelim Mazumder, Bharat Prakash, Nitheesh Kumar Manjunath, Houman Homayoun, Avesta Sasan, **Nicholas R Waytowich**, Tinoosh Mohsenin. "Energy-Efficient Hardware for Language Guided Reinforcement Learning". In: *Proceedings of the 2020 on Great Lakes Symposium on VLSI*, 2020
- Addison W Bohannon, Vernon J Lawhern, **Nicholas R Waytowich**, Radu V Balan. "The Autoregressive Linear Mixture Model: A Time-Series Model for an Instantaneous Mixture of Network Processes". In: *IEEE Transactions on Signal Processing*, 2020
- D. Watkins-Valls, J. Xu, **Nicholas Waytowich**, P. Allen, "Learning your way without a map or compass: Panoramic target driven visual navigation". In: *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2020
- D. Ramesh, AZ Liu, AJ Echeverria, JY Song, **Nicholas Waytowich**, WS Lasecki. "Yesterday's Reward is Today's Punishment: Contrast Effects in Human Feedback to Reinforcement Learning Agents". In: *Proceedings of the 19th International Conference on Autonomous Agents and MultiAgent Systems*, 2020
- 2019 **Nicholas Waytowich**, Sean L. Barton, Vernon Lawhern, Ethan Stump, Garrett Warnell. "A Narration-based Reward Shaping Approach using Grounded Natural Language Commands". In: *International Conference on Machine Learning (ICML) Workshop on Imitation, Intent and Interaction*, 2019
- Nicholas Waytowich**, Sean L. Barton, Vernon Lawhern, Ethan Stump, Garrett Warnell. "Grounding Natural Language Commands to StarCraft II Game States for Narration Guided Reinforcement Learning". In: *Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications, SPIE 2019*, 2019.
- Bharat Prakash, Mark Horton, **Nicholas Waytowich**, William David Hairston, Tim Oats, Tinoosh Mohensin "On the Use of Deep Autoencoders for Efficient Embedded Reinforcement Learning", March 2019
- Bharat Prakash, Mohit Khatwani, **Nicholas Waytowich**, Tinoosh Mohensin, "Improving Safety in Reinforcement Learning Using Model-Based Architectures and Human Interventiong", March 2019

Sean L. Barton, **Nicholas Waytowich**, Erin Zaroukian, Derrik Asher, “Measuring Collaborative Emergent Behavior in Multi-agent Reinforcement Learning”

Vinicius G. Goecks, Gregory M. Gremillion, Vernon J Lawhern, John Valasek, and **Nicholas R. Waytowich**. “Efficiently Combining human demonstrations and interventions for safe training of autonomous systems in real-time”. *Association for the Advancement of Artificial Intelligence 2019* February, 2019.

- 2018 **Nicholas Waytowich**, Vernon Lawhern, Javier Garcia, Jennifer Cummings, Josef Faller, Paul Sajda, and Jean Vettel. “Compact Convolutional Neural Networks for Classification of Asynchronous Steady-state Visual Evoked Potential”. In: *Journal of Neural Engineering*, 2018

**Nicholas R. Waytowich**, Vinicius G. Goecks and Vernon J. Lawhern. “Cycle-of-Learning for Autonomous Systems from Human Interaction”. *AAAI Fall symposium on AI-HRI* October 2018.

Warnell, Garrett, **Nicholas Waytowich** , Vernon Lawhern, and Peter Stone. “Deep TAMER: interactive Agent Shaping in High-Dimensional State Space”. In: *Association for the Advancement of Artificial Intelligence 2018* February, 2018.

- 2017 **Nicholas Waytowich** , Yusuke Yamani, and Dean Krusienski. “Optimization of Checkerboard Spatial Frequencies for Steady-State Visual Evoked Potential Brain-Computer Interfaces”. In: *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, June, 2017.

**Nicholas Waytowich** and Dean Krusienski. “Development of an extensible SSVEP-BCI Software Platform and Application to Wheelchair Control”. In: *Neural Engineering (NER), 2017 6th International IEEE/EMBS Conference*, 2017.

- 2016 Lawhern, Vernon, Amelia Solon, **Nicholas Waytowich** , Steven Gordon, Chou Hung, and Brent Lance. “EEGNet: A Compact Convolutional Network for EEG-based Brain-Computer Interfaces”. In: *Journal of Neural Engineering*, November, 2016.

Nicholas Waytowich , Vernon Lawhern, Addison Bohannon, and Kenneth Ball. “Spectral Transfer Learning using Information Geometry for a User-Independent Brain-Computer Interface”. In: *Frontiers of Neuroscience: Neuroprosthetics* September, 2016.

Saprou, Sameer, Josef Faller, Victor Shih, **Nicholas Waytowich** , Addison Bohannon, Vernon Lawhern, Brent Lance, and David Jangraw. “Cortically coupled computing: A new paradigm for synergistic human-machine interaction”. In: *IEEE Computer* September, 2016.

**Nicholas Waytowich** and Dean Krusienski. “Multiclass Steady-State Visual Evoked Potential Frequency Evaluation Using Chirp-Modulated Stimuli”. In: *IEEE Transactions on Human-Machine Systems* February, 2016.

Wang, Haiqiang, Yu Zhang, **Nicholas Waytowich** , Dean Krusienski, Guoxu Zhou, Jing Jin, Xingyu Wang, and Andrzej Cichocki. “Discriminative Feature Extraction via Multivariate Linear Regression for SSVEP-based BCI”. In: *IEEE Transactions on Neural Systems and Rehabilitation Engineering* February, 2016.

**Nicholas Waytowich** , Josef Faller, Javier Garcia, Jean Vettel, and Paul Sajda. “Unsupervised adaptive transfer learning for Steady-State Visual Evoked Potential brain-computer interfaces”. In: *IEEE International Conference on Systems, Man and Cybernetics (SMC)* October, 2016.

Bohannon, Addison, **Nicholas Waytowich** , Vernon Lawhern, Brian Sadler, and Brent Lance. "Collaborative image triage with humans and computer vision". In: *IEEE International Conference on Systems, Man and Cybernetics (SMC)* October, 2016.

- 2015 **NR Waytowich** and DJ Krusienski. "Spatial Decoupling of Targets and Flashing Stimuli for Visual Brain-Computer Interfaces". In: *Journal of Neural Engineering*. April, 2015.
- 2014 NR Waytowich and DJ Krusienski. "Novel Characterization of the Steady-State Visual Evoked Potential Spectrum of EEG." In: *BrainKDD: International Workshop on Data Mining for Brain Science*, 2014.
- 2011 GJ Johnson, **NR Waytowich** , and DJ Krusienski. "The Challenges of Using Scalp-EEG Input Signals for Continuous Device Control". In: *Foundations of Augmented Cognition. Directing the Future of Adaptive Systems*, 2011
- 2010 **NR Waytowich** , A Henderson, DJ Krusienski, and DJ Cox. "Robotic application of a brain computer interface to Staubli TX40 robots - early stages". In: *World Automation Congress (WAC)*, 2010 , p. 6.

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## Honors, Awards, Societies and Service

- 2021 Won 1st place and the award for the most human-like agent at the NeurIPS 2021 MineRL Benchmark for Agents that Solve Almost-Lifelike Tasks (BASALT) competition.
- 2018 Winner of the Counter-sUAS Hackathon hosted by MD5 and the Army Futures Command, Austin Texas
- 2018 Human Research and Engineering (HRED) Excellence in Science award for the development Deep-TAMER (teaching agents manually through evaluative reinforcement), Army Research Lab.
- 2017 Human Research and Engineering (HRED) Excellence in Engineering award for the development of the Human-AI Image Labeler (HAIL), Army Research Lab.
- 2012 Graduate Assistantship In Areas of National Need (GAANN) Scholarship Award Recipient (2012)
- 2011-Present Member of Association for the Advancement of Artificial Intelligence (AAAI), IEEE Member, Society for Neuroscience, American Society of Mechanical Engineers
- 2009-2010 President of the Florida Engineering Society at the University of North Florida Chapter
- 2010 1st place regional winner of the MATE ROV (Marine Advanced Technology Education for Remotely Operated Vehicles) Competition in Coco Beach FL

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## Skills

- Research Machine Learning and Reinforcement Learning, Multi-agent systems, Deep Convolutional Neural Networks, Signal Processing, Reinforcement Learning, EEG Signal Mapping and Characterization, BCI Development, Data Mining and Visualization
- Programming Tensorflow, PyTorch, Python, ROS, Matlab, C, C++, C#, Java, Android, .NET, HTML, Javascript, OpenGL, DirectX, XNA,  $\LaTeX$ , OpenOffice, Linux, Embedded Systems, Microcontroller Programming