Small: Multi-Human Assisted Learning for Multi-Agent Systems using Intrinsically Generated Event-Related EEG Potentials

Dr. Raghupathy Sivakumar (PI), Dr. Faramarz Fekri (Co-PI)
Georgia Institute of Technology

http://gnan.ece.gatech.edu/brain

- Human-assisted Machine Learning: Provide rich reward functions to machine learning algorithms in a CPS that are generated by a human-in-the-loop while minimizing the burden on the human
- Intrinsic human feedback is captured using EEG based brain waves, inspired by a high-level error-processing system in humans that generates error-related potential/negativity (ErrP)
- Superiority of EEG-based intrinsic human feedback to manual feedback in terms of labeling accuracy and user comfort is demonstrated
- Transfer learning of error potentials (ErrP) is explored across RL agent movements, environments, and users

Key Challenges:

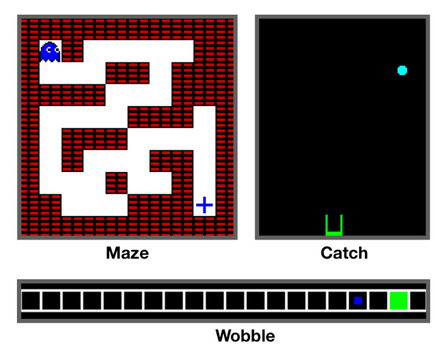
- Using a game as a proxy for CPS
- Capturing/Decoding intrinsic EEG feedback
- Generalizing ErrP over unseen environments
- Data-efficient RL assisted by ErrP
- Reducing stochasticity of decoded ErrP
- Diminishing the effect of wrongly decoded ErrP labels on the RL algorithm
- Reducing the number of queries to human feedback to reduce burden on a human observer

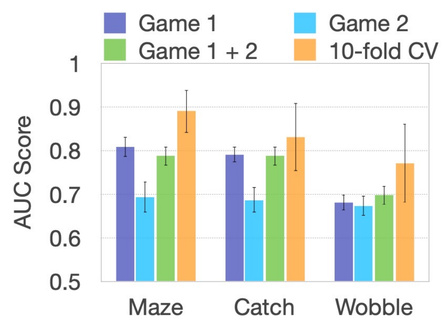
Technical Approach, key innovations and new contributions

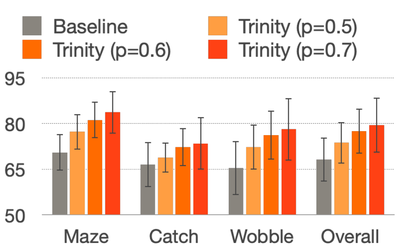
1. Generalizability of ErrP over environments, agent movements, and human users
2. Combine recent advances in DRL into ErrP based feedback system in a practical, sample-efficient manner
   - First framework: Human-feedback while training in the loop
   - Second framework: Learning from imperfect demonstrations criticized by human ErrP
   - Scaling to reasonably complex environments
3. Leveraging the spatial, temporal, and frequency characteristics of ErrP signals to create a robust ErrP decoder
4. Reduction in stochasticity of ErrP decoding by utilizing prediction confidence intervals
5. Using a feedback attenuation coefficient to mitigate the impact of wrongly decoded ErrP labels
6. Illustrating the advantage ErrP feedback offers over manual input in terms of user comfort and labeling accuracy
7. Exploring the gradation of ErrP accuracy with respect to inter-stimulation interval and agent error probability
8. Assessing RL acceleration using different techniques like action biasing, reward shaping, and inverse RL
9. Reduction in auxiliary reward queries using inverse RL with initial imperfect trajectories

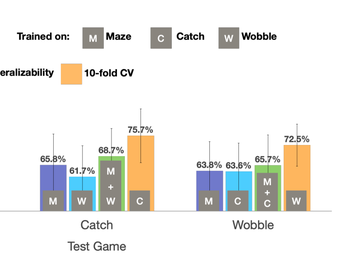
Scientific Impact:

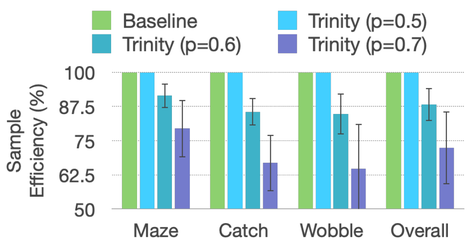
- The use of game proxy will considerably speed up the pace of CPS research
- Accelerating the training of RL algorithms deployed in CPS

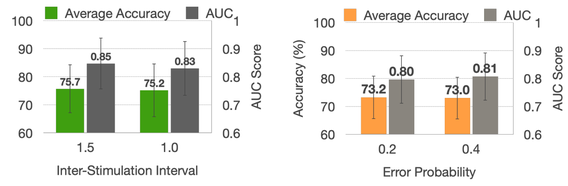


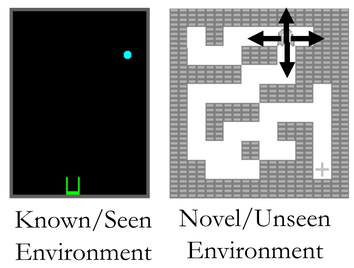


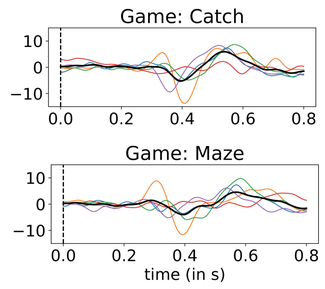


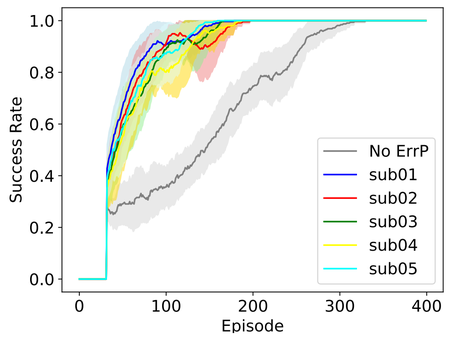


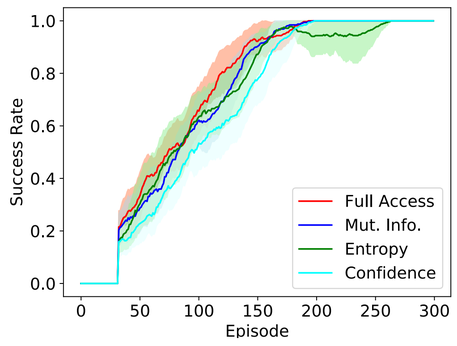












Radically change learning research for CPS

- Using proxy games to study learning problems for CPS
- Speed up the deployment of complex CPS driven by sophisticated learning algorithms

Science and Education

- Train graduate students, underrepresented students and involve UGs in research
- Integrate material in courses: Probabilistic Graphical Models, Information Theory and Wireless Networks

Broader Impact (Quantify Potential Impact)

- Human-assisted CPS
- Improve machine intelligence through intrinsically generated human-feedback
- Commercialization through CREATE-X

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