Cognitive Autonomy for Human CPS: From Novices to Experts
NSF CPS Frontier

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http://autonomy.unm.edu

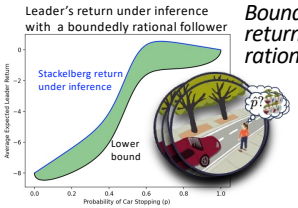
Analysis, design, and control to make autonomous cyber-physical systems highly responsive to human cognitive state.

Cognitive Autonomy

1. Is robust to uncertainty in the environment and in the human's actions
2. Assures desired human-CPS properties
3. Prevents loss of attention and over-reliance
4. Responds to the physical, computation, and human cognitive state
5. Provides guidance / takes control as needed, and communicates appropriately with the human
6. Anticipates and prevents willful misuse

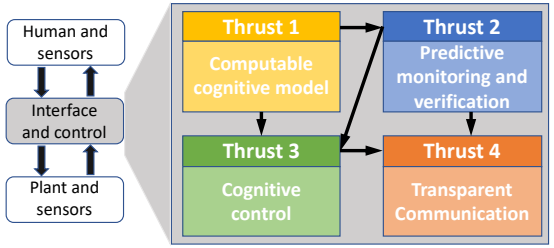
Key innovations and new contributions

- Inference of learning stages for self-confidence and trust calibration
- Generative AI for formative feedback on psychomotor learning tasks
- Identification of mode changes in human-in-the-loop data
- Adaptive function allocation in for human-autonomy teaming in uncertain environments
- Bounded rationality in Markov games

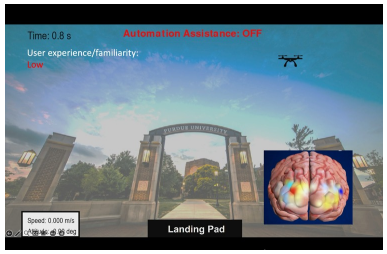


Bounds on expected returns with bounded rationality

Vibrotactile feedback for operator re-engagement

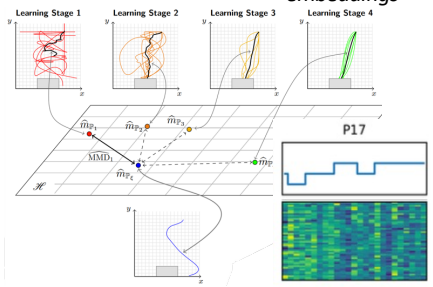


Human cognitive state dynamics are required for effective analysis and control of human CPS.



Psychophysiological sensing for self-confidence and trust calibration in a learning task

Inferring learning stages via kernel embeddings



Impact on CPS Research

- Computationally tractable, data-driven models, for individual human state, actions, and priorities
- Offline verification + online predictive monitoring
- Control of physical *and* cognitive system state
- Model-based, multi-modal, transparent communication

Broader impacts

- Prevention of "misuse, disuse, and abuse" of automation
- Human-centric algorithms and tools at the intersection of controls and learning
- Methods to accommodate human heterogeneity and variability

Summer Intensive Research Internship (SIRI)

- Culturally responsive undergraduate research
- Targets underrepresented students in New Mexico to work with Purdue faculty
- Characterization of environments for student success and belonging

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