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

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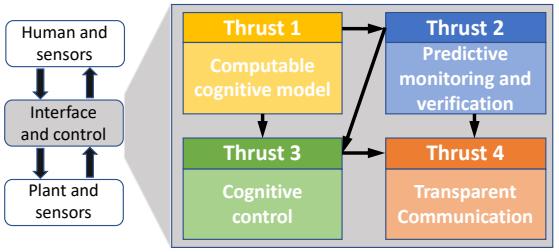
http://autonomy.unm.edu

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

Cognitive autonomy

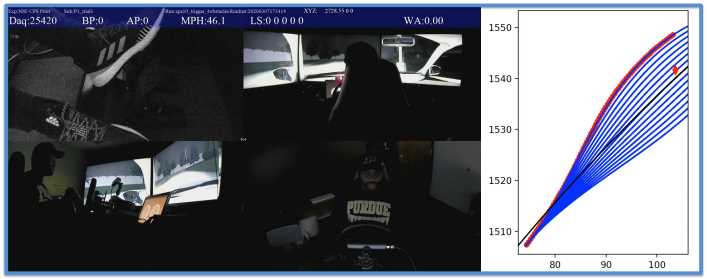
1. Is robust to uncertainty in the environment and in the human's actions
2. Assures desired human-CPS properties
3. Prevents loss of attention and over-reliance
4. Responds to the physical, computation, and human cognitive state
5. Provides guidance and/or takes control as needed, and communicates appropriately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



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

Impact on CPS Research

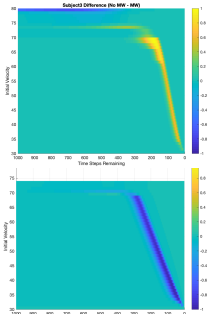
- Computationally tractable, data-driven models, for individual human state, actions, and priorities
- Offline verification + online predictive monitoring
- Control based on physical *and* cognitive system state
- Model-based, multi-modal, transparent communication



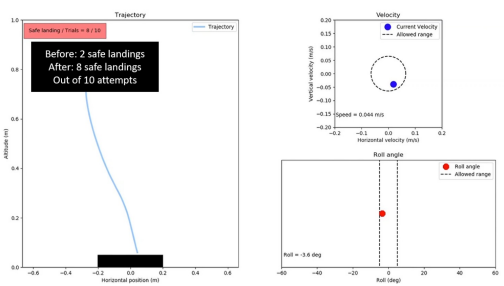
Algorithms for prediction and control must account for heterogeneity in likely driver responses.

Proposed solution

- POMDP models of trust and self-confidence
- Conformal prediction for online, customizable constraint satisfaction
- IRL for customizable shared control with stability guarantees
- Non-parametric learning for offline verification with a human in the loop



RKHS for braking dynamics



IRL infers human preference for blended control at discrete levels of intervention.

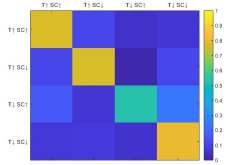
Summer Intensive Research Internship (SIRI)

- Culturally aware undergraduate research program
- Targets underrepresented students in New Mexico to work in pairs with Purdue faculty
- Mentor training for faculty and graduate students
- Characterization of environments for student success and belonging

Broader impacts:

- Prevention of "misuse, disuse, and abuse" of automation
- Human-centric algorithms and tools at the intersection of controls and learning

POMDP models of human state reveal that trust and self-confidence are coupled, and that operators with high trust can calibrate reliance



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