CPS: Small: Data-Driven Modeling and Control of Human-Cyber-Physical Systems with Extended-Reality-Assisted Interfaces

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https://www.nsf.gov/awardsearch/showAward?AWD_ID=2223035

Goal: Develop a holistic data-driven design framework of modeling, interaction, and control for Human-Cyber-Physical Systems (h-CPS).
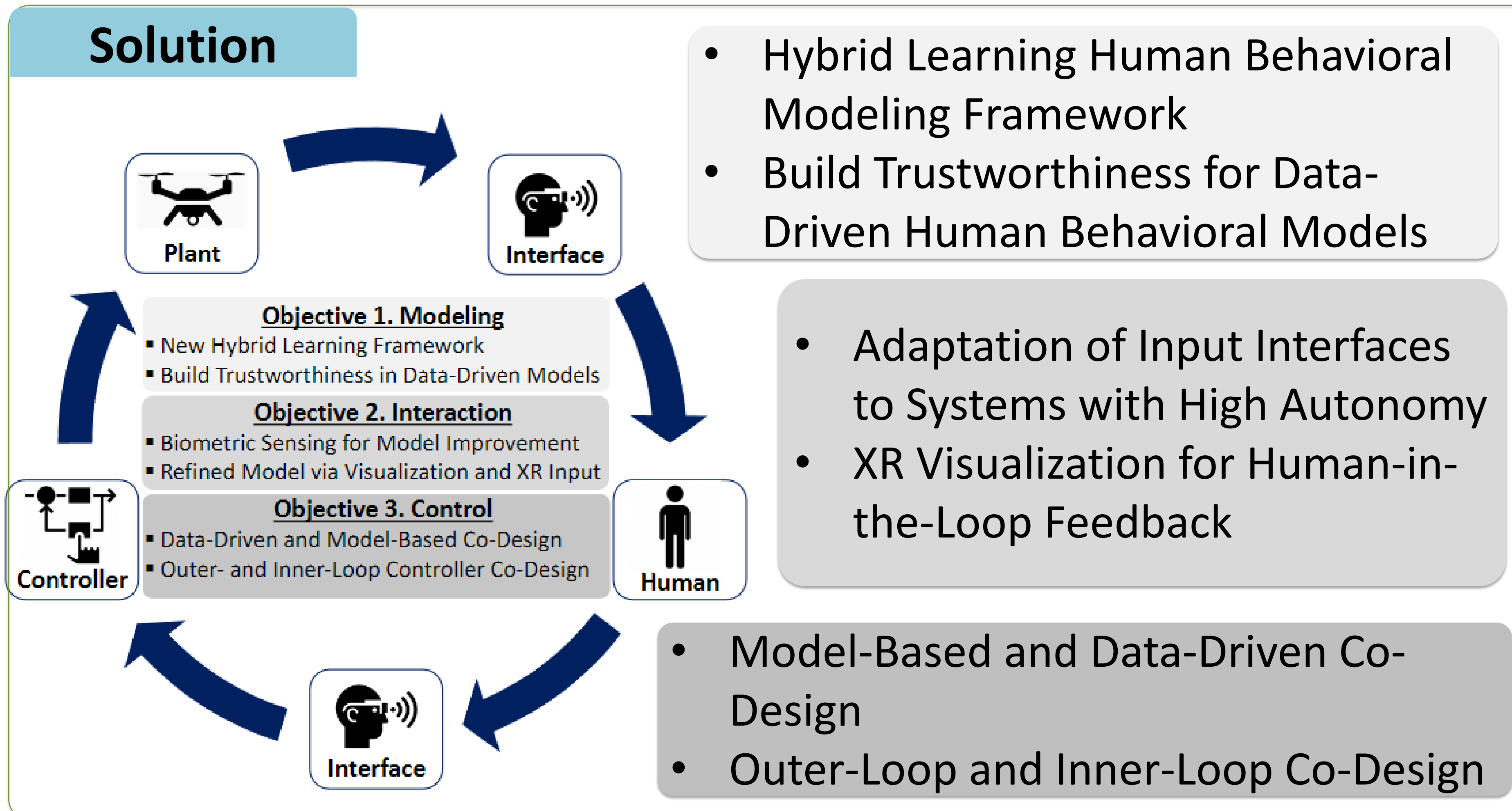
Challenges

- Modeling Complex Human Behaviors
- Effective Human-Machine Communication Interfaces
- Adaptable, Reliable, and High-Performance Control

Scientific Impacts

- New Hybrid Learning Architecture for Data-Driven Modeling of Human Behaviors
- XR-Assisted Human-Machine-Environment Interface
- Co-Design Control Framework for CPS with Human-in-the-Loop

Solution

Objective 1. Modeling
- New Hybrid Learning Framework
- Build Trustworthiness in Data-Driven Models

Objective 2. Interaction
- Biometric Sensing for Model Improvement
- Refined Model via Visualization and XR Input

Objective 3. Control
- Data-Driven and Model-Based Co-Design
- Outer- and Inner-Loop Controller Co-Design

- Hybrid Learning Human Behavioral Modeling Framework
- Build Trustworthiness for Data-Driven Human Behavioral Models

- Adaptation of Input Interfaces to Systems with High Autonomy
- XR Visualization for Human-in-the-Loop Feedback

- Model-Based and Data-Driven Co-Design
- Outer-Loop and Inner-Loop Co-Design

Project Progress

Modeling

D³NN: **D**ata-**D**riven **D**ual-level **N**eural **N**etwork Tool for Dynamical System Modeling and Abstraction
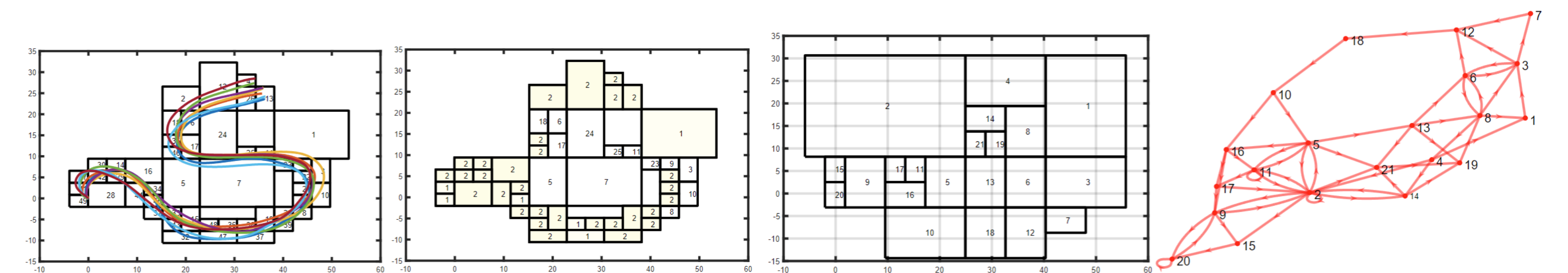
(a) S-Shape Samples and 49 Partitions Obtained. (b) 22 Cells Abstraction for $\mathcal{H}$ of S-Shape Data Set. (c) 21 Cells are Obtained in High-Level Transition System Abstraction. (d) Transition Map based on $\mathcal{T}$ of S-Shape Low-level NHS Model $\mathcal{H}$.

Interaction

EyeShadows: Peripheral Virtual Copies for Rapid Gaze Selection and Interaction
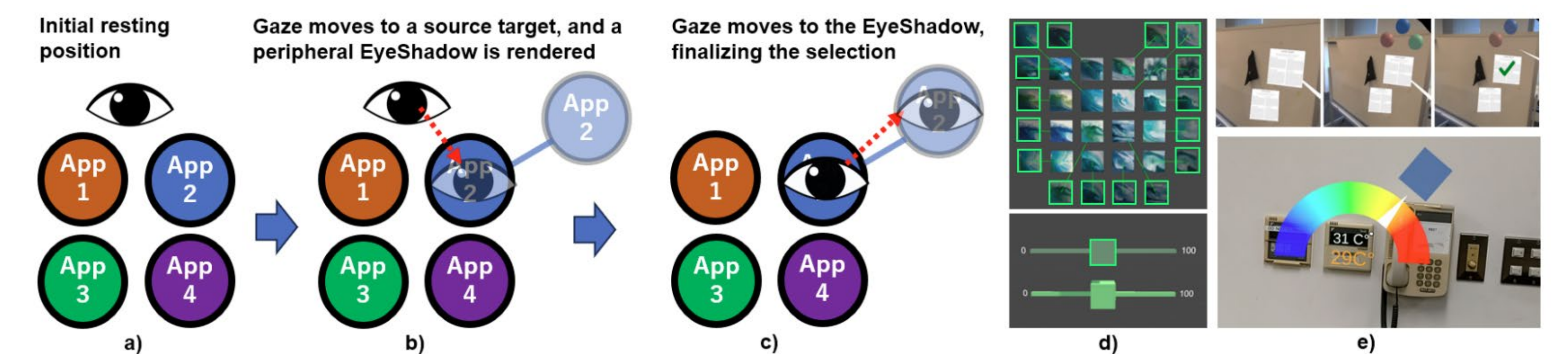
Broader Impacts

Impact to Society

- Benefit a broad class of h-CPS applications to provide efficient and reliable modeling, interaction, and control tools.

Education and Outreach

- CPS Workforce Training and Education: One student won DoD scholarship.
- Curriculum Development: Game Design Club, CPS and Game Design Courses, etc.
- STEM Outreach: GenCyber Camp, High School Spotlight Event, etc.