CPS: Medium: Resilient-By-Cognition Cyber-Physical Systems

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Motivations:

- Autonomous CPS will always face new situations which the human designer failed to examine during the design phase.
- Malicious agents could exploit the lack of CPS capability to adapt to new situations to impose safety-threatening scenarios.

Objective:

- Equip CPS with a layer of "cognition" that allows them to learn and adapt from adversarial situations.
- Acquire a level of resilience against the unforeseen.
- Realize this framework experimentally on automotive systems and Quad-rotors.

Students

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- Xincheng Li (UMD)
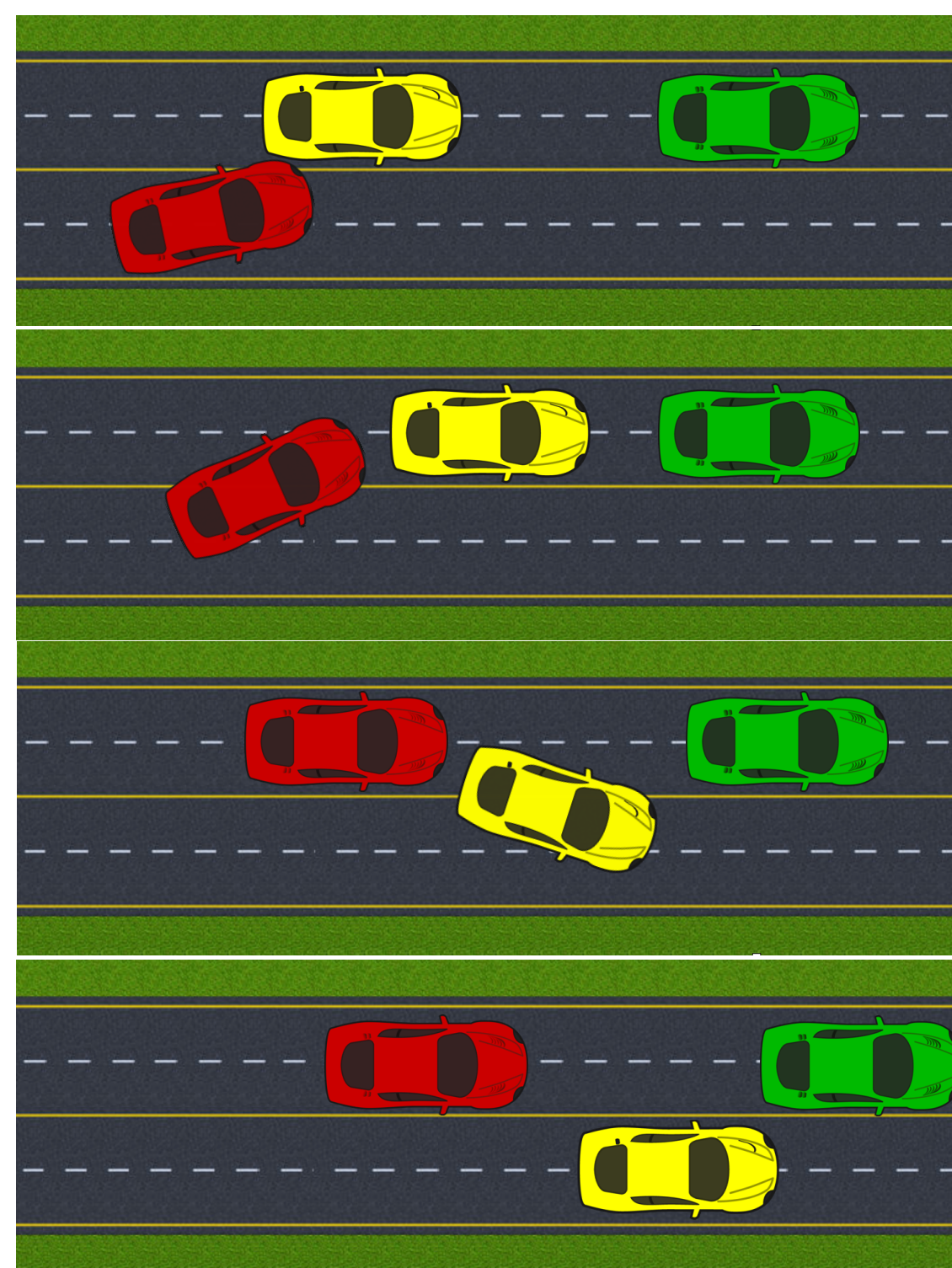
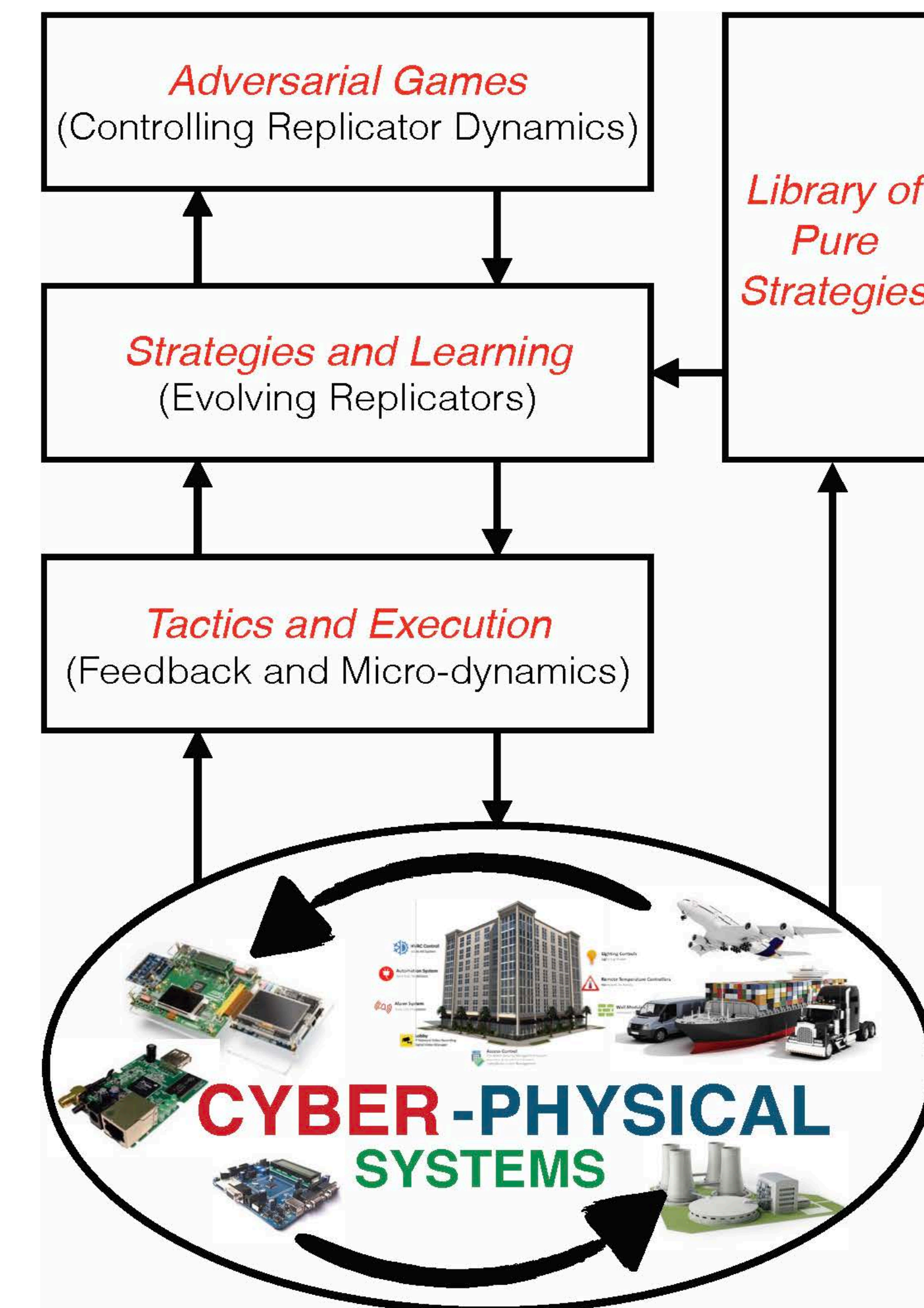## Three-layer Architecture for CPS Cognition:

- In biological context, adversarial situations stimulated species to evolve and thrive in their ecosystem e.g., threat avoidance behavior in starling flocks, and prey-capture abilities of echolocating bats.
- We study the use of biological evolution as a basis for cognitive autonomy in the presence of adversarial agents.

Scalable Controller Synthesis for Polynomial Nonlinear systems:

- Numerical tools for constraints solving are the cornerstone for control synthesis and verification.
- Linear and convex programming are limited and not adequate for design and analysis of nonlinear systems.
- PolyAR: A highly parallelizable solver for polynomial inequality constraints using convex abstraction refinement.
- Orders of magnitude faster than state-of-the-art solvers.

Geometric Models for Human-Robot Interaction:

- Equi-affine speed expresses empirically observed power laws in human movement trajectories (hand-writing, tool-wielding, arm and hand manipulation, bipedal locomotion).
- Shape space of relative equilibrium is of interest as a parameter space contained in a Cartesian product of multiple copies of SA(2).
- Associated affinity landscape (heat-map of curvature) can be computed and compared with rigidity landscape arising from the rigid motion group SE(2).