Constraint Aware Planning and Control for Cyber-Physical Systems

Challenge:

Enable robust, adaptive planning & control for nonlinear, nonsmooth, & constrained systems, while respecting their physical constraints and meeting specifications.

Solution:

- Generate a framework for design of algorithms that self-adapt to jointly plan the motion and control the CPS, with robustness
- Design algorithms that self-learn and self-adapt in real time to cope with unexpected changes in the physics and in the specification to enable autonomous systems to perform tasks robustly and safely
- Formulate tools that reason about specifications and physics as vertically-integrated modular and reconfigurable constraints

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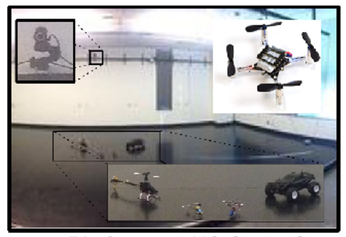
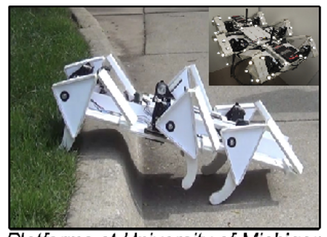
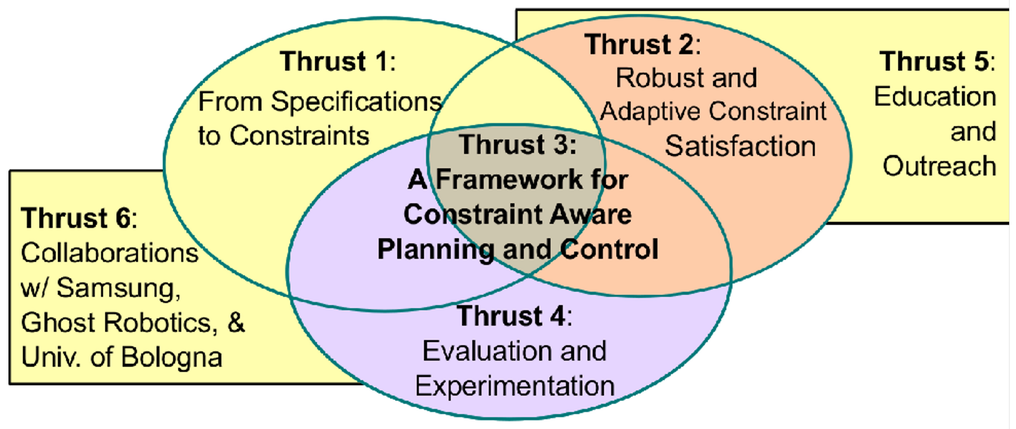


Platforms at UC Santa Cruz



Platforms at University of Michigan



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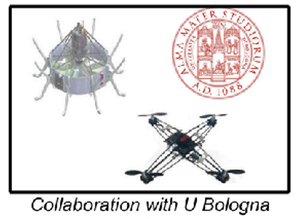
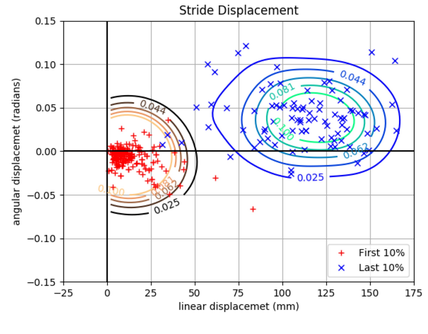


Collaboration with U Bologna on regulation for aerial vehicles

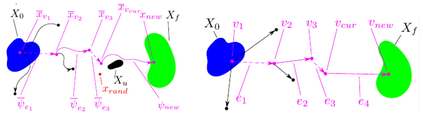


Forward invariance with multiple constraints

$$K = \{x \in C \cup D : B(x) \leq 0\}$$

$$B(x) := [B_1(x)\ B_2(x)\ \dots\ B_m(x)]^\top$$

Motion planning with hybrid dynamics



Scientific Impact:

- Mathematical framework to rigorously formulate learning-based planning and control for CPS with awareness of its constraints
- Novel architectures that lead to robust adaptive constraint satisfaction.
- Deep understanding of roles and priorities of system constraints in CPS
- Tools and design techniques that permit engineers to deploy constraint aware algorithms

Broader Impact:

- Broad application of the results to CPS that require planning and control, especially autonomous systems in air and ground transportation
- Benefit to industry developing multi-legged robotic systems and solutions for real-time planning and control under dynamic obstacles
- Collaboration with colleagues at the University of Bologna
- Outreach to high school students through Summer outreach and STEM mentoring
- Publishing of teacher resources online and offering of teacher training
- Impact is quantified by successful collaborative activities, adoption of results by industry and academic, and by student enrollment in outreach activities