NRI: FND: COLLAB: Design of Dynamic Multibehavioral Robots:

New tools to consider design tradeoff and enable more capable robotic systems

Key question: How do we design robots that are good at multiple behaviors?

State of the art mobile manipulators in robotics:

In biology:

Carnegie Mellon University
Robomechanics Lab

PIs: Prof. Aaron M. Johnson, Carnegie Mellon, and Prof. Sam Burden, University of Washington

NSF Award #: 1924723, 1924303 Dates: Sep 2019 – Aug 2022 Poster #54

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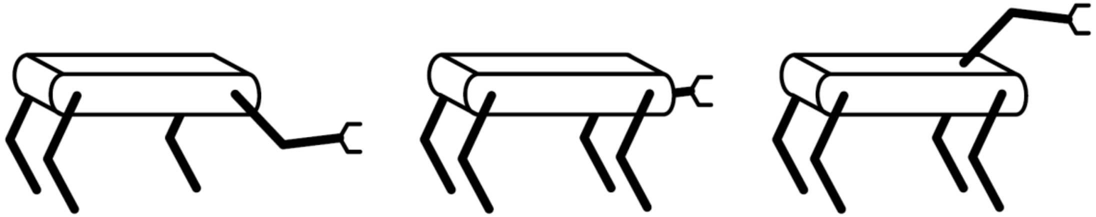
Approach:

1. Develop new methods of evaluating the suitability of a design for a single behavior
2. Break apart the large multi-objective design optimization problem into tractable components

Rather than solve for particular solutions for a given problem setup (e.g. with trajectory optimization), define reduced order models that capture a family of successful behaviors.

Then, derive metrics how well a design achieves a behavior (possibly based on Gaussian curvature of the dynamics or control bandwidth required)



All of these designs can pick up an object. But which is the best at picking up objects in general?

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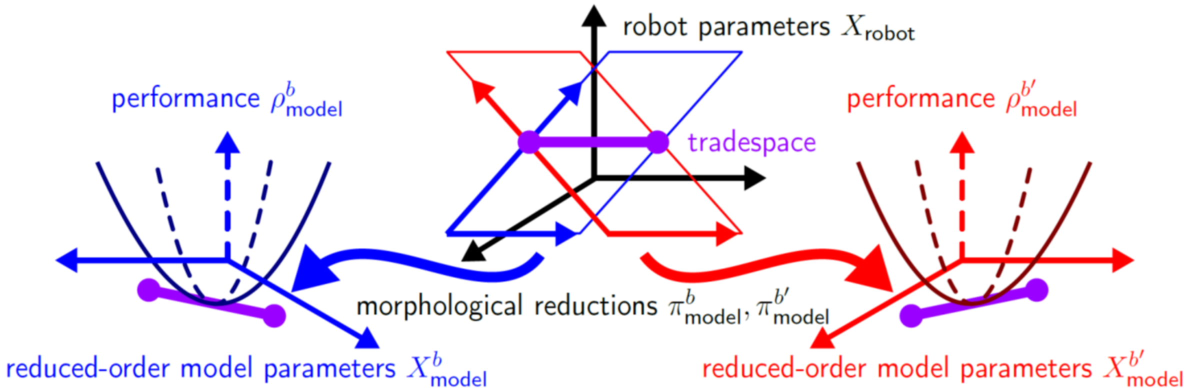
Separate out four components of the design space:

1. A tradespace that both behaviors are sensitive to
2. A subspace that only affects behavior 1
3. A subspace that only affects behavior 2
4. A subspace that has no sensitivity to either

Derive a basis for this space decomposition and then find and explore the pareto set of designs



$$Tr \oplus N_1 \oplus N_2 \oplus N_f =: S$$

$$\begin{aligned} Tr(p) &:= D\varphi \cdot Ar(p) \\ N_1 &= \ker(DC_1) \\ N_2 &= \ker(D\tilde{C}_2) \\ N_f &= \mathrm{Im}(D\varphi)^{\perp} \end{aligned}$$

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Broader Impact: Design for multibehaviorality will help produce e.g. home assistance robots that must move and interact in human environments.

REU: Undergraduate project to build legs that are good at both running and climbing by optimizing material properties and dimensions.

Outreach: Hosting virtual afterschool program for middle schoolers teaching CAD.

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