Near future applications for robots

Requirements for robots of the future

Autonomy requires
- Traversing complex environments
- Operating for long periods

Versatility
- Doing many kinds of work
- Performing simultaneous locomotion and manipulation

State-of-the-art robots aren’t up to the task

- For many years research focused on locomotion.
- Despite this, state-of-the-art struggles with endurance.
- Furthermore, manipulation is treated post-hoc.
- The result: robots have limited autonomy and versatility

Multi-behavior design methods are needed

• We seek general methods to design robots for multiple sets of behaviors.
• These methods should provide a rational basis for design decisions and quantify tradeoffs among behaviors.
• We propose employing those methods to design robots which reuse limbs for locomotion and manipulation tasks.

Example concept: a 4-limbed robot which performs tasks in bipedal and quadrupedal configurations. Each limb gets repurposed in the different behavioral regimes.

Design study: reusing a limb for hopping and weight-lifting

• The behaviors are respectively described by dynamical systems i.e.
  \[
  \frac{d}{dt}y(x) = A\pi y(x)
  \]
• We computationally optimize the limb by altering its passive mechanics and mechanical advantage.
  \[
  \frac{d}{dt}x = f_y(x) + g_y(x)\upsilon x(x)
  \]
  \[
  \upsilon x(x) := (d\pi y[x, y(x)])(A\pi x - f_y(x))
  \]
• Motivated by the need for endurance, we present an electrical power metric for evaluating designs.
  \[
  C(y) := \frac{1}{\text{Vol}(D)}\int_D \|\upsilon x(x)\|^2 dx
  \]