Cyber-Physical Systems: Exploiting Morphological Diversity for Multi-Agent Intelligence

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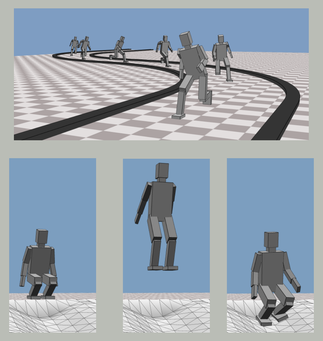
Introduction

- A wide class of robots is in position to have great impact, alongside or in place of humans, in the next 10-15 years
  - in the home
  - as first responders
  - on the front lines
- Tasks often rely on one specific type of robot
  - centralized sensing and computation burden
  - any morphology has associated weaknesses
- **Morphologically diverse** teams of robots could accelerate the impact in these domains

Research Background



- Humanoid robots
  - fit for human spaces
  - potential for natural HRI
- Capacity for agile, terrain robust operation
  - area of my current research
- CPS support to enable operation outside of the lab

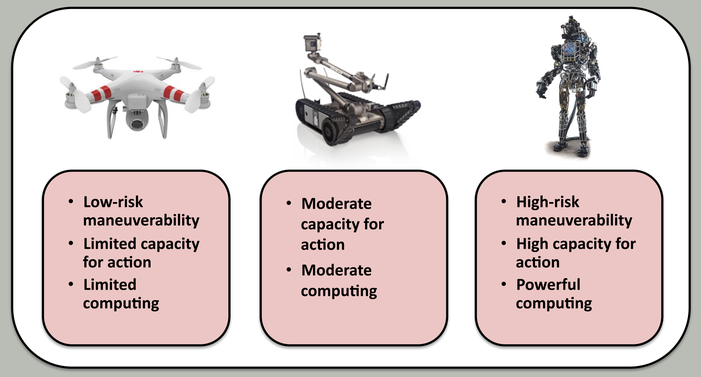
Application: Domestic Service Robots

- Annual growth of 20+%
- Potential to support an increasingly elderly population
- Navigation/manipulation in uncertain environments
  - prevents immediate impact
  - teaming could reduce uncertainty

Application: Disaster Recovery Robots

- DARPA robotics challenge
  - inspired by Fukushima disaster
  - mainly humanoid robots
- Preventing mission-critical failure
  - other easily-replacable systems could be used in supporting roles

CPS Challenge: Coordinated 3-D Perception



- Robust 3-D perception is a main challenge facing autonomous robots
  - difficult in cluttered/degraded environments
- Real-time coordinated perception
  - uses strengths of diverse agents to perceive a scene
  - accounts for navigation risks and constraints
  - uses appropriate system abstractions unique to each agent
- Incorporation into low-level perception/action loops
  - will require online re-assignment of perception goals

CPS Challenge: Teleoperation for Multi-Agent Sys.

- Advantage of semi-autononomy
  - improved immediate applicability
- Morphologically diverse systems
  - potential for rich agent-to-agent interactions
- Challenges for single operator teleoperation
  - natural interfaces to coordinate multiple agents
  - ability to convey high-level intention to other agents

CPS Challenge: Coordinated-Skill Learning

- Cooperative actions
  - can leverage each agent's different ability to interact with the physical world
  - difficult to learn synergistic behaviors
- New theory to
  - enable learning of coordinated skills
  - allow coordination learning that is distributed across agents

Conclusions

- Networked teams of diverse robots provides benefits over relying on a single morphology for many tasks
- CPS challenges
  - to develop coordinated perception plans
  - to remotely operate and learn coordinated behaviors

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