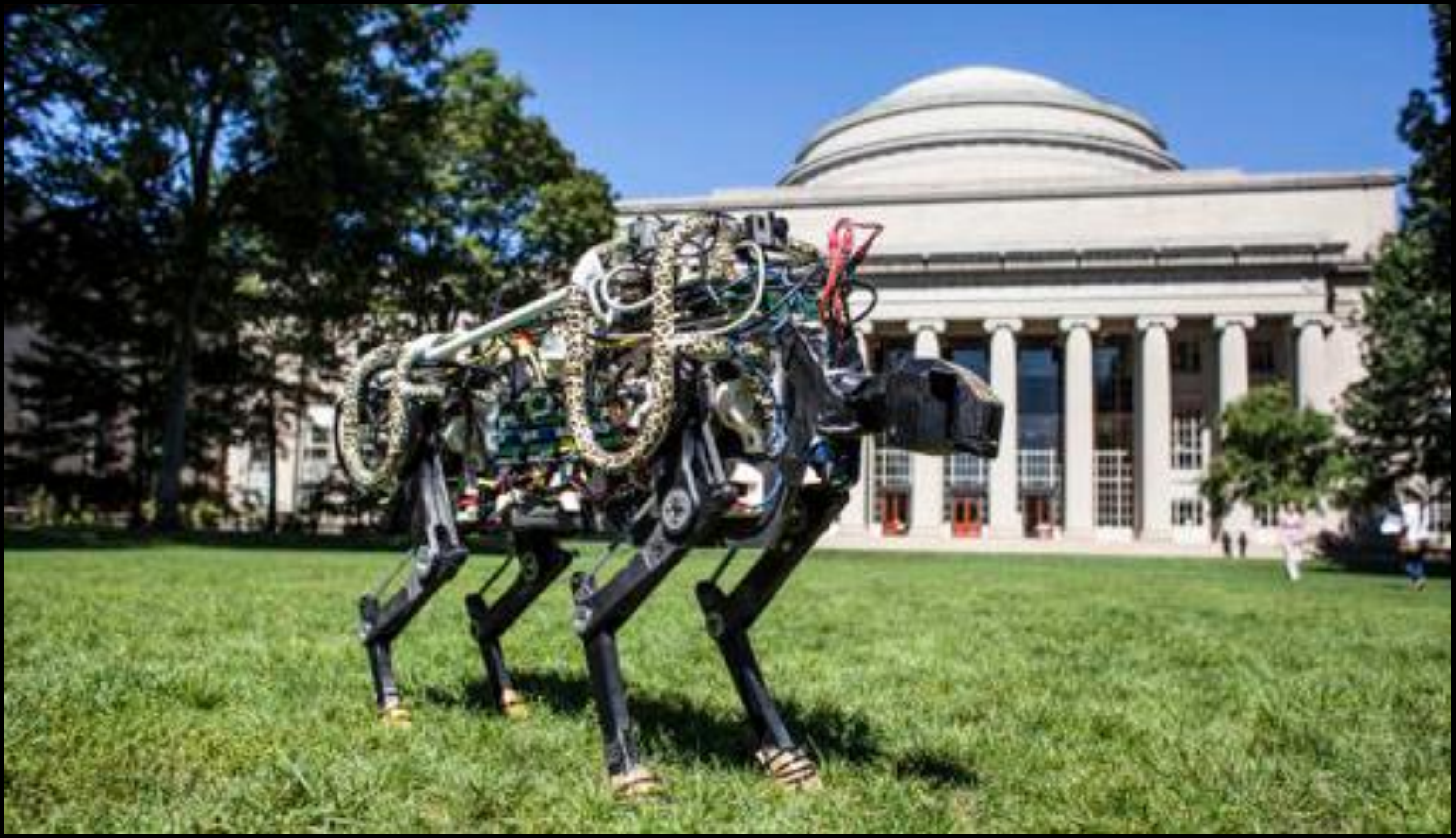


Mobile robots for remote survey and telemanipulation

Sangbae Kim

Associate professor

Mechanical Engineering, MIT

MIT MECHE Biomimetic Robotics Lab

Rigid, high precision, and repetitive position control

- **BUT NO DYNAMIC PHYSICAL INTERACTIONS**

BMW i3 factory

NHK World Documentary: Robot Revolution – from YouTube.
Nuclear disaster at the Fukushima Daichi Power Plant, Japan, March 2011.

Robots for Nuclear Plants

Inspection robot (TOSHIBA)

Pipe Inspection robot (Savanna River)

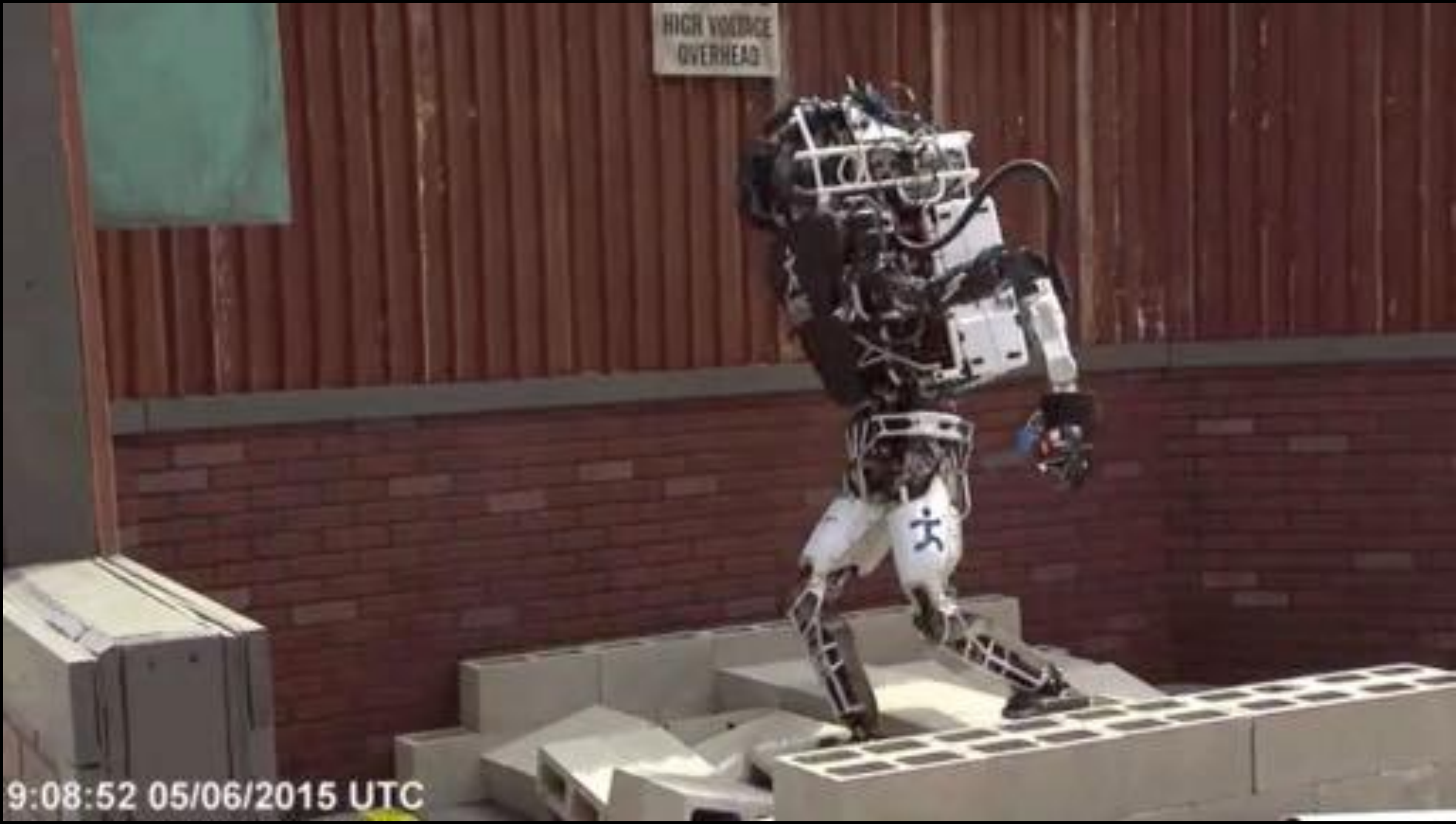
Bolt inspection robot
(Westinghouse Electric Company)

Brokk 100

- **Specialized machines for specific tasks**
- **Inspection purposes**
- **Limited mobility**
- **Quasi-static position control**

State-of-art Robot Design

- Quasi-static, high impedance locomotion and manipulation
- Collision is NO, NO, NO



Mobility → Impacts

Life of mammal – *meat eaters,* BBC

Robot design paradigms

Manufacturing tech.

- high ratio Harmonic drive

Lack of compliance
Lack of efficiency
Lack of power (?)

Construction tech.

- Hydraulic robots

Lack of efficiency
Heavy components

- Grounded
  Structured/expected environment
- High-precision/speed position control for pick and place tasks

Design paradigm shift

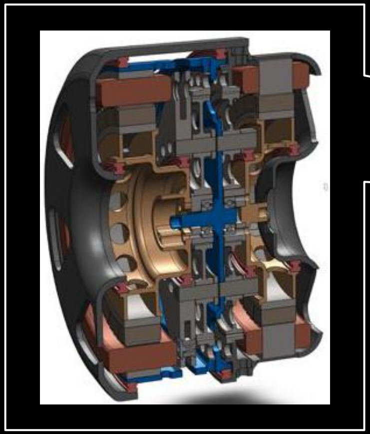
- Mobile
  Unstructured/unexpected environments
- Dynamic Balance control
- Force control for interaction with environments

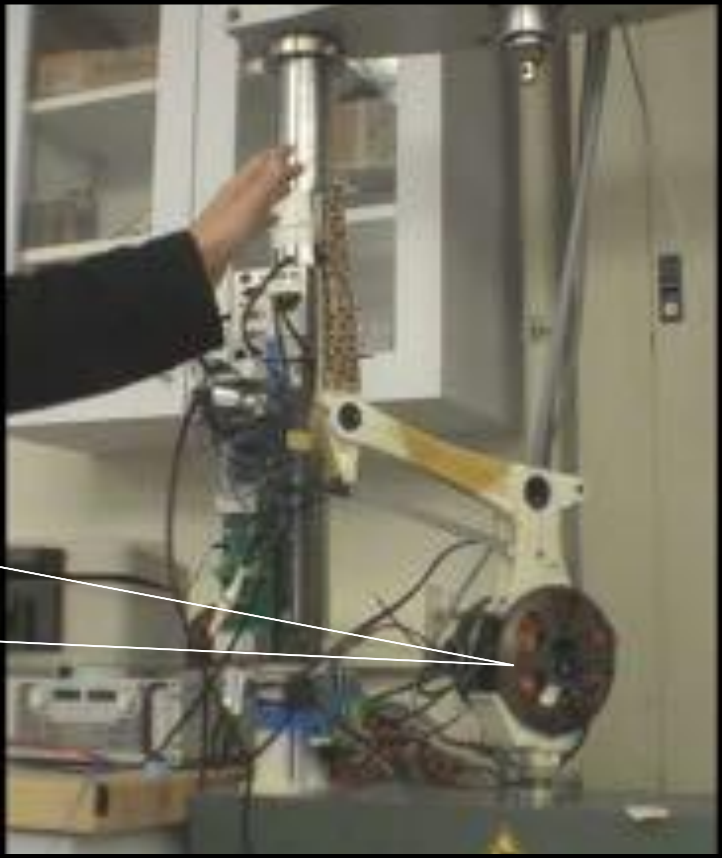
MIT Cheetah

Biomimetic Robotics Laboratory

Unique actuation for physical-interaction

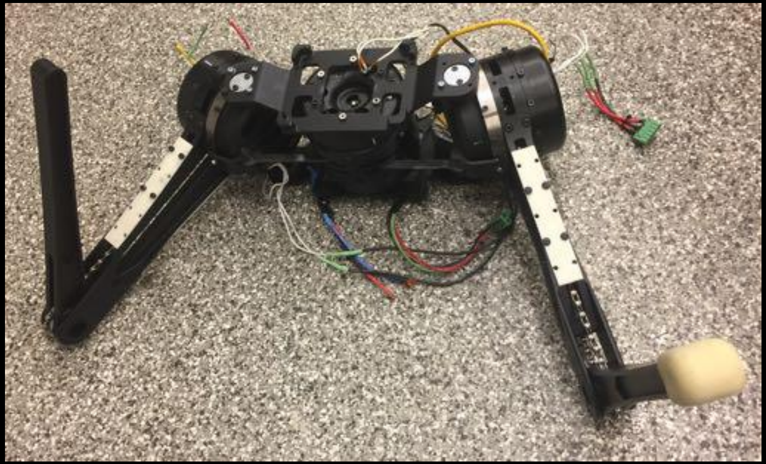
1. Minimum distal mass
2. Max. torque density – Min. mechanical impedance
3. Proprioceptive control (collocated sensing, no force sensors)

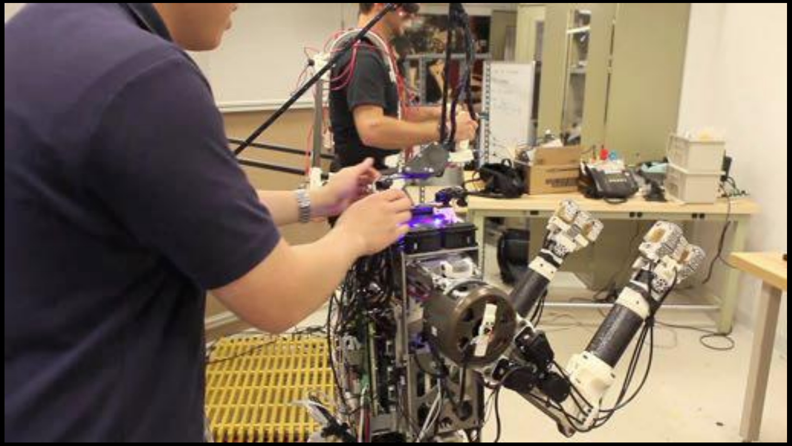




Robots in Power Plants

1. The legged robots can achieve ground mobility to match humans within next 5 years to cover stairs and obstacle
2. Teleoperation for physical interactions will allow further interventions in contaminated areas.





- What issues do robotics need to overcome? (They need to be worth their high capital cost, replace multiple humans, perform multiple functions, be highly mobile, not jeopardize safety, and be cryptographically secure? Will they require significant shielding?)
- Approximately how much would you expect the average NPP robot to cost? The average drone? Do these costs scale significantly with the number of functions you expect the machine to perform?
- How can we maximize the utilization of these robots and drones? What are examples of multiple functions that the same one machine could perform?
- Are there previously impossible tasks that a robot could perform? (E.g. dropped part retrieval?)
- Where in a plant are the most challenging locations to monitor or access measurements from, as
- these will likely be the best places to introduce drones?
- What do you see being a possible timeline for the implementation of this technology? (E.g. Drones now→Limited-function or remote-controlled robots in 10 years→Humanoid robots?) How might advancements in the technology over the life of the plant affect this timeline? How does regulation affect it?
- What possibilities could you see for robots in security procedures? (Non-lethal or remote-controlled robots? Patrol drones? Advanced warning of hostile forces?)