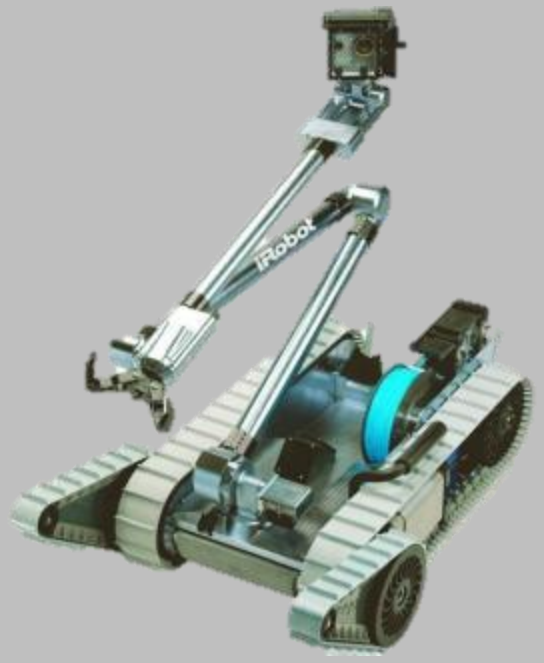
R3

reconfigurable
rescue
robot

The Problem

Problem

How can we explore an environment that is either impassable or dangerous for human beings?



Use Cases

- Urban
  - Natural disasters
  - Warzones
  - Reconnaissance
- Natural
  - Cave exploration
  - Mining rescue

Goals

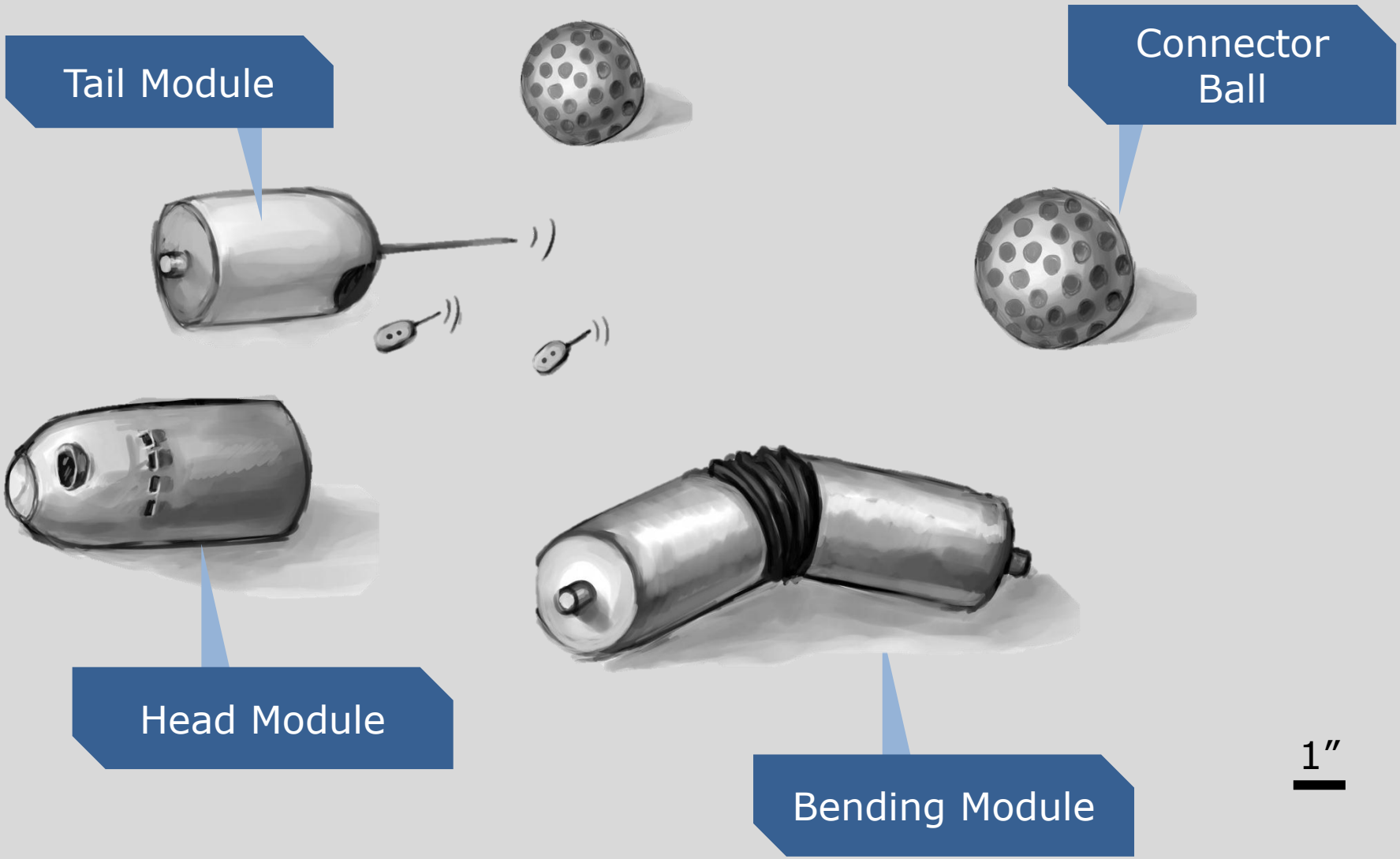
- Finding survivors
- Environment evaluation
- Shoring wreckage
- Reconnaissance
- Deposition

Requirements

- Capable of navigating tight spaces
- Must relay information regarding the environment
  - Visual
  - Chemical
- Robust
  - Fire Resistant
  - Water Resistant
- Quiet
- Lightweight

Design

Reconfigurable

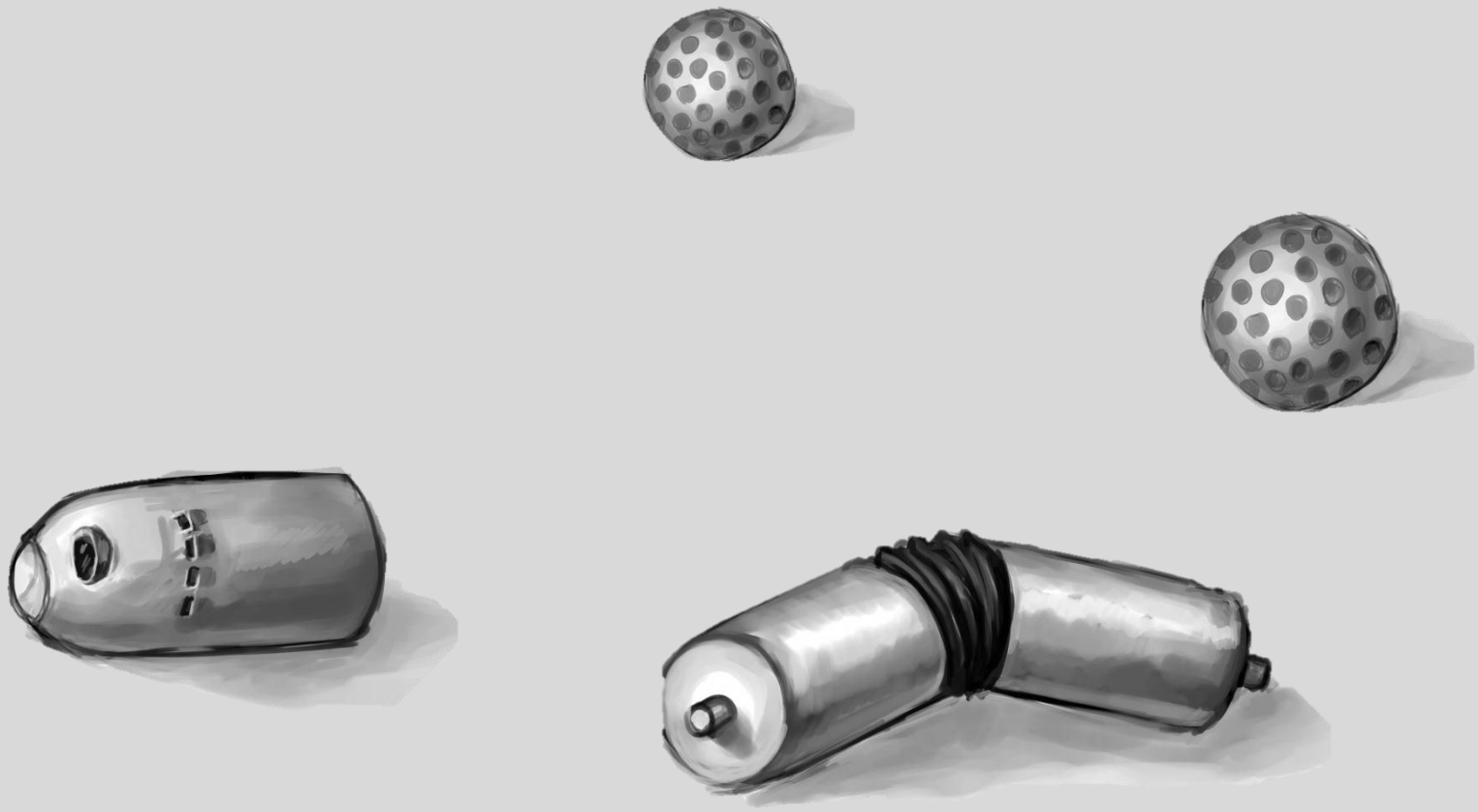


Centipede

Snake

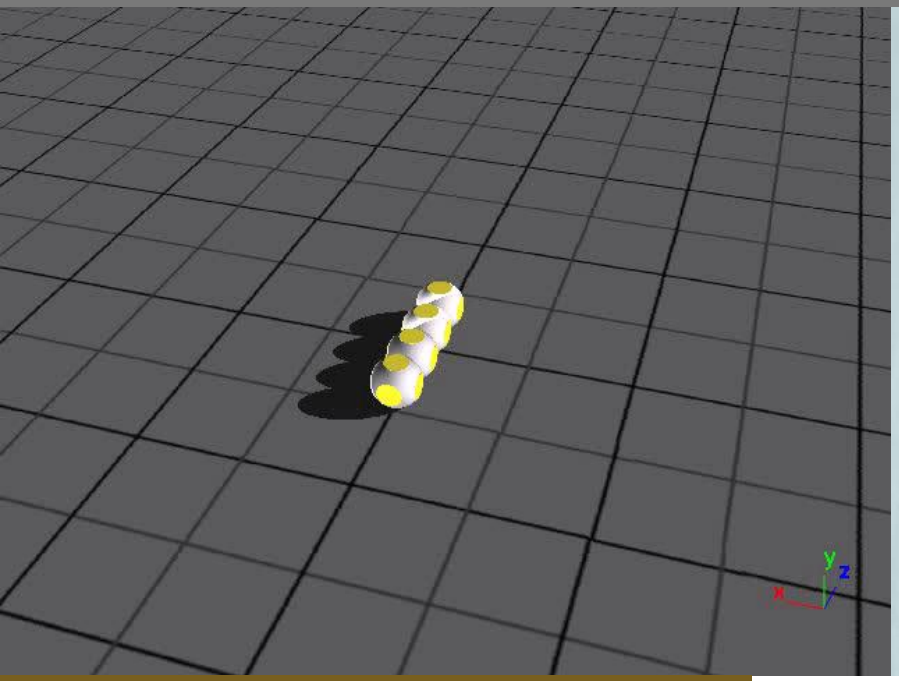
Spider

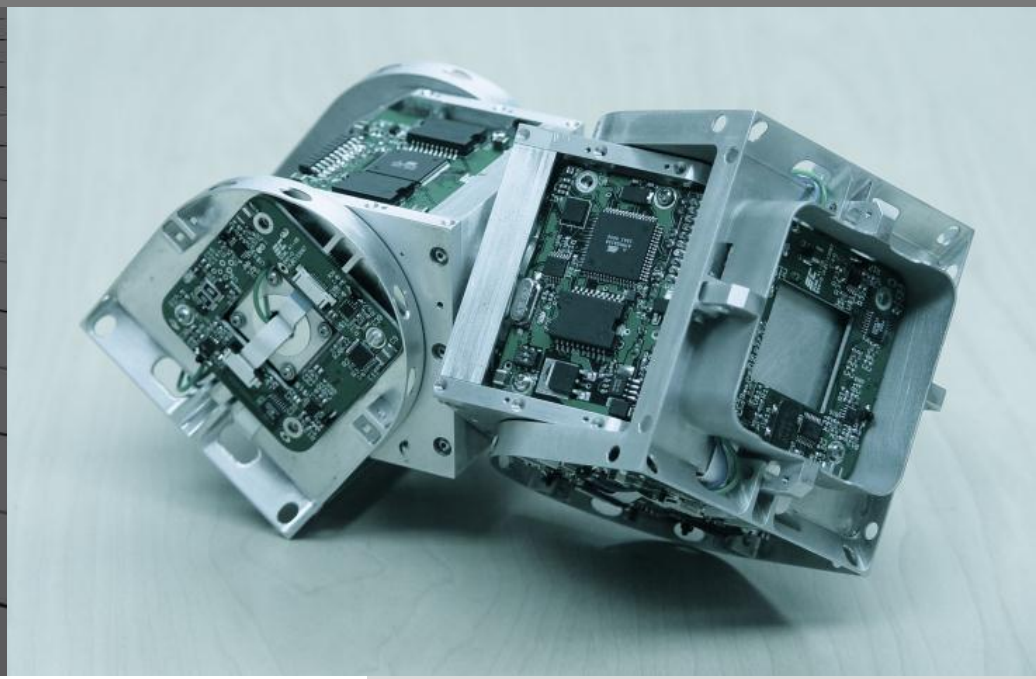
Modularity

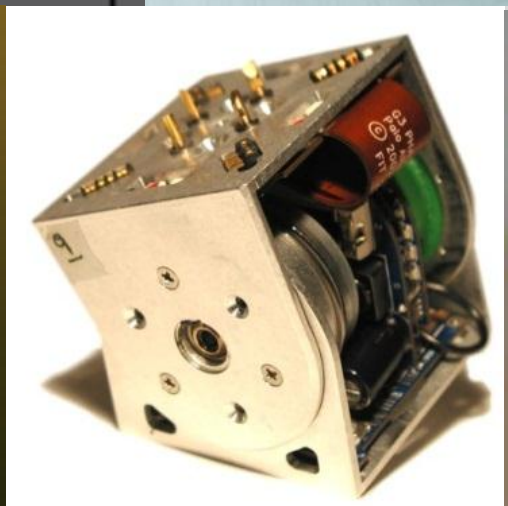


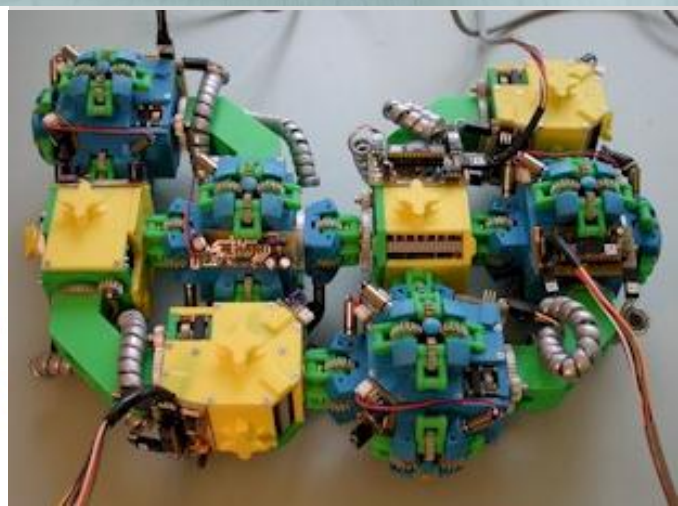
1”

Modular/Self-Assembling





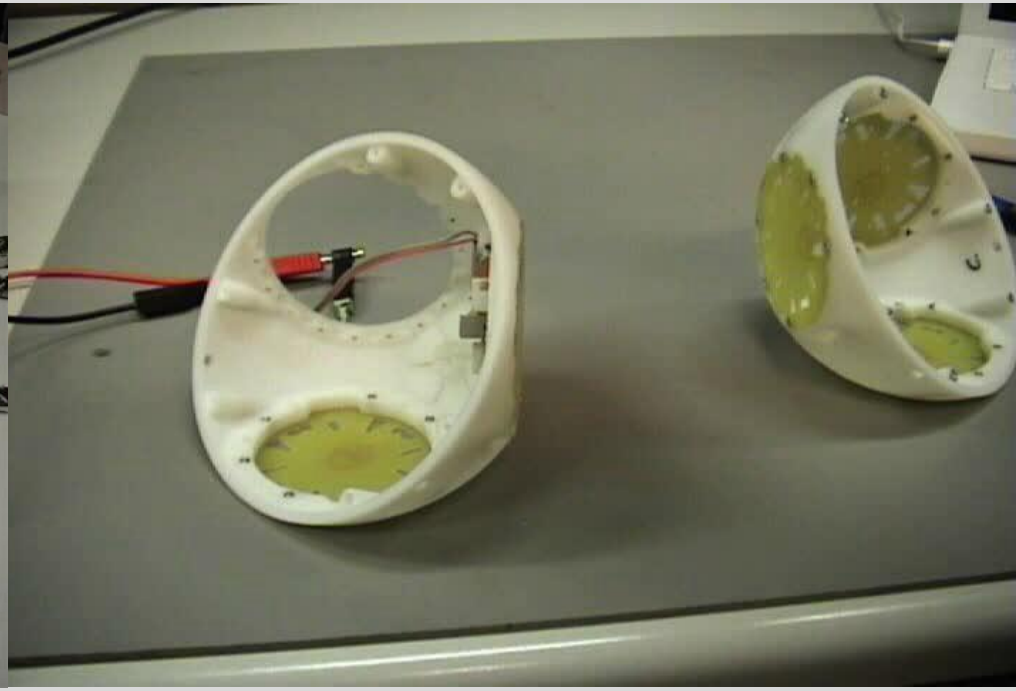




- Independent, interchangeable modules
- Actuated parts create large scale motion
- Reconfigurable

Connections

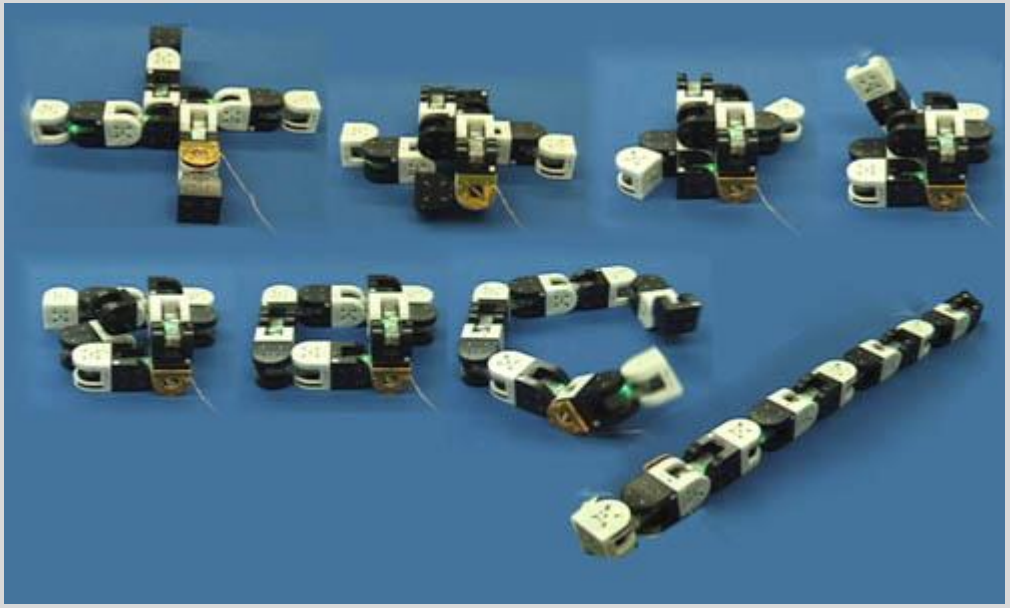
- Mechanical stability
- Actuation
- Communication/power connections




USC/ISI Polymorphic Robotics Laboratory
http://www.isi.edu/robots

Sensing

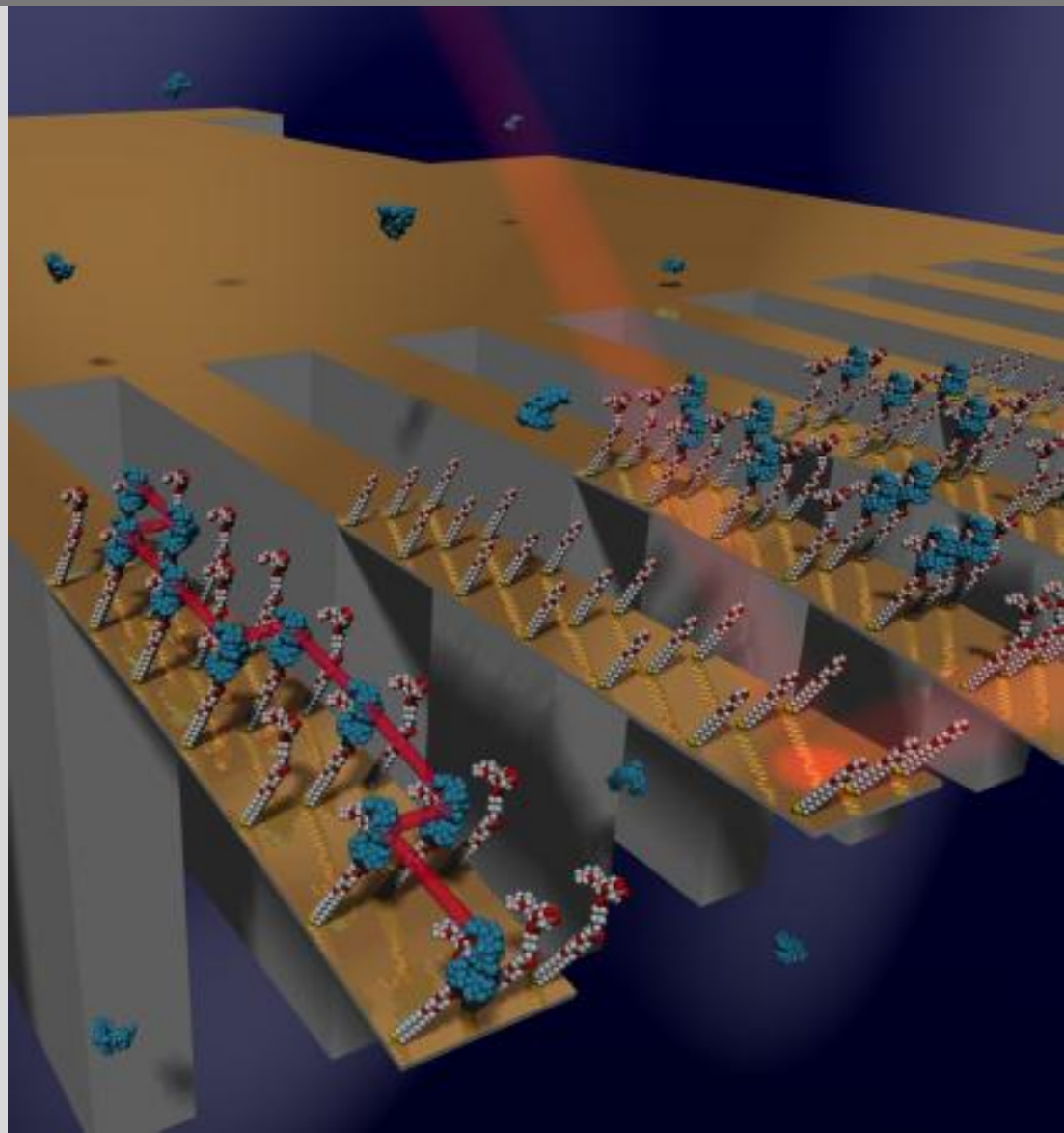
Head Module: User Interface



- Central hub of robot sensing for display to the operator
- Also “location” of robot - difficult for a typical user to remotely operate a highly distributed vehicle

High Resolution Chemical Sensing

- Microcantelievers are highly sensitive to aerosol compounds
- Arrays allow for parallel sensing of a wide set of chemicals
- Technology could be expanded into micro-labs for assessing atmosphere in enclosed spaces

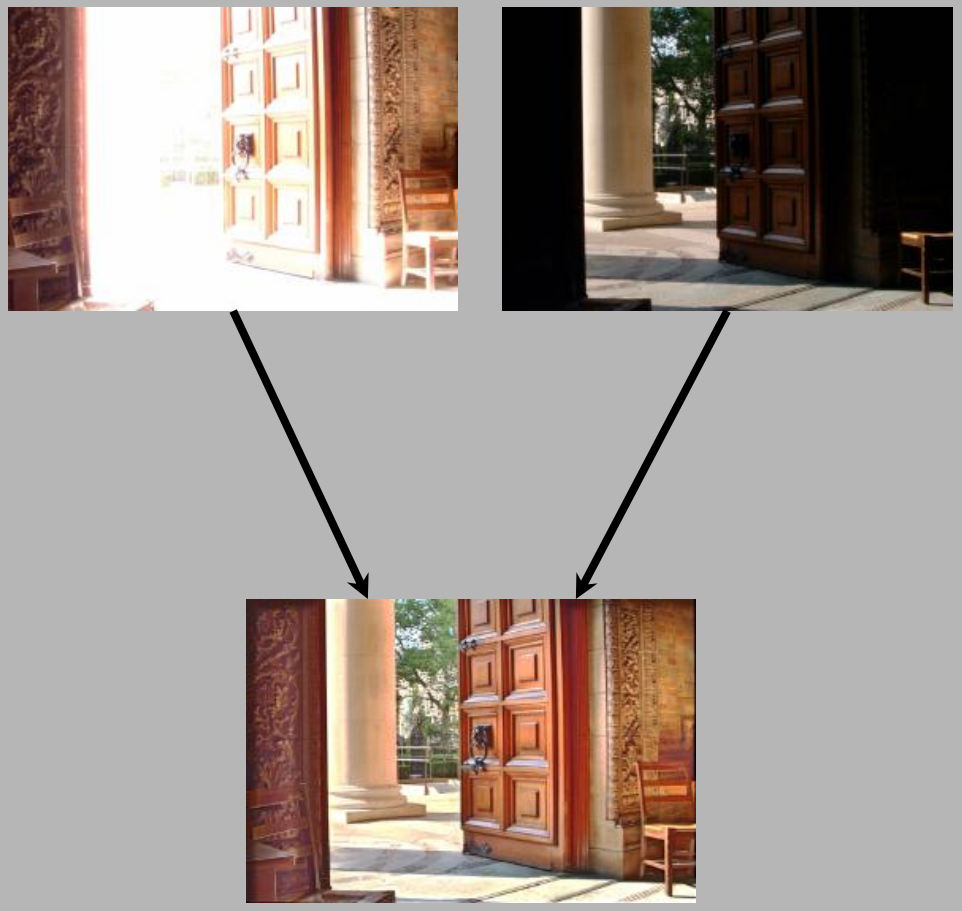


IR Sensing

- Long history, and now exist with high resolution
- Research into injury detection from increased blood flow
- Optical recognition of other important thermal informat

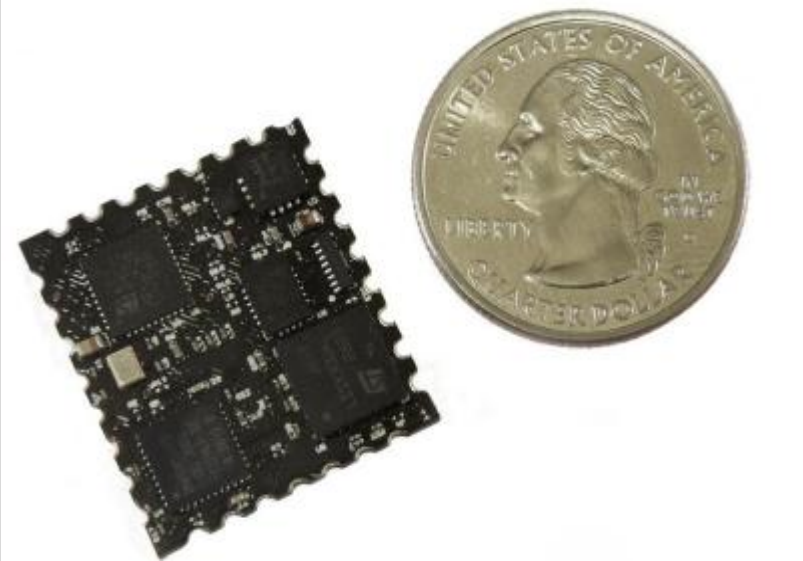
HDR Photography

- Classic camera problem – dynamic range outdoors
- Research solution: individually adjusting exposure of each pixel

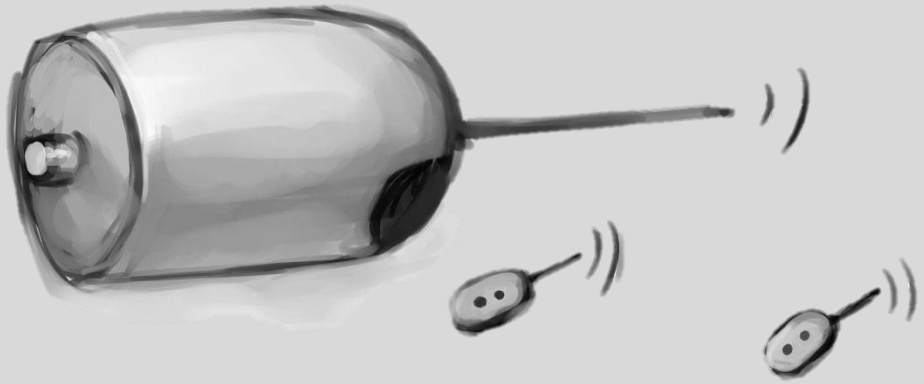


Micro-Navigation Sensors

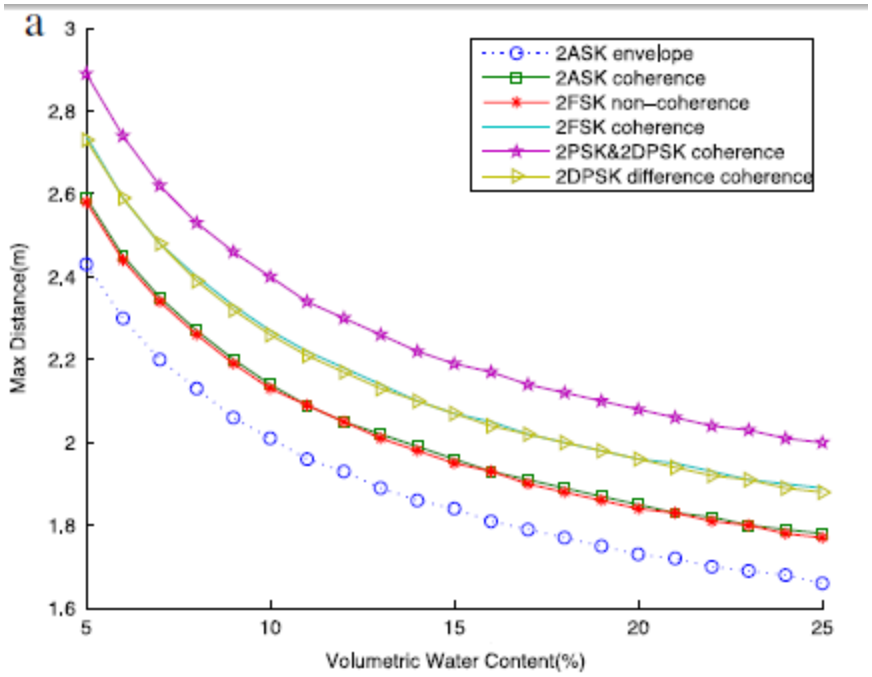
- Rapid miniaturization of existing sensing technology
  - Gyros, Magnetometer, Accelerometers
  - Bending sensors
- Highly plausible to have localization and position sensing in each modular section within 5 years

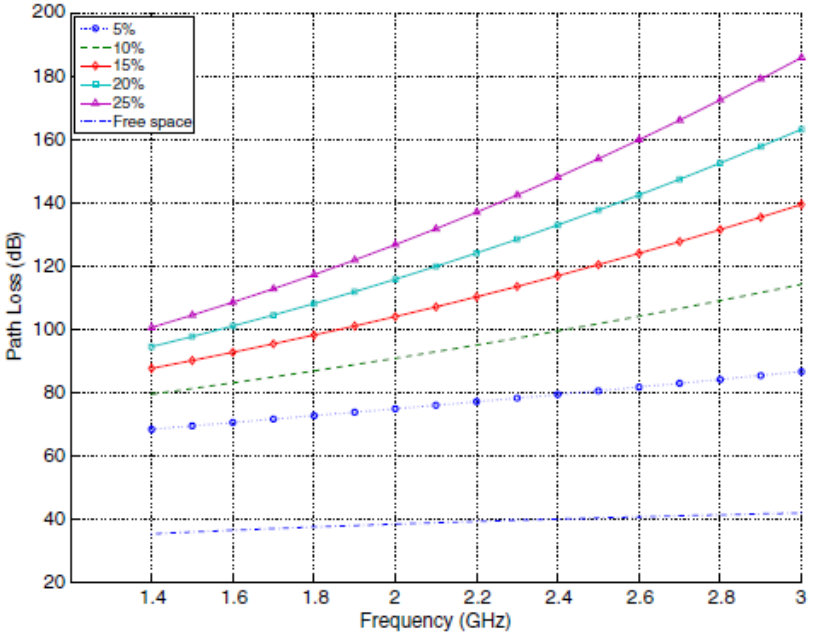


Communication

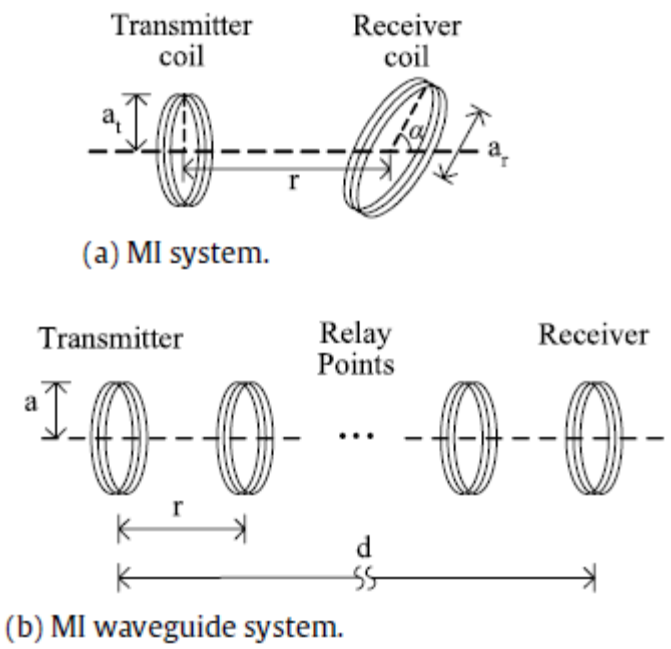


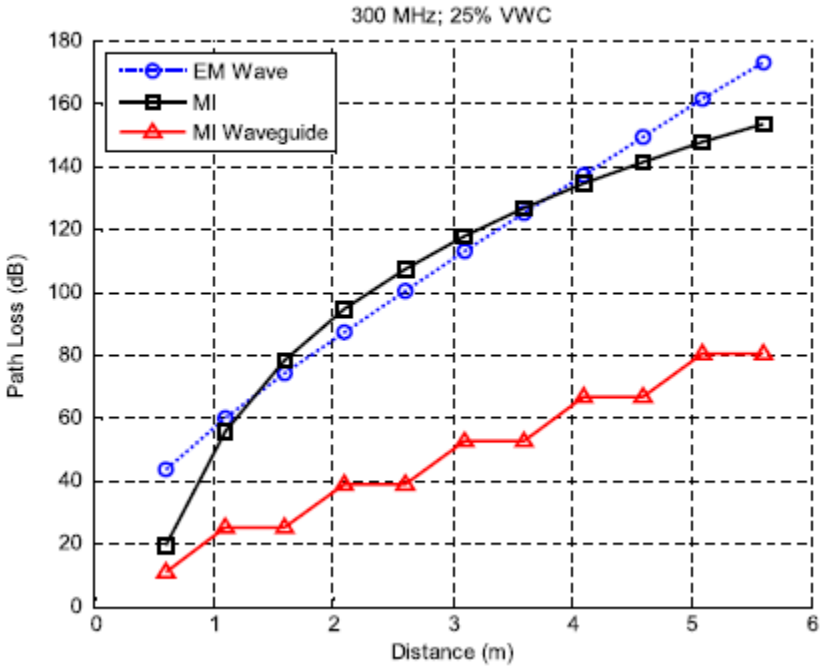
Wireless Communication



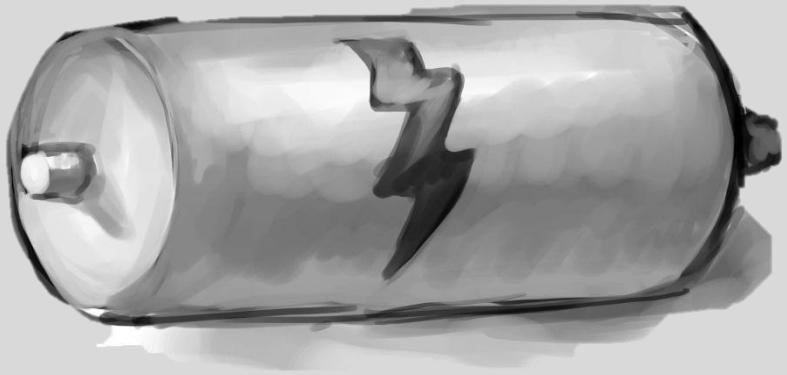


Magnetic Induction



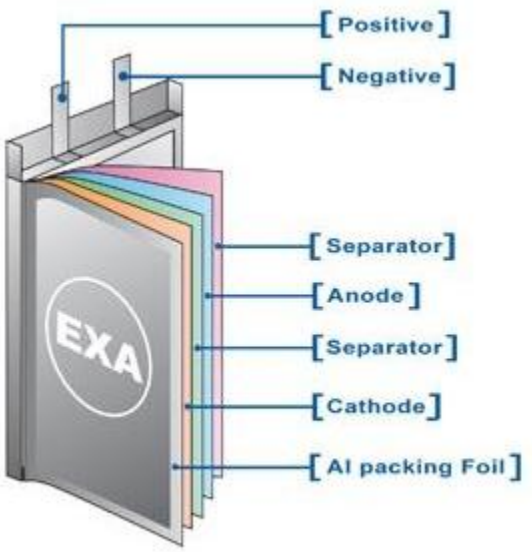


Power



Batteries

- Lithium Polymer (LiPo)
  - Current Specific Energy: 250 Wh/kg
  - Current Energy Density: 360 Wh/L
- Advantages
  - High specific energy and energy density
  - No memory effect and low self discharge
- Disadvantages
  - Dangerous, requiring special protection circuitry

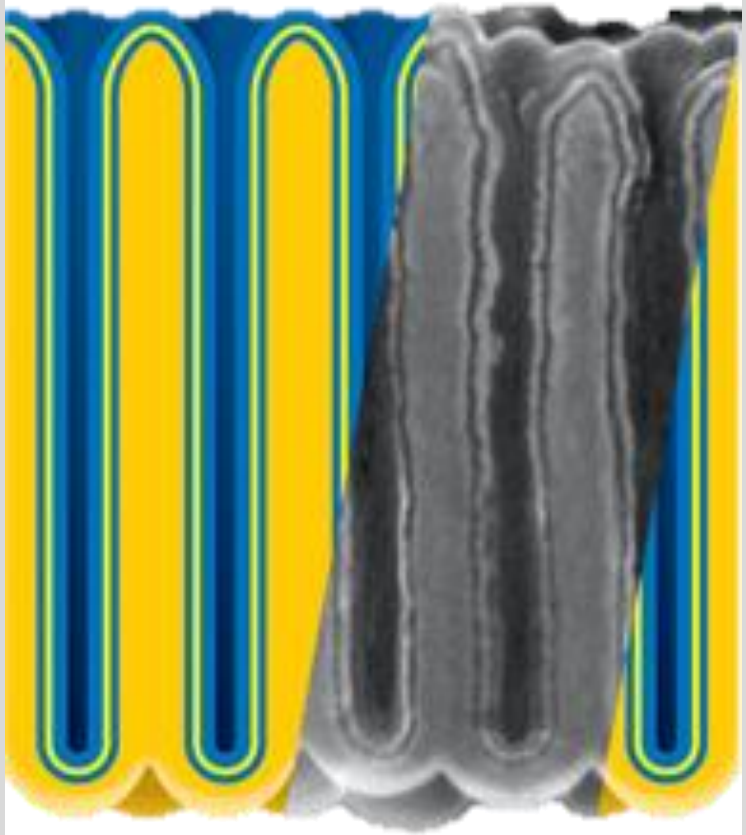


Capacitors

- Supercapacitor, Ultracapactior, etc
  - Current Specific Energy: 30 Wh/kg
- Advantages
  - Very robust, long life with many charge cycles
  - High specific power
- Disadvantages
  - Low specific energy
  - Self discharging

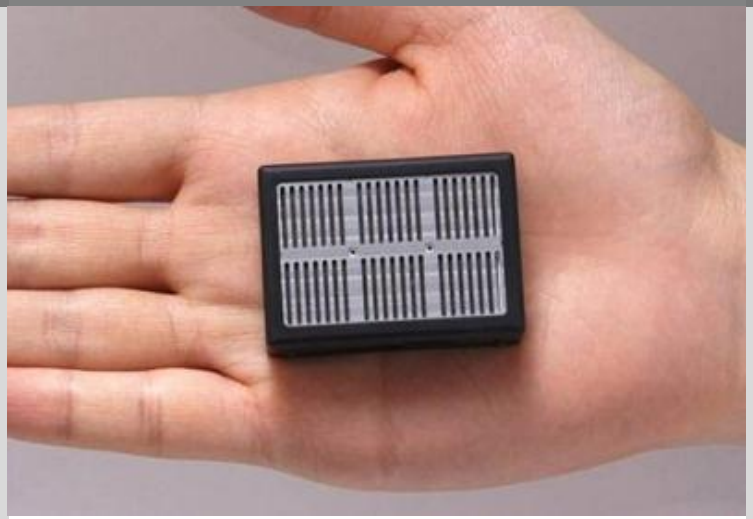
Capacitors

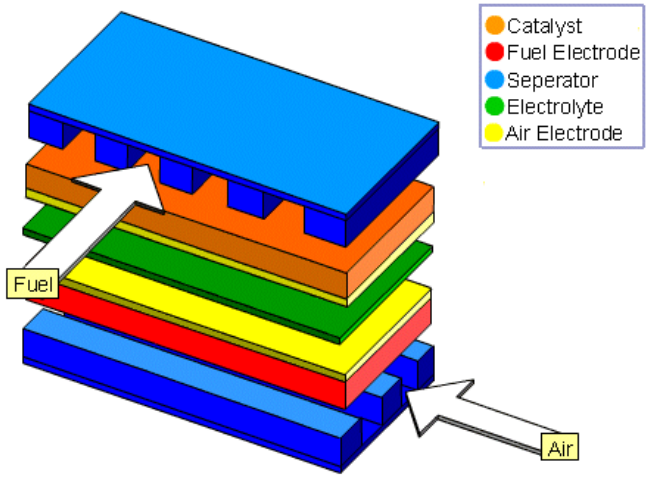
- Nanocapacitors
  - Self assembling
  - 10x improvement over current technology
- Lab proof of concept at University of Maryland



Fuel Cell

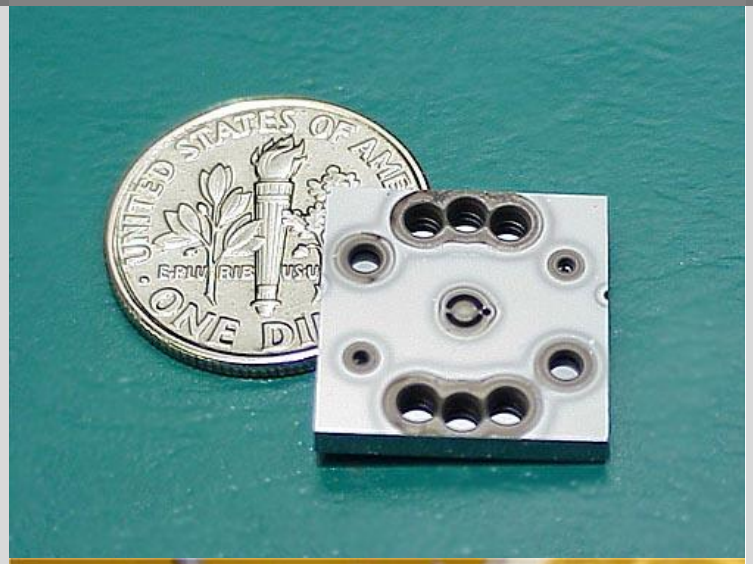
- Constant power output
- Advantages
  - No recharging, just refuel and go
  - Constant power output
- Disadvantages
  - Expensive, mainly due to the platinum
  - Constant power output

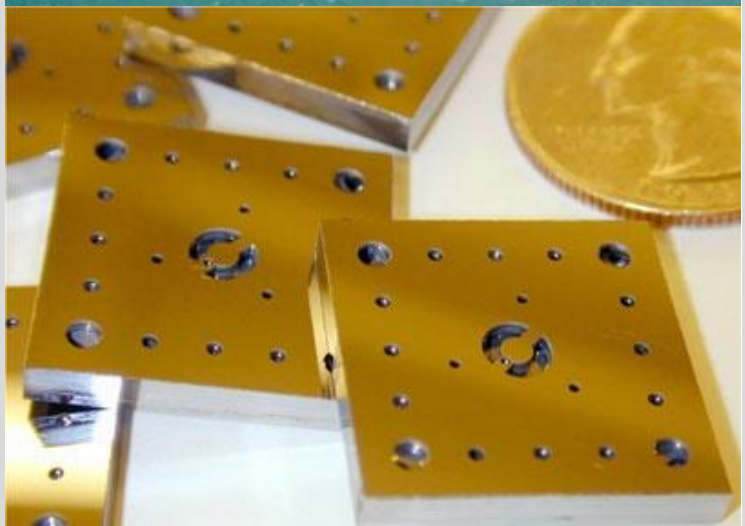




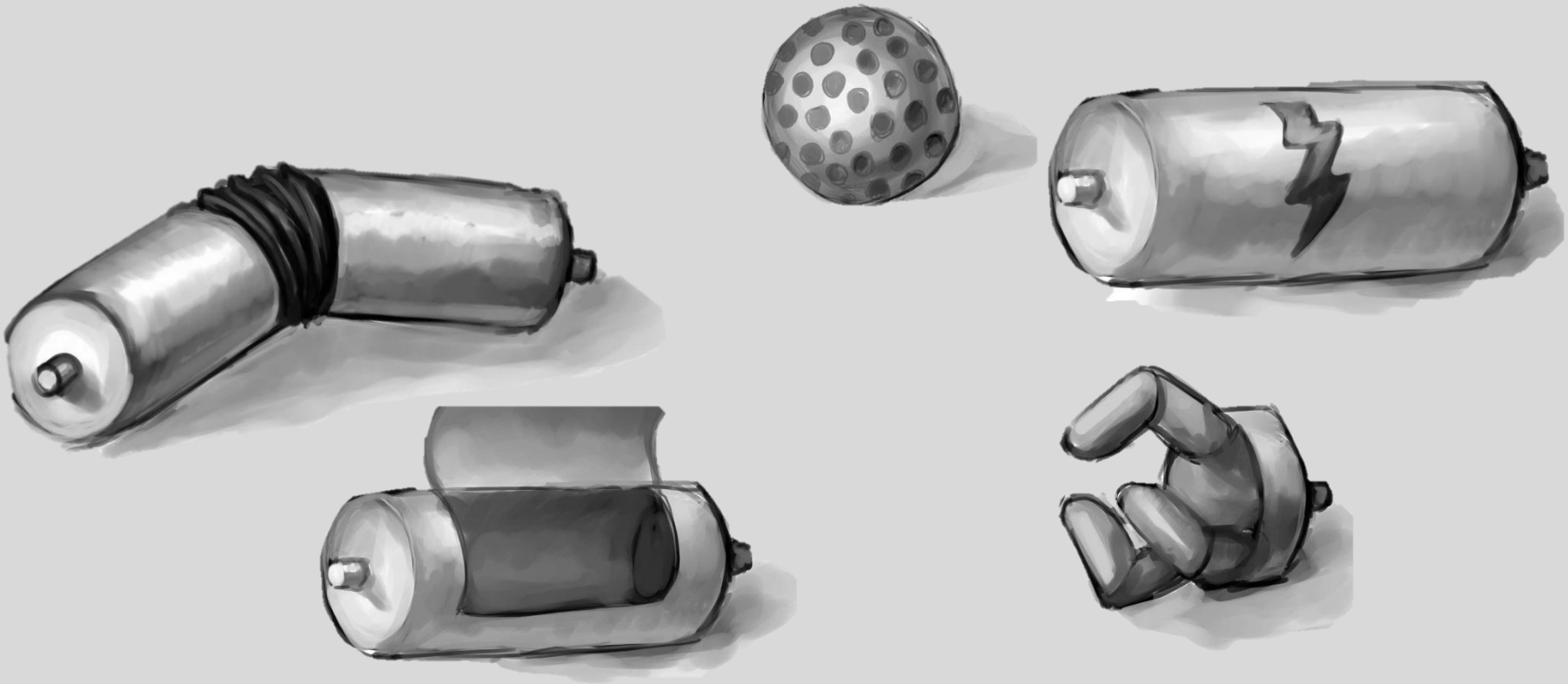
Micro Turbine Generator

- MIT research project
- MEMS fabrication
- 6 silicon layers
- ~10 Watts





Extensible Platform



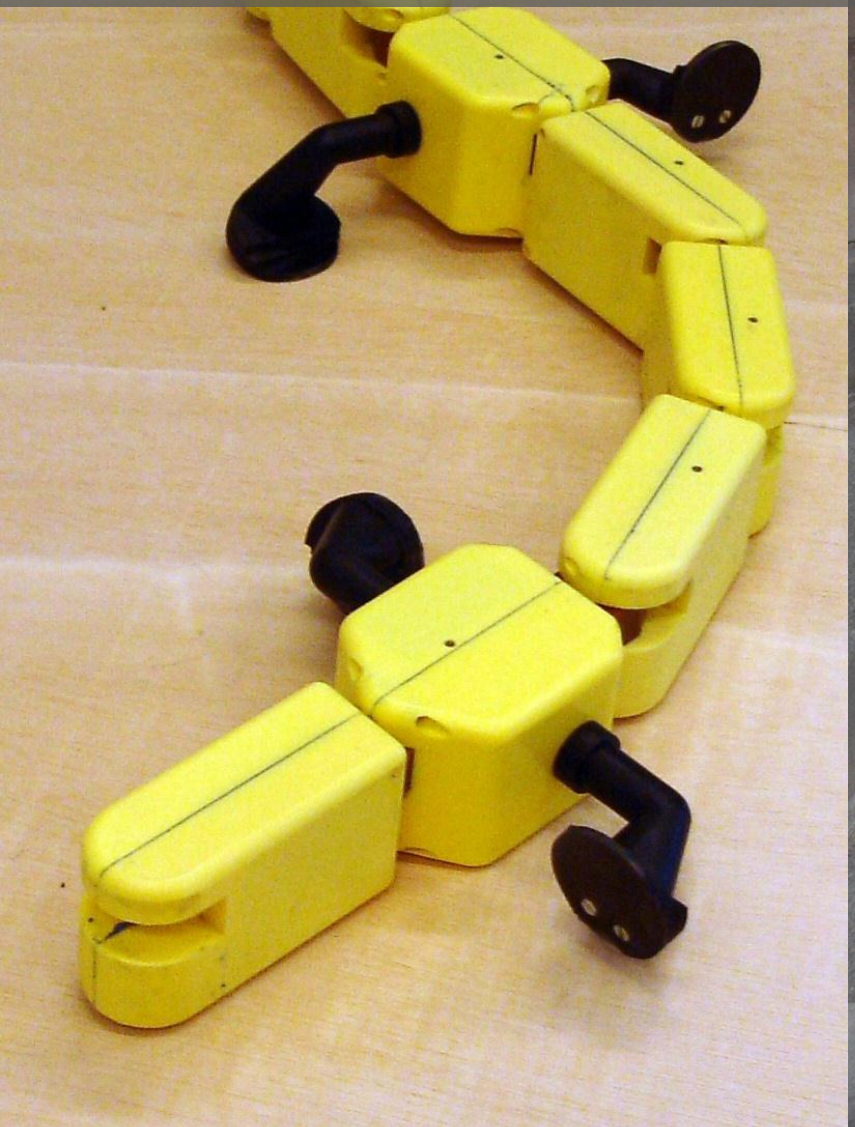
Use Case

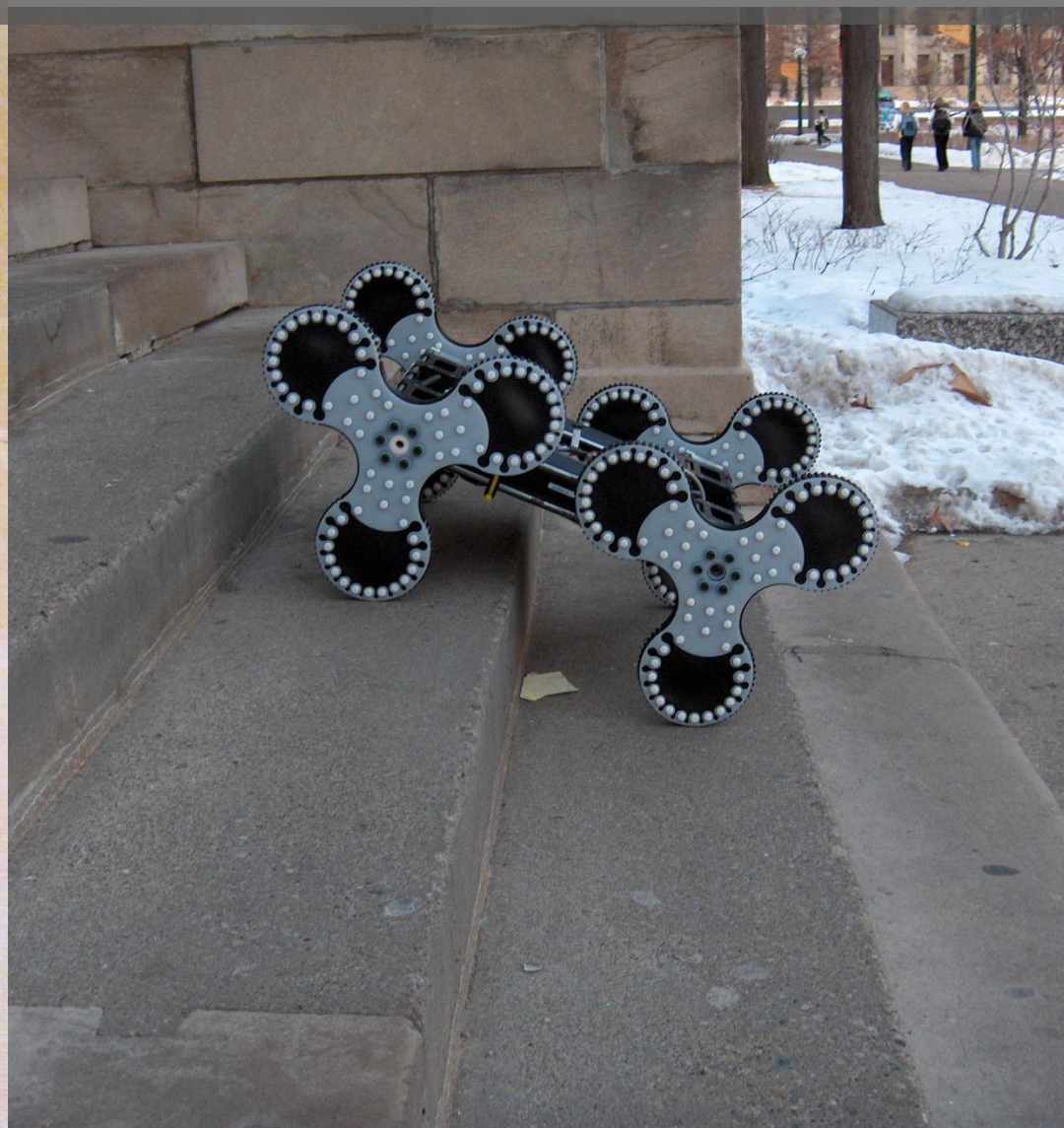
Questions



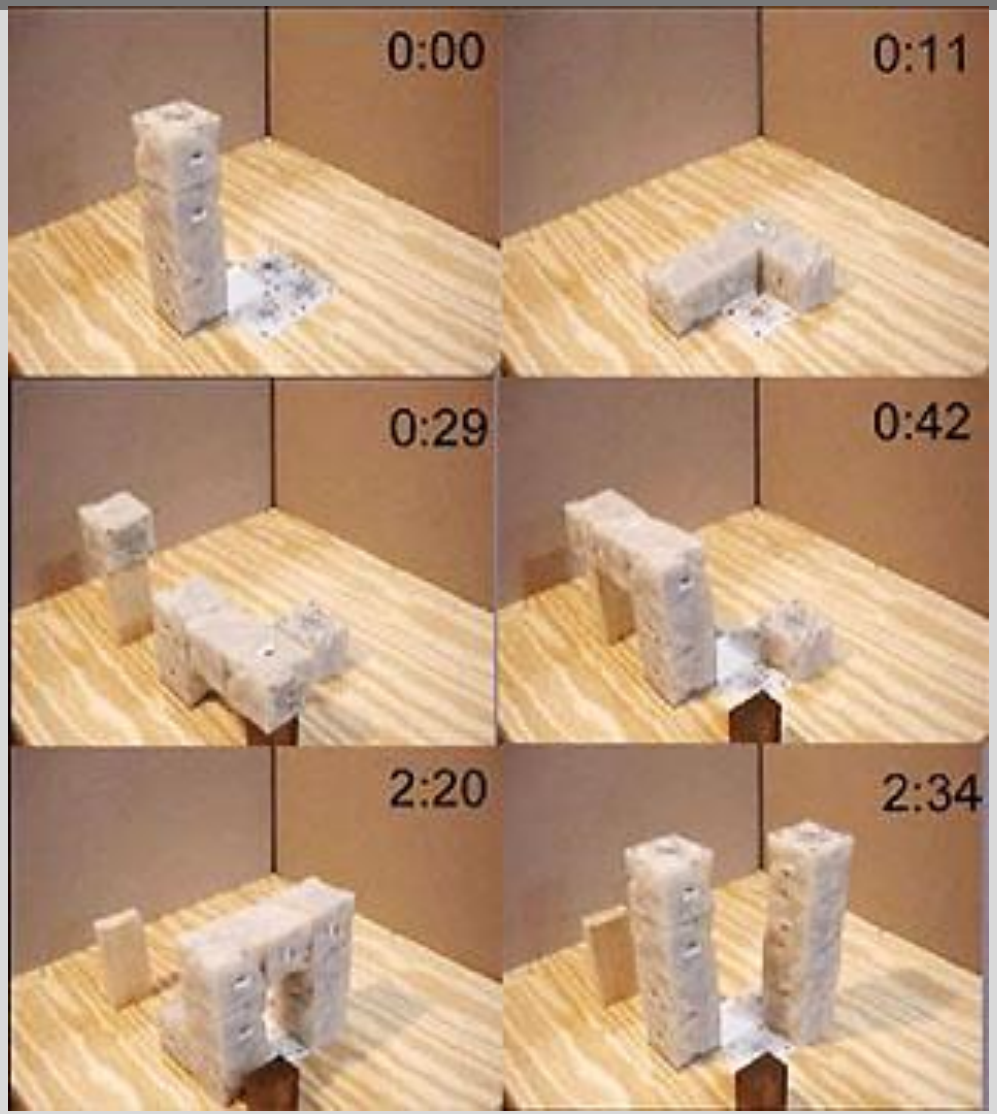
Appendix

Whegs





Self Reordering



Modular Snake

Centipede

Conformable Traction

- Wheeled movement for speed
- Gripping for rough terrain
- Shape changing for confined spaces