# Robotics and Artificial Intelligence

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# Report Documentation Page

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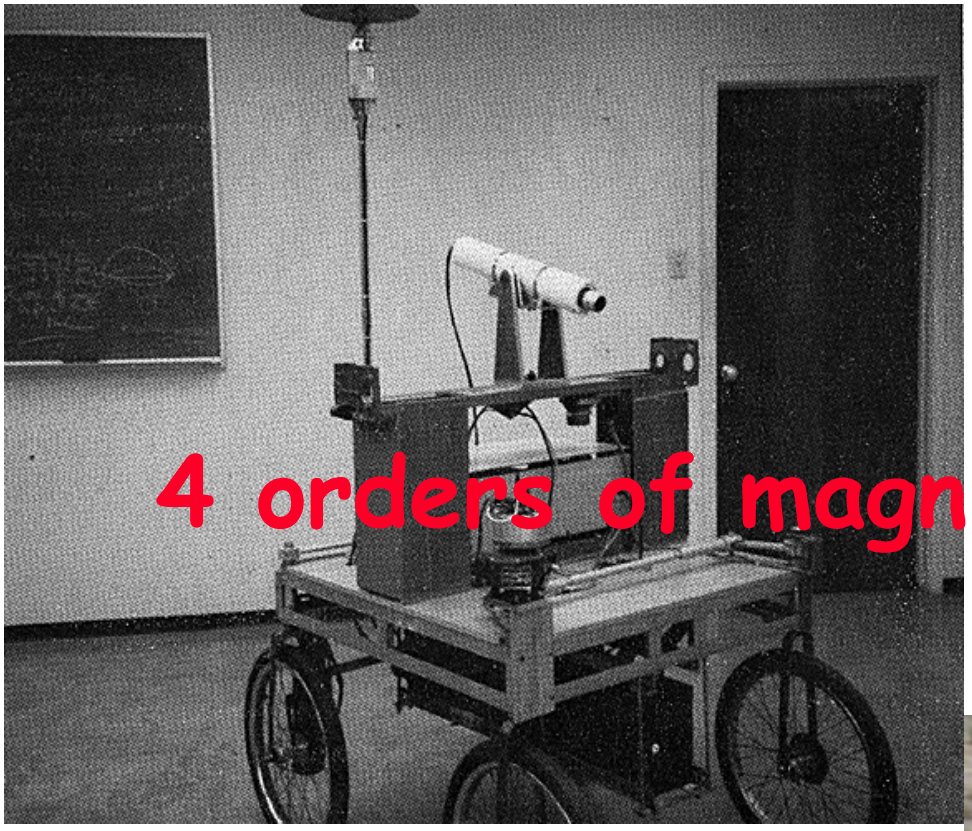
# Stanford AI Lab

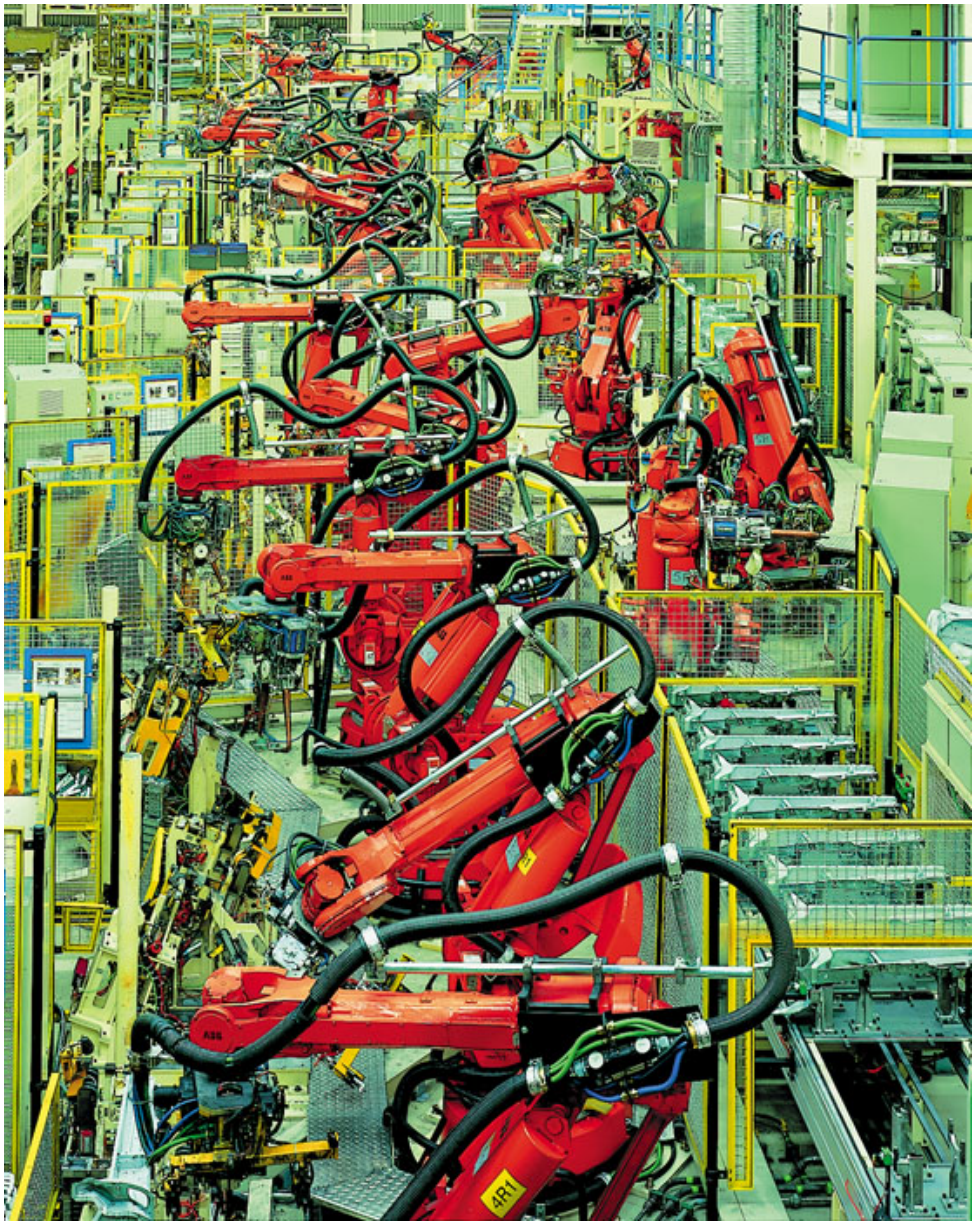


1979: 20 meters/6 hours

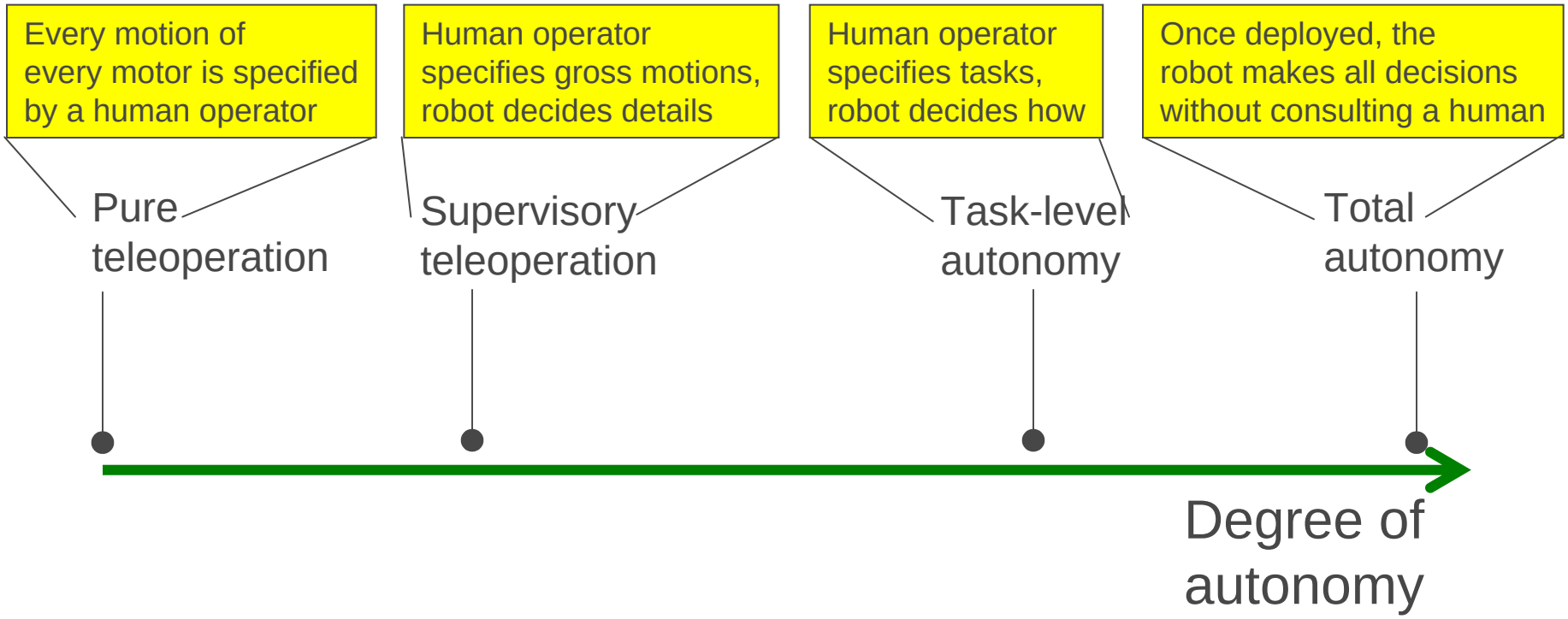
**4 orders of magnitude in 26 years**

2005: 200 kilometers/6 hours

# Our Recent View of Robots



# Autonomy For Robots



# Autonomy Levels

Pure teleoperation

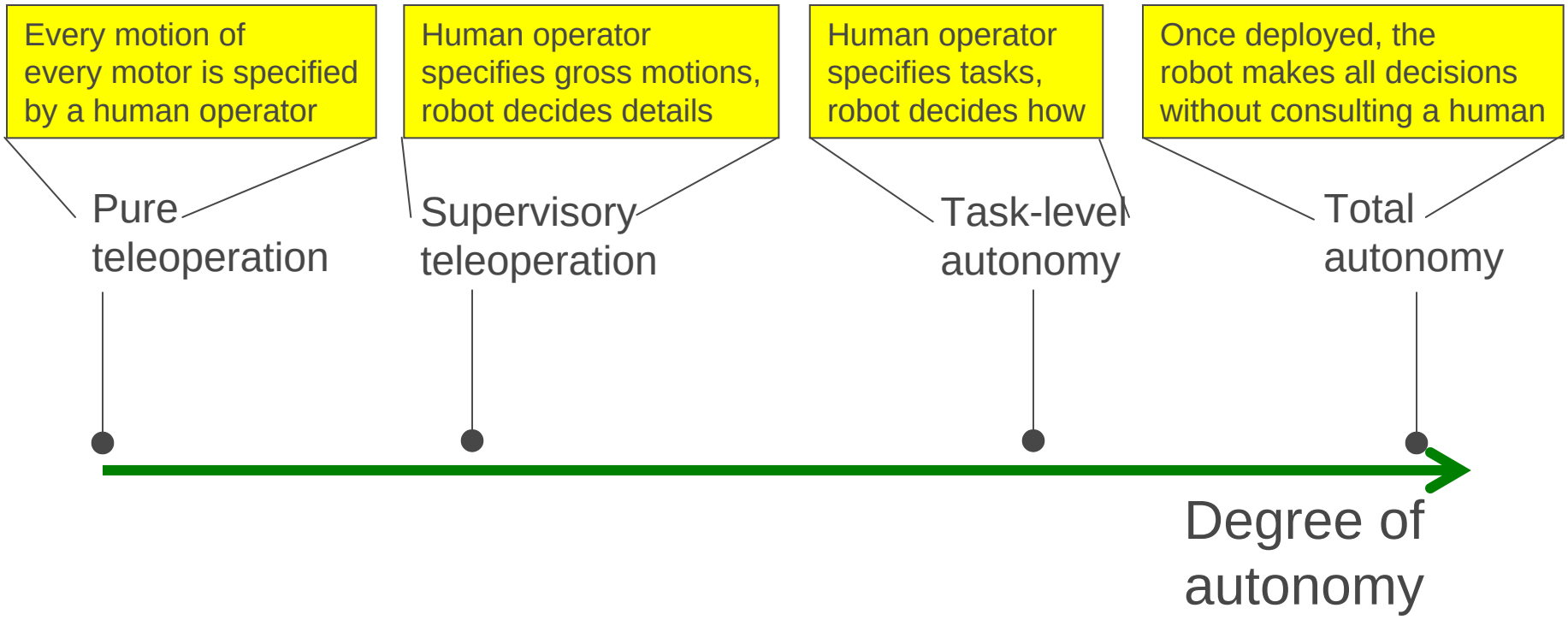
Supervisory teleoperation

Task-level autonomy

Total autonomy

Degree of autonomy

# Autonomy For Robots



# iRobot Autonomy Levels

Pure teleoperation

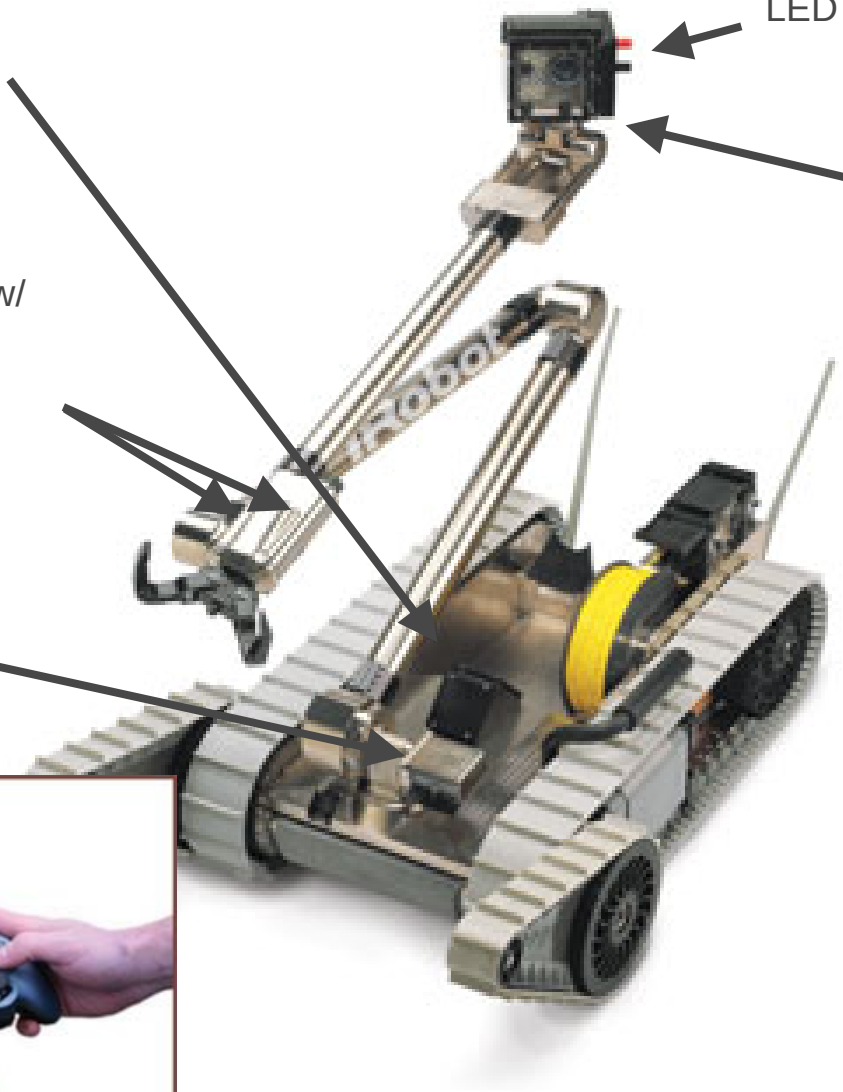
Supervisory teleoperation

Task-level autonomy

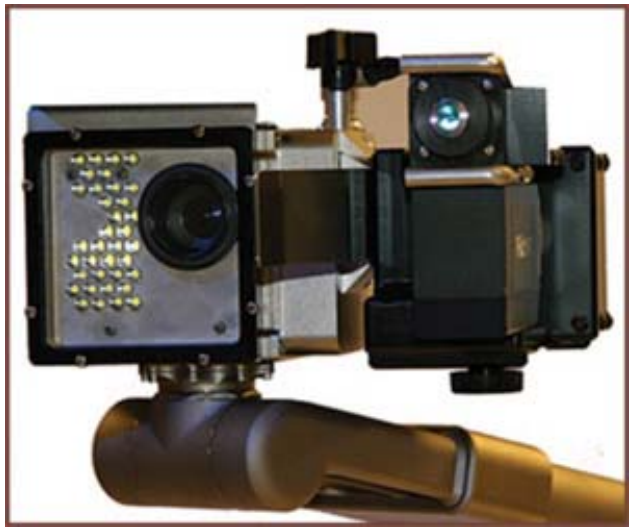
Total autonomy

Degree of autonomy

# PackBot EOD




300X Zoom Camera with Low Light mode



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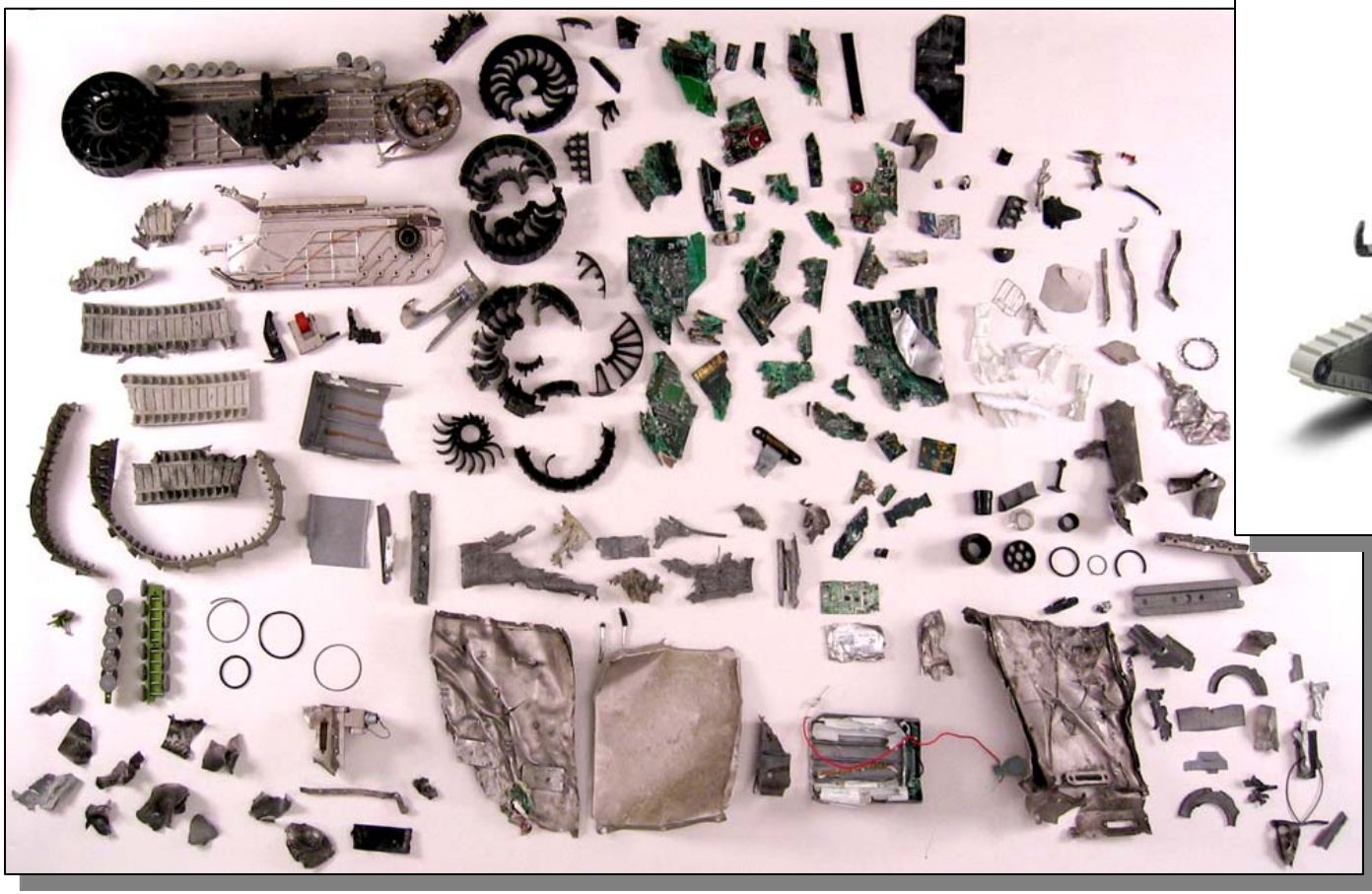

**PackBot #129**

**Killed In Action**
**April 8, 2004**
**Iraq**

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# Why Manipulation for Robots?

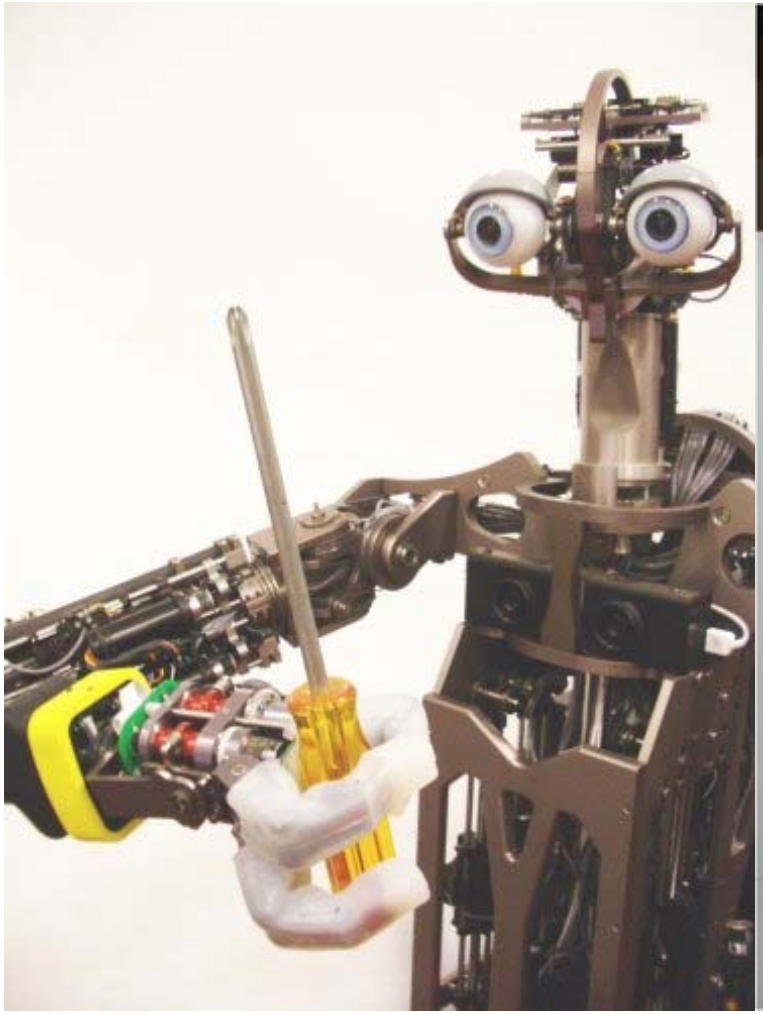
- Teleoperation of manipulation is slow and difficult
  - for EOD missions this is currently acceptable but not optimal
  - for tactical situations it is not acceptable
- Tasks for manipulation in tactical situations
  - opening doors
  - rapidly placing charges
  - poking and lifting
- Tasks for manipulation elsewhere
  - logistics and supply
  - casualty removal

# State of Art in Robot Manipulation

- Deployed
  - pre-engineered in carefully controlled environments
  - pure (or marginally supervisory) teleoperation
    - » perhaps after a task-level or fully autonomous traverse

- Touch Sensors
  - mostly rigid
  - mostly require too much pressure
  - mostly measure only normal force

# Lab Robots For Grasping



Force only

Force and touch

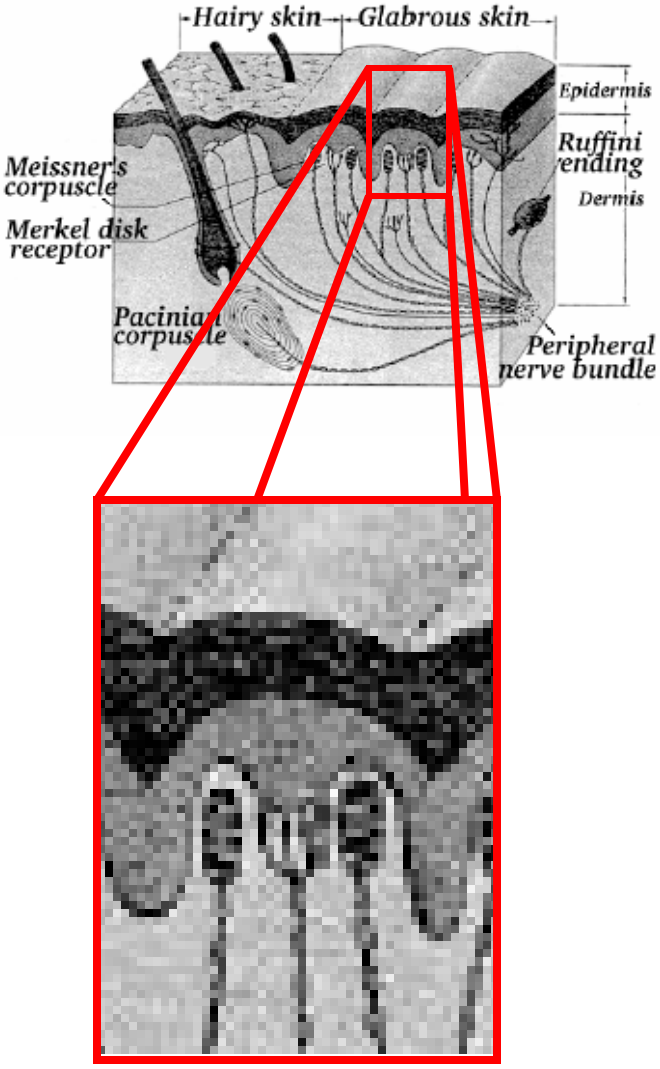
# Pure Force Control

Movie File

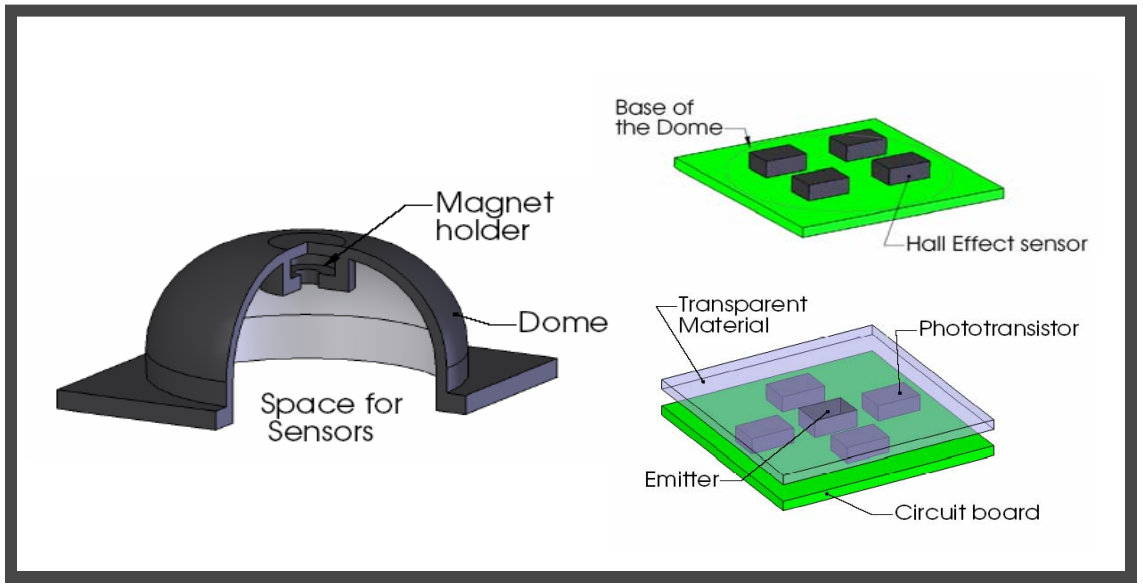
# Our Approach to Touch

- Biological inspired sensors.
  - Dome shaped
  - Deformable
- Sensors favor compliance over spatial resolution.

- RIDGES



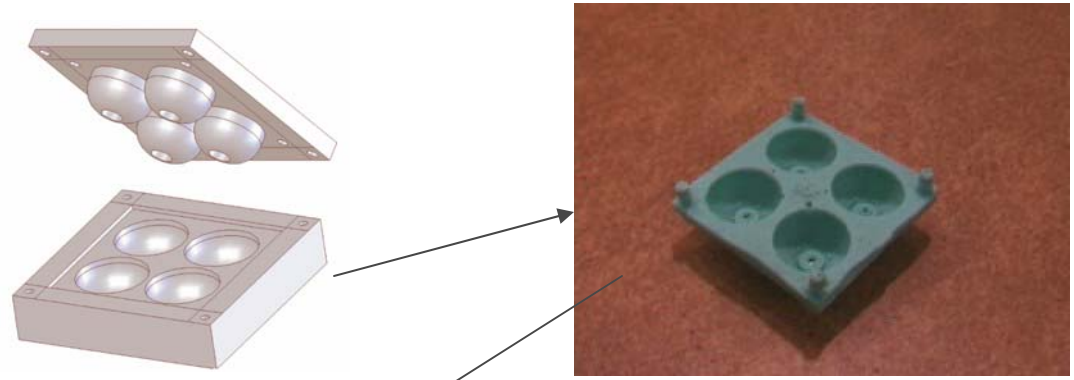
# Approach to Tactile Sensing

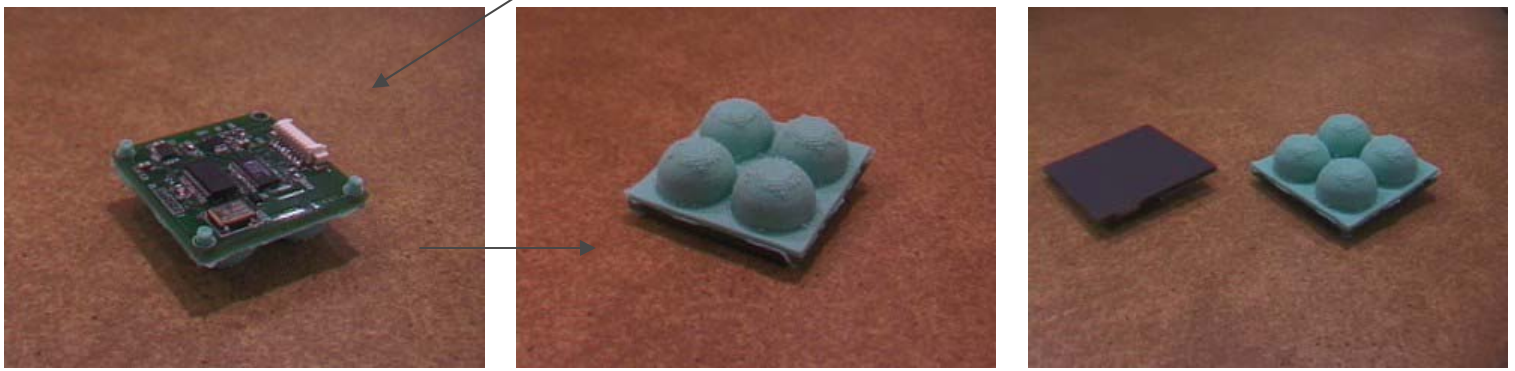


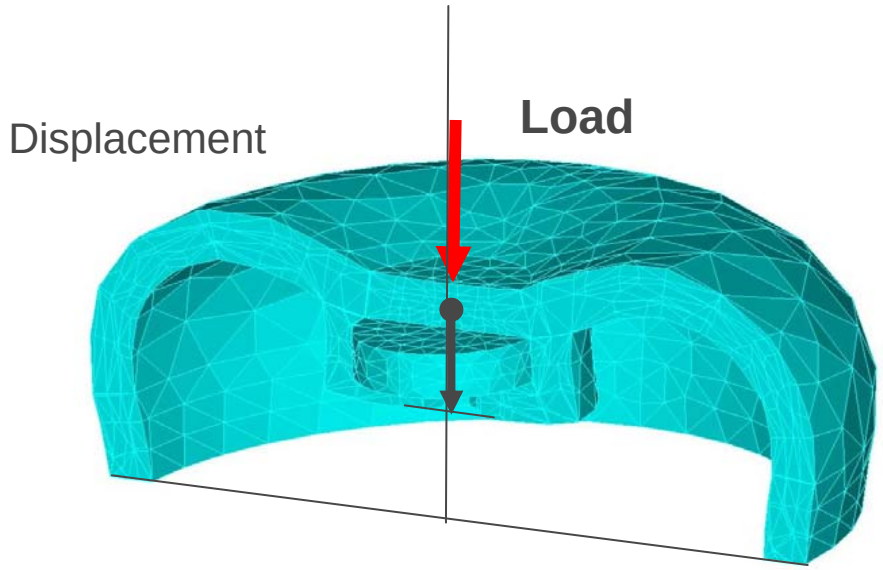

- Position of the top of the sensor gives an estimation of the force applied
- Magnetic:
  - A magnet on the dome, 4 hall effect sensors on the base
- Optical version
  - A LED and 4 photo receptors on the base

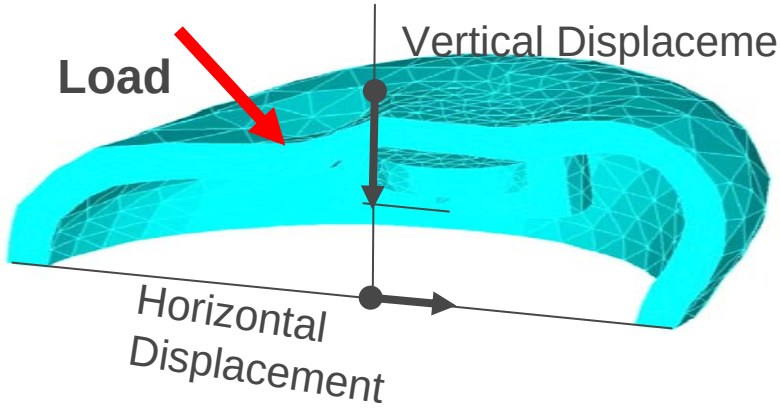
# Sensor Prototyping

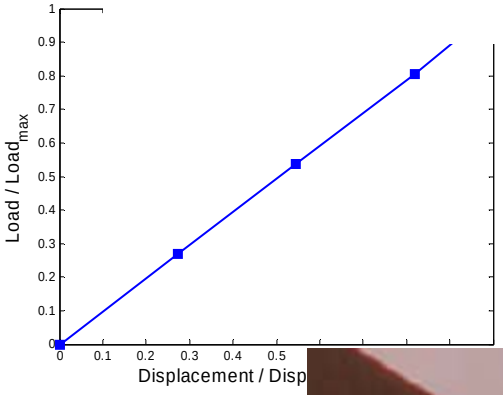
- Molding silicon rubber

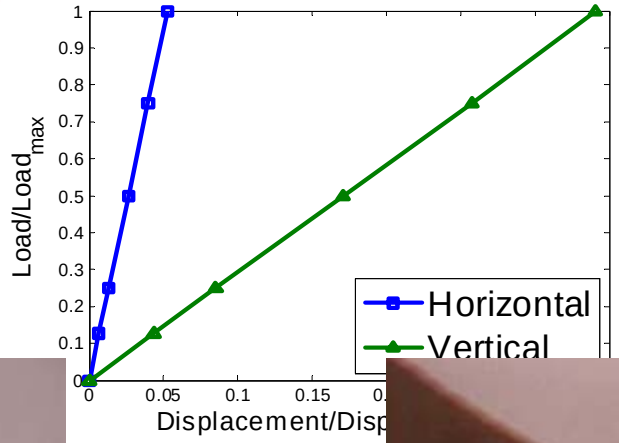





Displacement
Load


Load
Vertical Displacement
Horizontal
Displacement


Load / Load_max
Displacement / Disp


Load/Load_max
Horizontal
Vertical
Displacement/Disp

## Movie File

# Slip Detection + Correction

# Micro Technology & Manipulation

- Embedded processing
  - for images, planning, control
- Tactile sensors
  - transistors in compliant materials
  - large arrays
  - sheets that can be cut and shaped
- Other tactile modalities
  - intertwined with temperature sensors
  - intertwined with sniffers
- More generally
  - not just faster, and lower power
  - embedded computation and sensing in materials