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System Design

ME 2984

“Design is a funny word. Some people think design means how it looks. But of course, if you dig deeper, it’s really how it works.” - Steve Jobs

WHAT AM I TRYING TO DO?

- Design is about making choices
  - Law of Unintended Consequences
- Several different approaches
- Operates at multiple levels
- Write it down so you can come back to it later
  - What *and* why

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GET ME A DRINK!

- I want soda, but don't want to leave my desk
- What does my robot butler need to do?
- How do we approach the problem?

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BRAINSTORMING TIME

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SOLUTIONS

Credit: Youtube

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SOLUTIONS

Credit: Willow Garage

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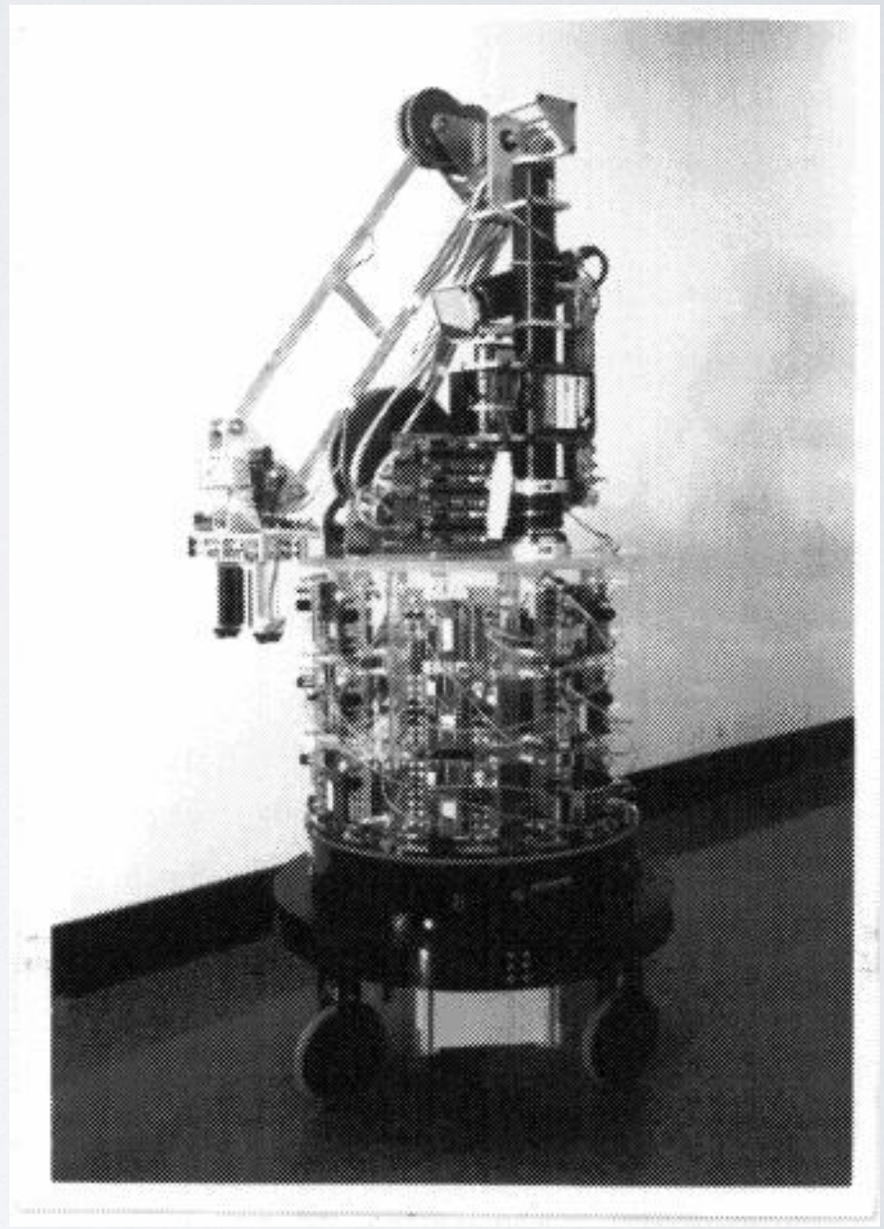
WHICH IS BETTER?

HERBERT

- 3 wheels
- Laser Sensor
- IR Sensors
- Independent, small processors



Source: Brooks *et al*

PR2

- Kinect
- 5 MP Camera
- Stereo Camera
  - Wide and narrow
- LIDAR
  - Shoulder and base
- Accelerometers
  - Base and Hands
- Pressure Sensors
- Forearm Camera

Source: Willow Garage

REQUIREMENTS AND DESIGN

- Similar on the face
  - Mobile base
  - Manipulator
    - Task performed
- Major differences in approach

WHICH IS BETTER?

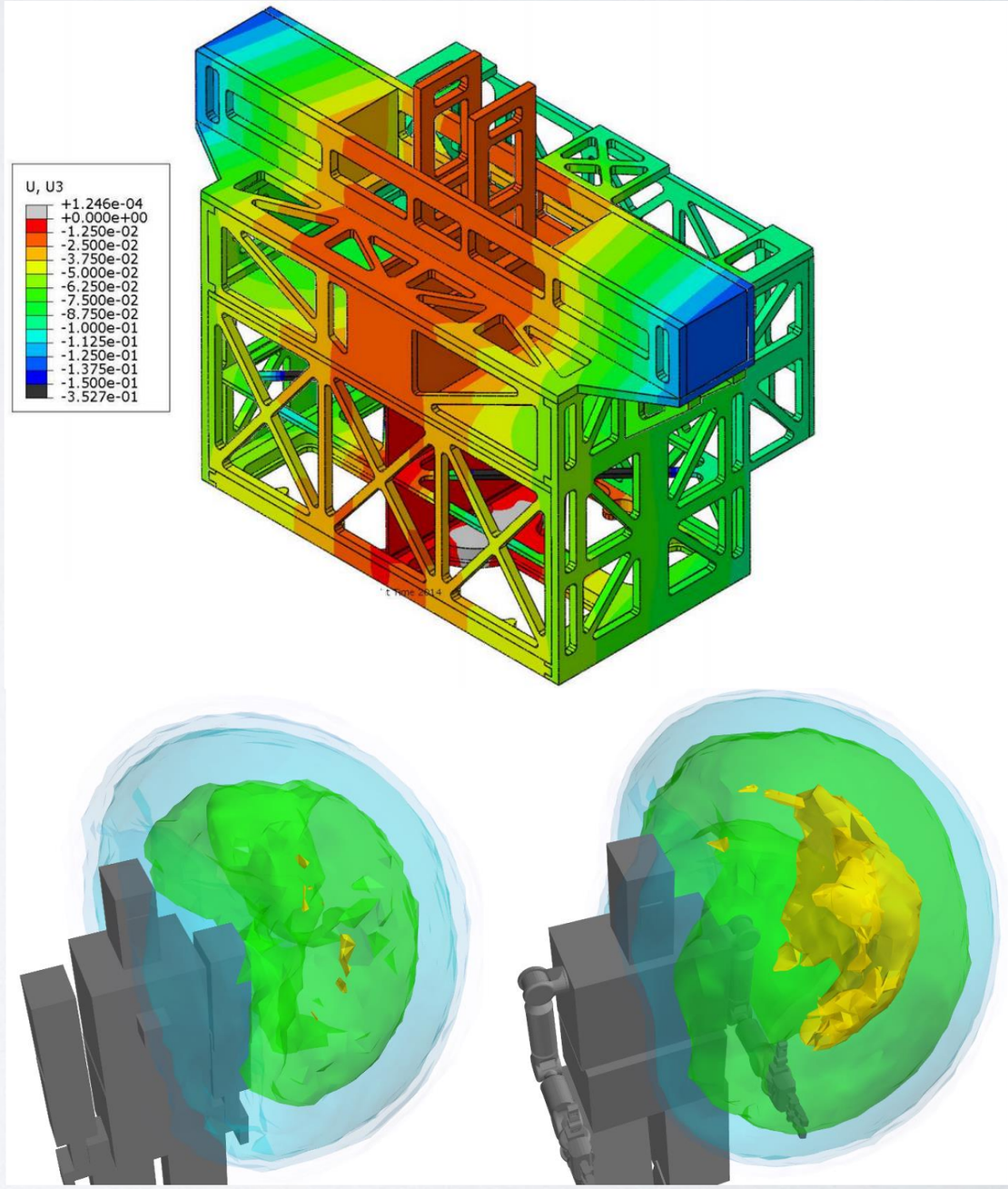
- Herbert can achieve the goal with less sensors and technology
  - Designed with a specific goal in mind
  - Complex behavior from simple systems
- PR2 is a more general design
  - Bottom up approach
  - How do we achieve a goal with a given system?
- Better depends on metrics chosen

SCALES OF DESIGN

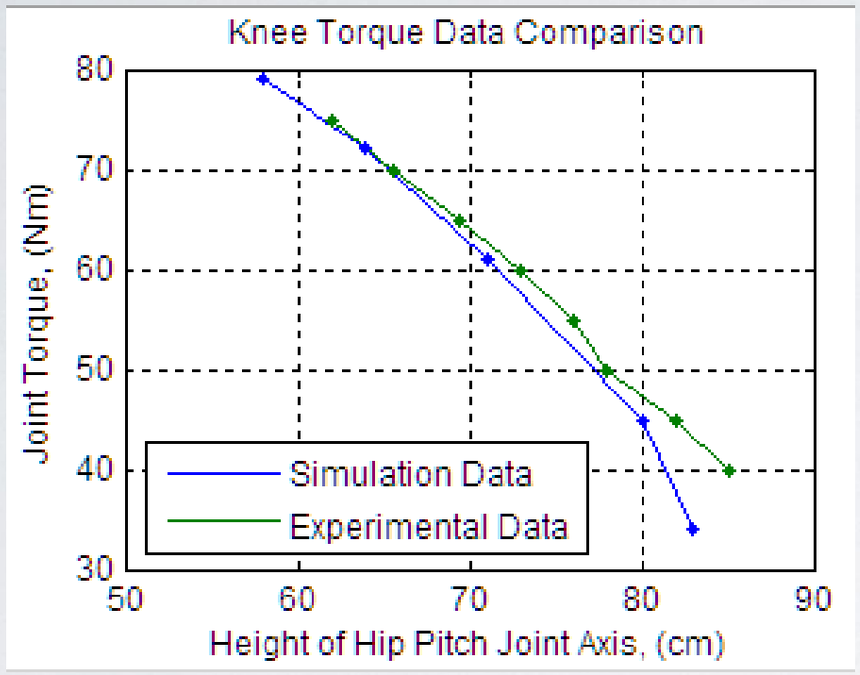
- Design operates over many scales
  - Technical
  - System
  - Environment
  - Small Scale Interaction
  - Society

TECHNICAL DESIGN

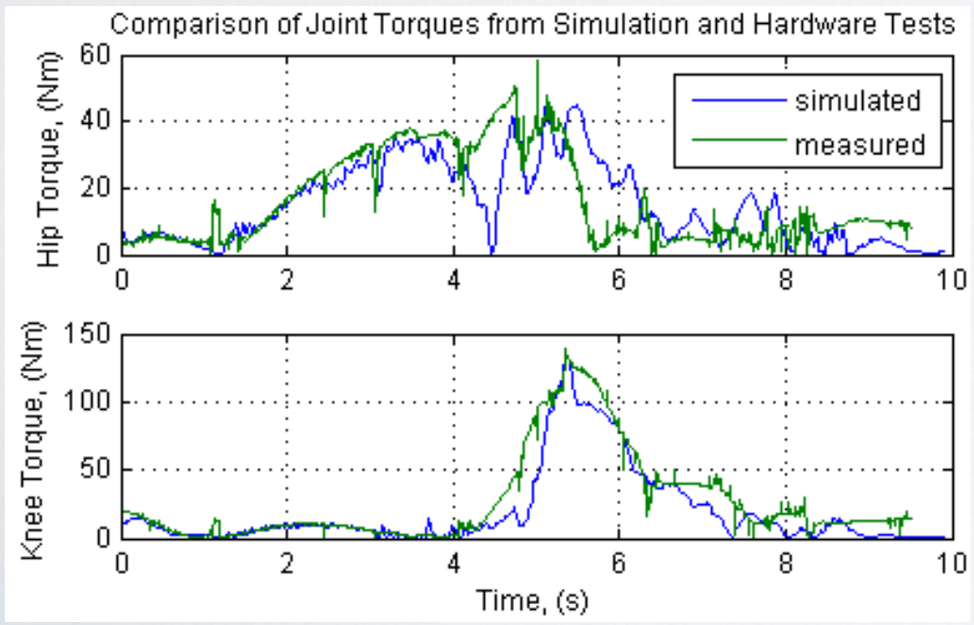
- Define technical requirements
  - Understand how requirements evolve
- Analysis is crucial
- Think about factors of safety
- Leave room for the future



V&V



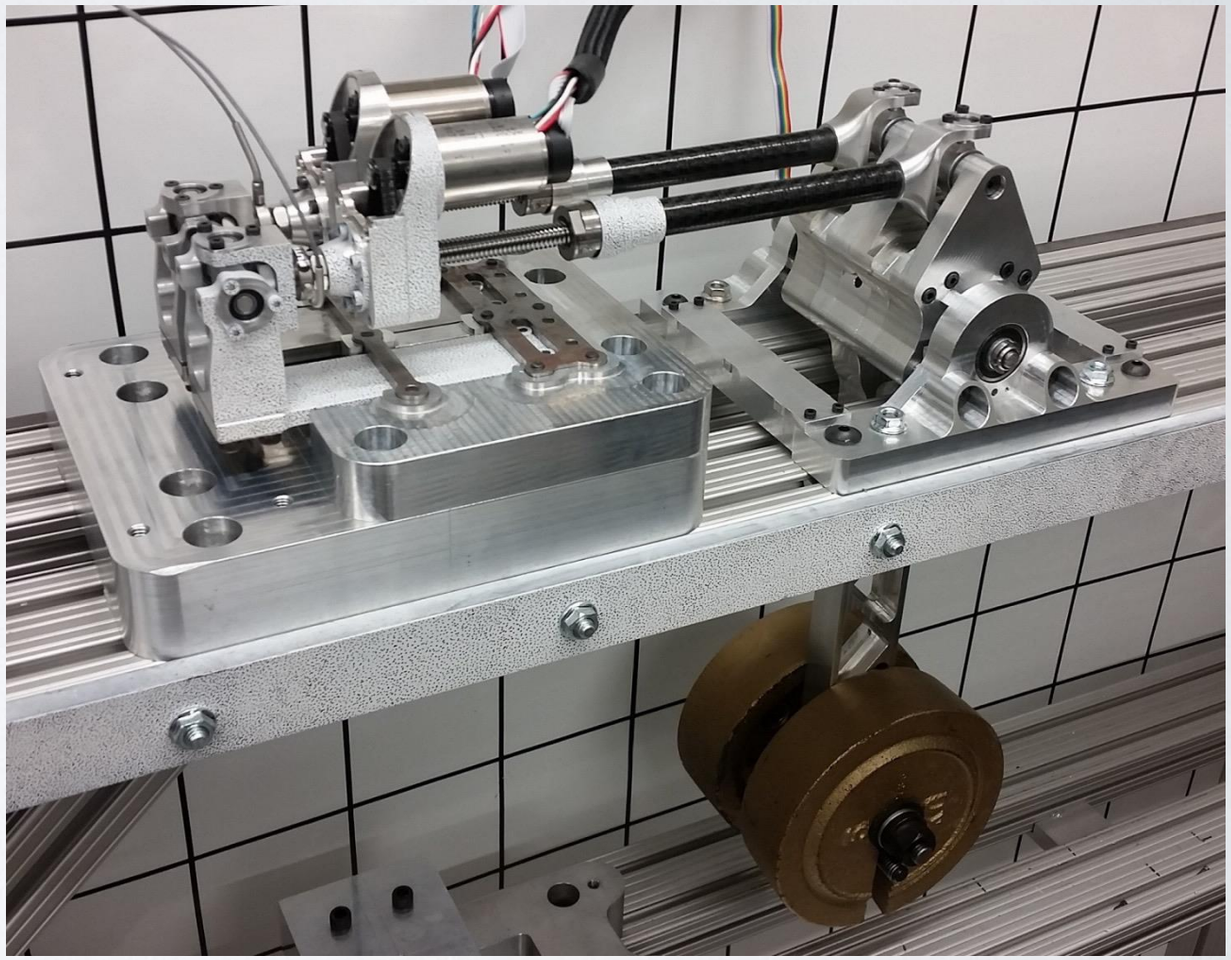
- Validation
  - Are you building the right thing?



- Verification
  - Are you building it right?

TESTING

- Test from small to large
- Have a plan
- ALWAYS record data!
- Don’t just test for success, test for failure!



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TAKE IT FROM THE TOP

- Start with the big picture
- Decompose the problem
- Keep track of the puzzle pieces
- Over designing can be tempting

START WITH THE FIRST STEP

- Start with small, useful units of capability
- Keep adding new ones
- Eventually build up to higher levels of capability
- Emergent Behaviors

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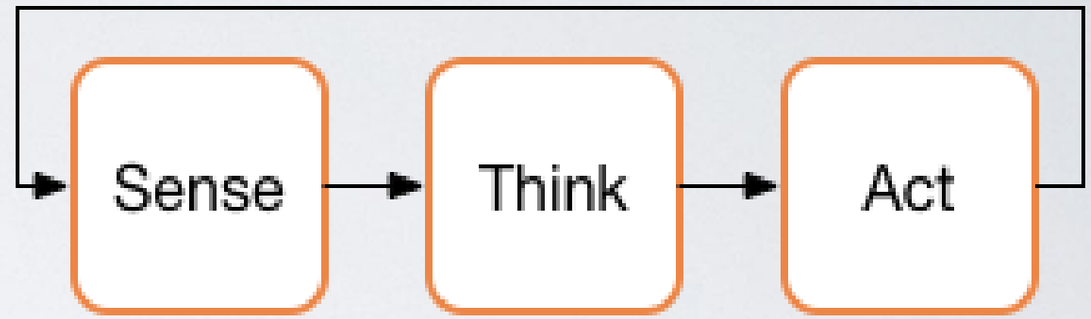
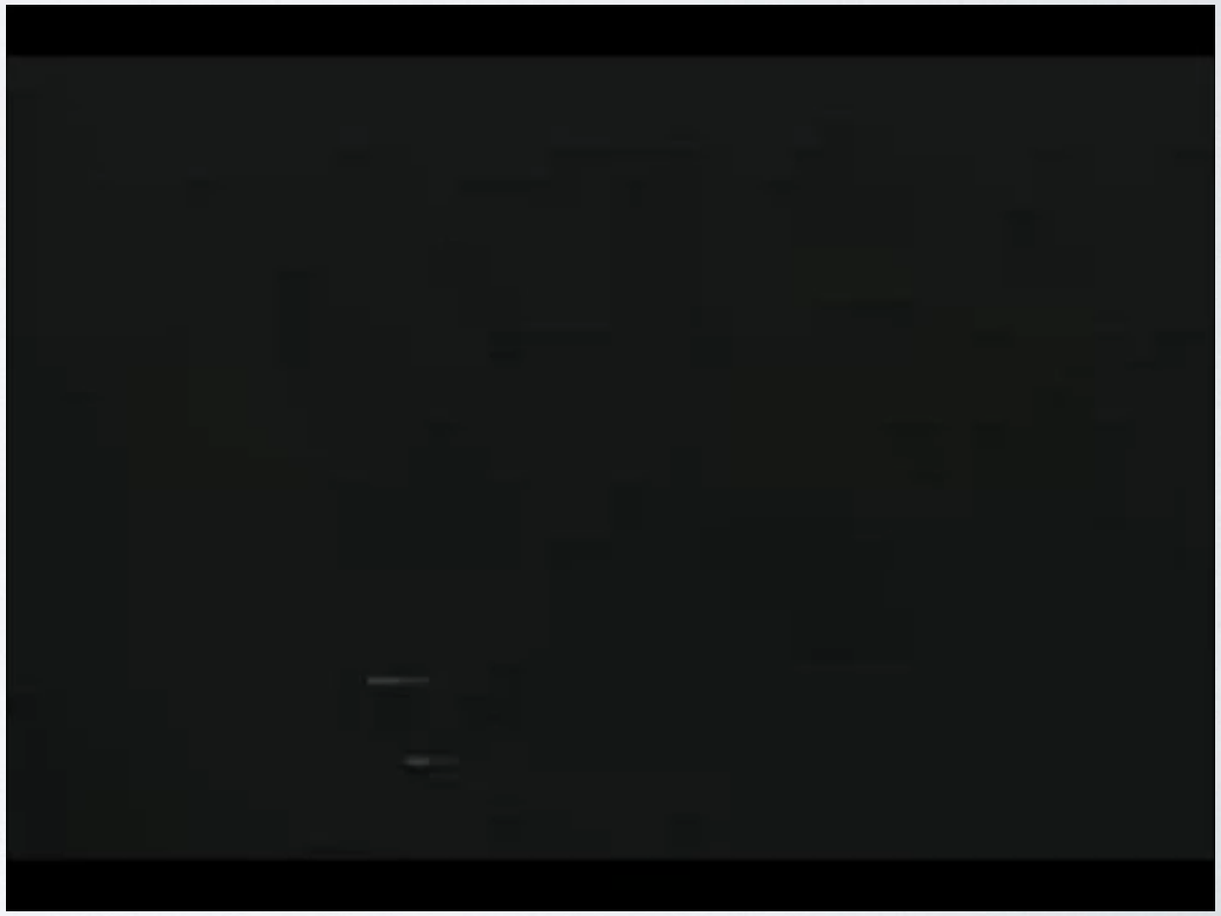
MEET IN THE MIDDLE

- Hybrid both approaches
- Minimize over-design
  - Encode useful concepts in the design
- Typically an iterative process
- Sometimes uses a voting scheme
- Needs care to reach a local minima

DELIBERATIVE SYSTEMS

- System uses data to plan for the future*
- Useful for encoding expert information into system
- Require much more structure





Credit: SRI

REACTIVE SYSTEMS

- Sensing directly leads to action
- Faster reactions, no lookahead

Credit: Frivolous Engineering

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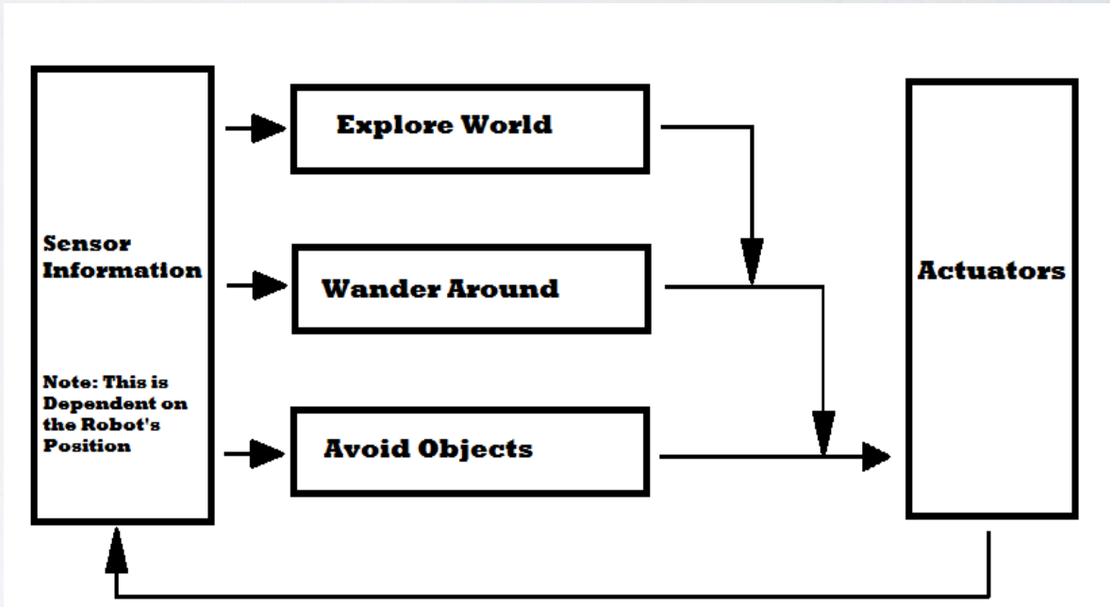
HYBRID SYSTEMS

- Try to capture best of both worlds
- Hard to transition between styles
- Sometimes referred to as Behavioral Robotics
- Plan sequence of behaviors

SUBSUMPTIVE ARCHITECTURE

- Developed by Rodney Brooks at MIT



Source: Wikipedia

- Independent sub-behaviors

- Bottom Up Layering

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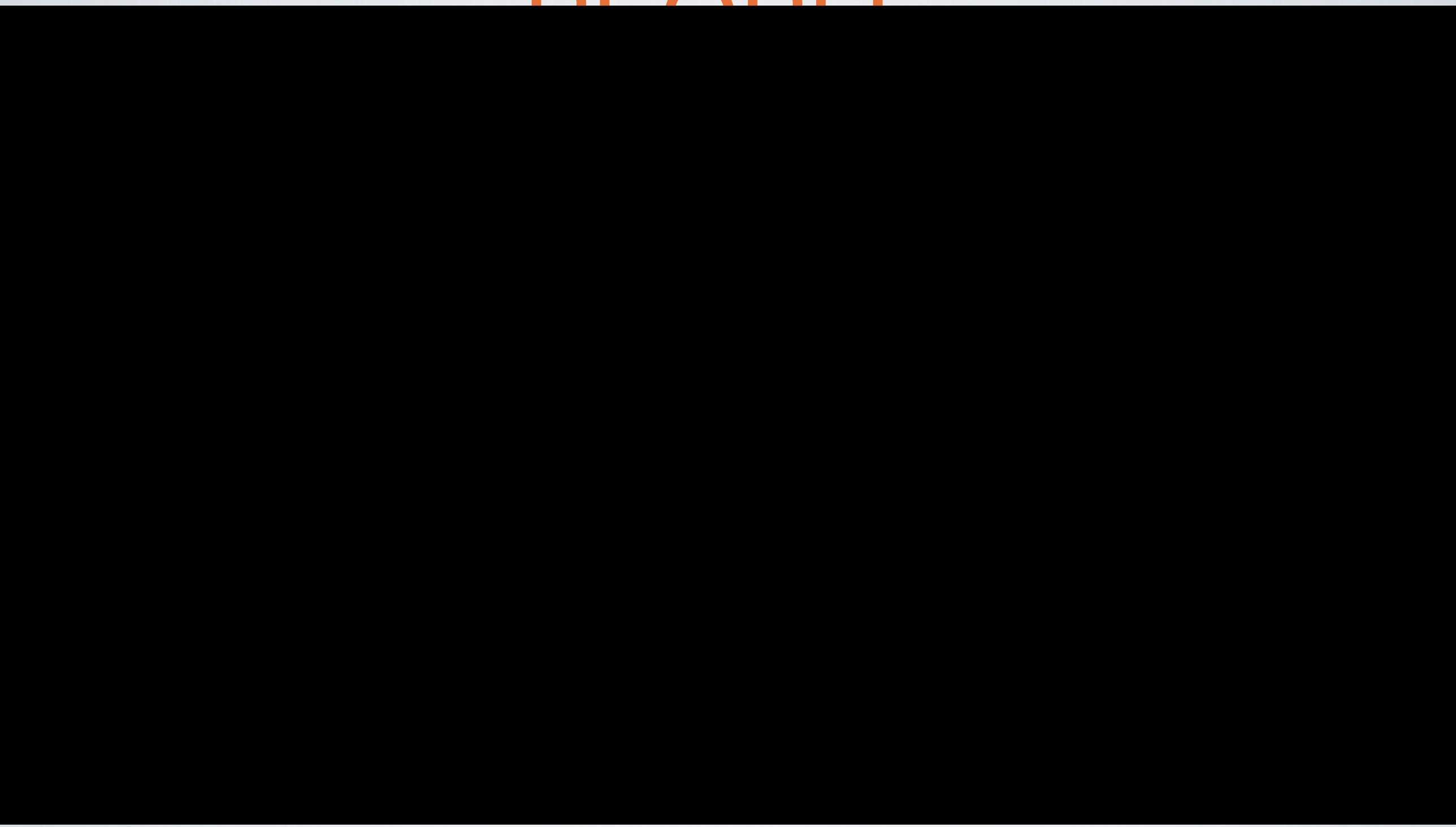
PROBLEMS IN CONTEXT

- Context drives how a problem is formulated
  - And how people think about a problem
- Problem definition can fundamentally alter the approach (and difficulty) of a project
- The inverse situation is true as well

INTERACTING WITH PEOPLE

- Robots interact with people in a variety of roles
- As roboticists, we can design the robot for interactions
- People are strange (and we can't design them)
- Covers a massive range of issues

INTERACTING WITH PEOPLE



Credit: ONRL

SOCIETAL DESIGN

- Role of robots in society?
  - Tool
  - Assistant
  - Cultural Participant

Credit: Construction Robotics

SOCIETAL DESIGN

- Role of robots in society?
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Credit: Google

SOCIETAL DESIGN

- Role of robots in society?
  - Tool
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Credit: Sony

WHY BUILD A HUMANOID?

- Navy wanted to fight fires
- Previous Experience
- Advancing Technology
- Analyzing Risk

Source: Logan Wallace

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SUGGESTED WORK

- ROS Tutorials will be very helpful
  - 1, 2, 5-8 are likely useful already
  - 3, 4, 12, 13, 17 will be useful soon

PROJECT PROPOSAL

- Cover required topics
- Start forming teams
- Teams can propose a budget of $20/member for the class to purchase to loan for projects
  - Subject to approval
- Using outside resources to acquire hardware is fine within reason