Control

How does that mobile robot know where to go?
Bridgewater State University

Moving the robot in the world

- Look at three types of robotics control in this class
  - Remote control <ick>
  - Teleoperated robots
  - Autonomous robots

Remote control

- Person controls all aspects of the robots actions
  - Usually use a joystick
  - Person uses own sensors to choose an action for the robot
  - Controls motor function and duration for robot.
  - Use robot like a remote control toy car.
  - not really considered a robot

Autonomous Robots

- Robot acts in the world under its own control and direction.
  - Human can tell robot to do some act but not how to do it.
    - Tell robot via language, button pushes, etc.
  - Very simple autonomous robots: Roomba
  - Other autonomous game playing robots: robot soccer.
    - Robots work together without human intervention
  - These applications explicitly forbid human interaction.

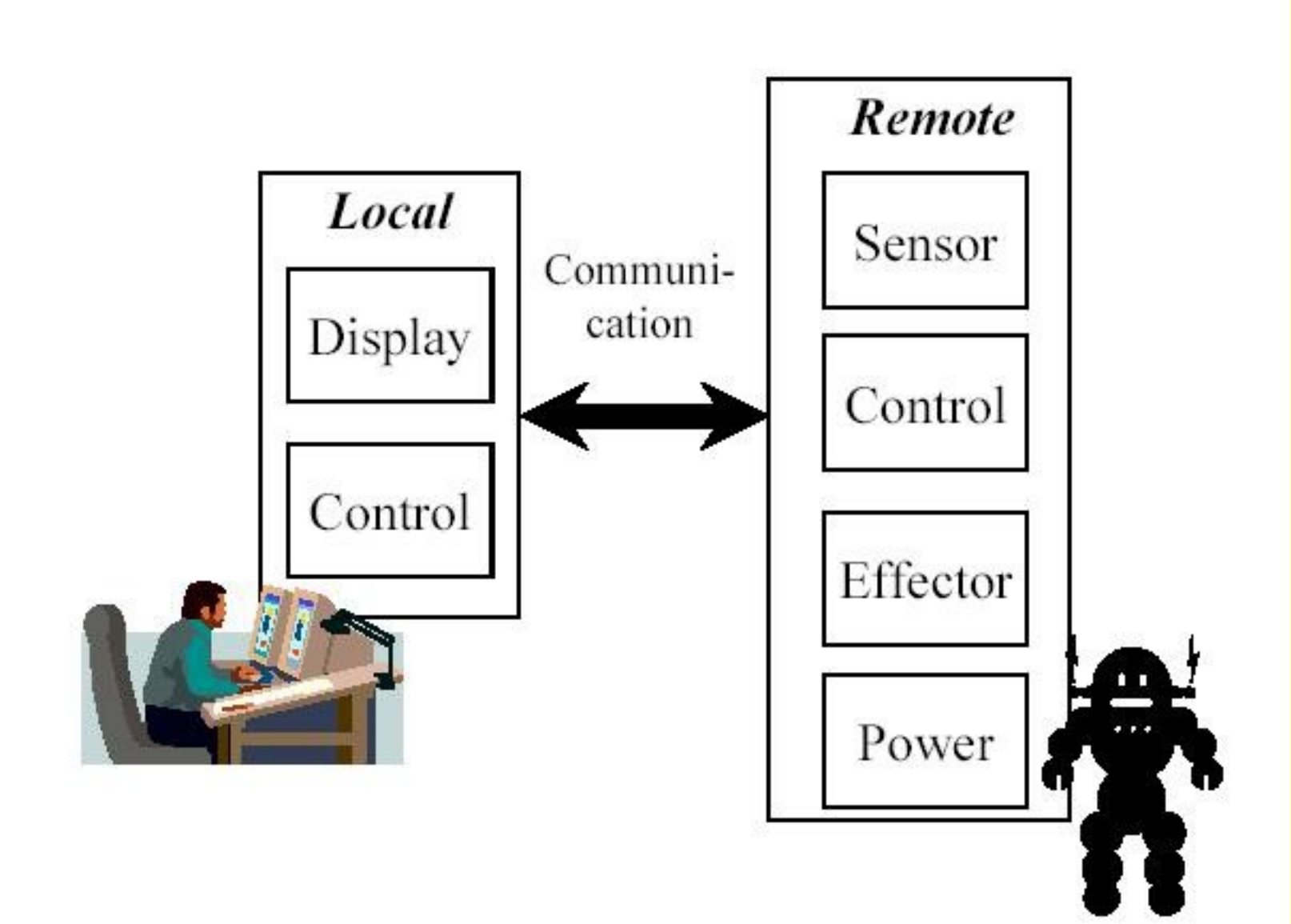
Between the extremes

- Remote control and autonomous represent the extremes of robot control
- Between the two is teleoperation.
  - Not only division, but will be broad in this class.
  - Teleoperation some times broken into more sub categories
  - Researchers still debating the precise meaning of the term.
  - So will look at teleoperation in more depth.

Whats and Whys of teleoperation

- Teleoperation used when human and robot are physically separated and must interact in order to accomplish the task.
- Why teleoperation and not autonomous robots?
  - Practical implementable AI is too limited in many situations
    - AI is really hard for solving general problems.
      - AI-Complete problems.
  - Some situations are just too dangerous to trust AI system with current state of AI
  - Sometimes, unmanned to reduce cost.

Components needed for teleoperation



Thanks to Robin Murphy's AI Robotics book for diagram.

Component breakdown I

- On local side (from person's point of view)
  - Display (show sensor data collected by robot)
  - Local control device
    - Joystick or buttons or keyboard etc.
- Some sort of communication is required to robot
  - Wireless Ethernet
  - Tethered control
  - Ethernet radio (wireless serial communication)

Component Breakdown II

- At remote side (on robot's side)
  - Remote control device
    - Method of receiving commands from user.
  - Sensors
    - Some subset of the sensors that we talked about earlier
    - And sometimes vision.
  - Effectors
    - Motors and more to allow robot to make changes in environment
  - Power supply for robot.

Teleoperated anthropomorphic systems

- https://www.youtube.com/watch?v=9yFl83L3d8U&t=
-

https://www.japantimes.co.jp/life/2020/07/08/food/remote-controlled-robots-f

Sort of Anthropomorphic

- Tele-presence and industrial

Teleoperated Non-anthropomorphic

- Urban search and rescue competition
  - https://www.skillsusa.org/wp-nt/uploads/2021/02/Robotics-U Search-and-Rescue.pdf
  - Biggest group teleoperated
    - In this one autonomous disqualified
  - Goal to add more automation.
  - Why are robots good for this task?

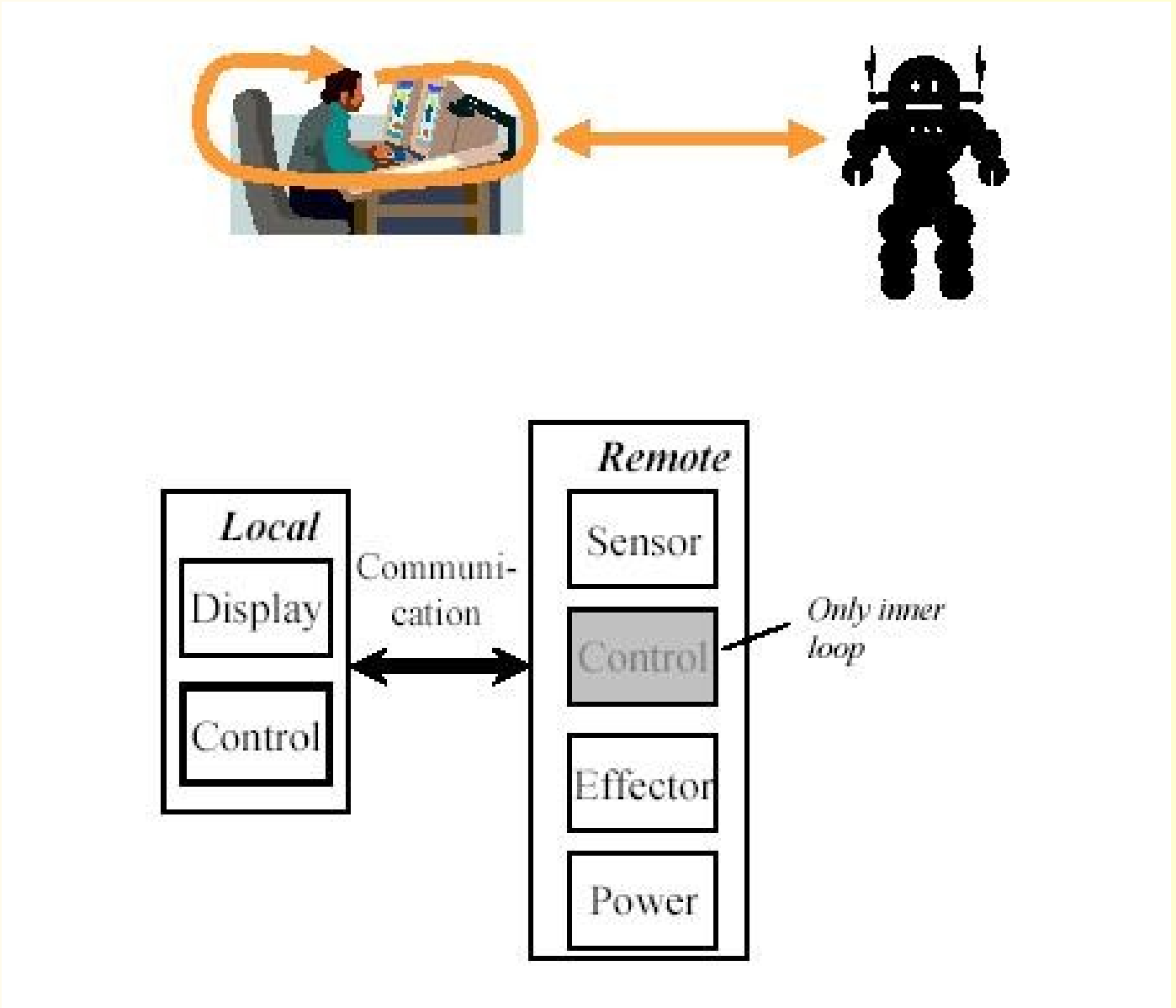
Human supervisor

- Robot has a human supervisor if
  - One or more human operators are (at least intermittently) giving directives and (continually) receiving information from robot that itself closes a loop between its own sensors, effectors in a process or task environment.
- With human supervisor,
  - Human always in the loop.
    - May only set high level objectives.
  - Information “”received” may be lack of info
    - Nothing new happening

Human Supervisor II

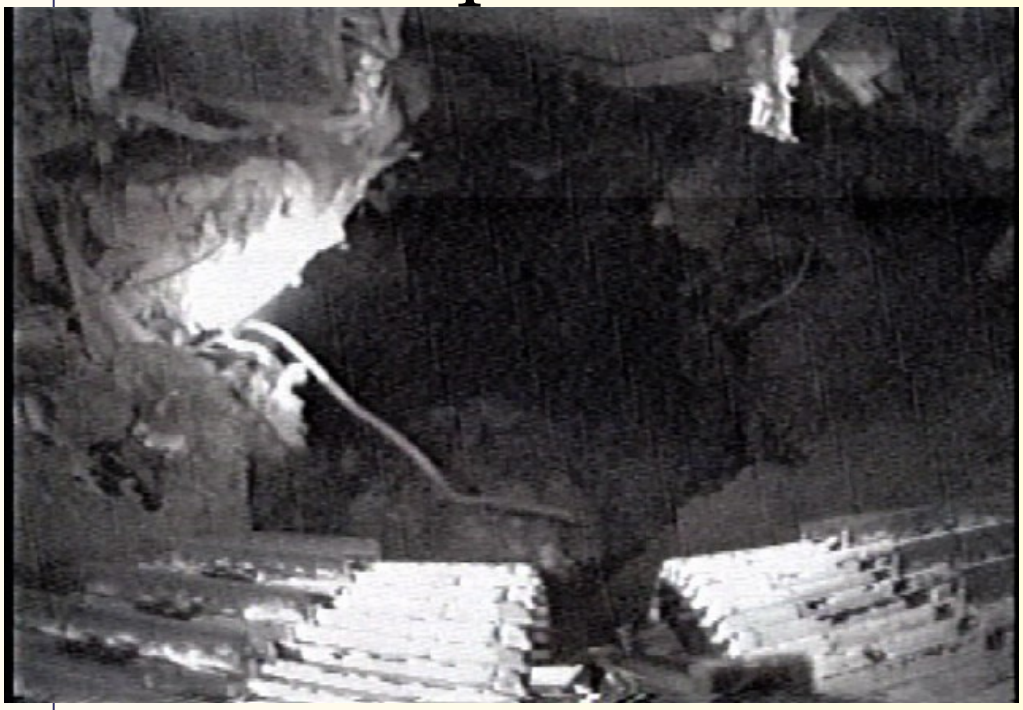
- Teleoperated Robot also always involved.
  - Project best way to accomplish task
  - Compensate for time delays
    - Space robots.
  - Safety, self preservation reflexes
  - “inner loop” control
    - Do requested high level action as sequence of primitive actions.

Manual control Teleoperation



Example of manual control

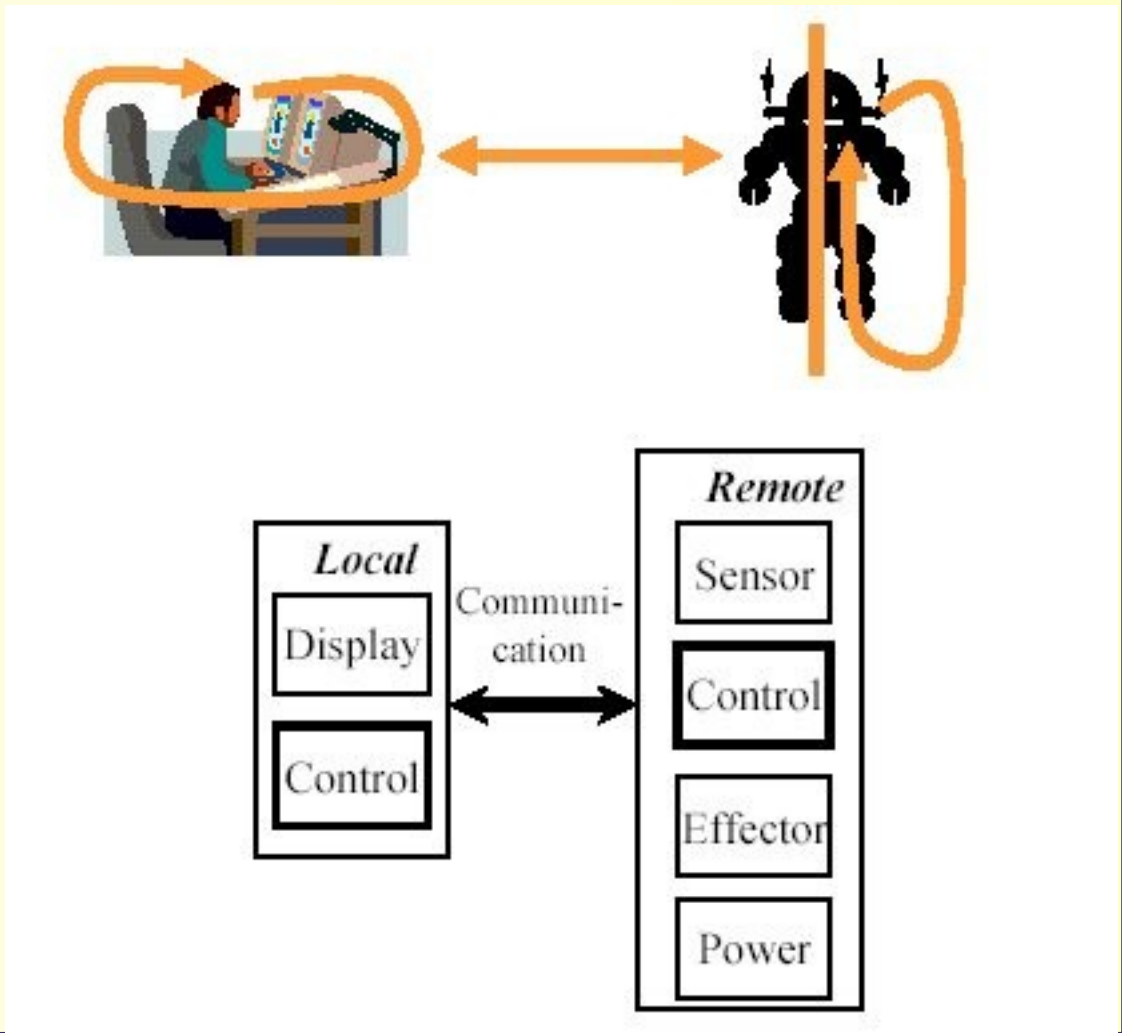
- Urban search and rescue
- Pictures are from 9/11/2001, but Turkey Earthquake would look similar



Why manual control?

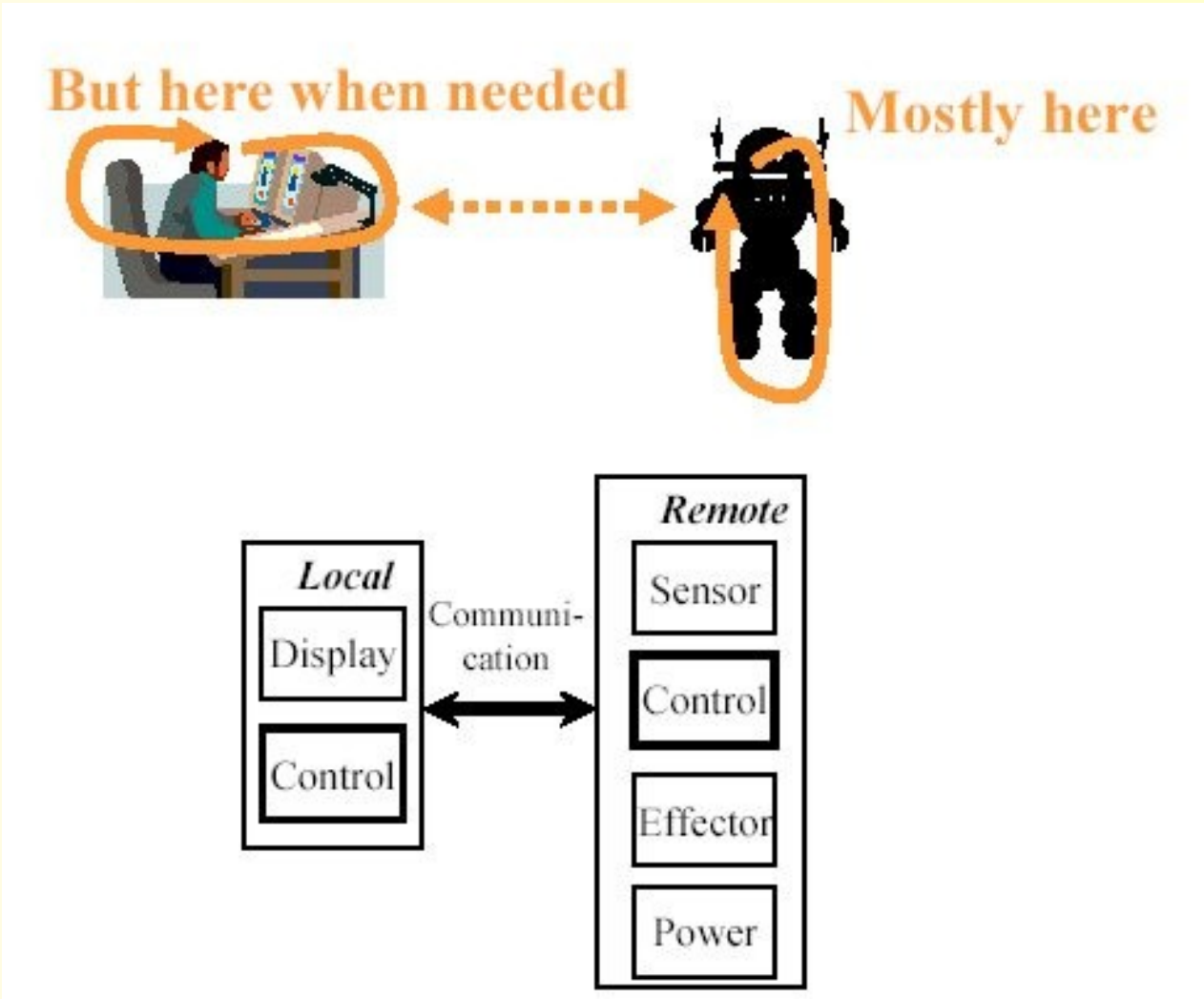
Supervisor-robot sharing control

- Some aspects supervisor controls, others robot controls



Traded Control

- Robot controls most of own actions, but supervisor can take control when needed



Traded Control in real life

- Lots of Mars rovers in the last 20 years

Question for class: why are the techs in protective suits?

- https://www.space.com/38922-extraterrestrial-bacteria-international-space-station.html
- https://microbiomejournal.biomedcentral.com/articles/10.1186/s40168-024-01916-8

In depth look at teleoperation

- Used at world trade center search and rescue
- Complex environment
- Human acceptance
  - Use robot to find your husband/sister/spouse?
- AI available, but brought new robots and AI tested on old robots.

Exercise for class

- Here's what the robot operator saw of the environment
- List some problems for robots and control in this environment

Some problems the team encountered

- Communications from supervisor to robot difficult
  - Wireless impossible: concrete, asbestos, metals
  - Even tethered required two people.
- Operator had a hard time telling what was going on
  - Went from bright to dark to bright quickly.
  - “key hole” problem.
  - No localization; operator has no external viewpoint.

Personnel costs: supervisor to robot ratio

- Research robot assumption: single operator single robot (SOSR) and want to get to SOMR
  - Amazon and fast food getting there.
  - Issue: USAR (urban search and rescue org) study:
    - 9 times more likely to find victim with two people per robot than single supervisor.
- Lots of maintenance: two o
  - 4 for WTC robots
  - Preditor drone:
    2 to fly + ground crew

Single Operator Multiple Robots (SOMR)	**Multiple Operators Multiple Robots (MOMR)**
Single Operator Single Robot (SOSR)	**Multiple Operators Single Robot (MOSR)**

Another domain: teleoperated surgical robots.

- From UC Health
- https://www.uchealth.com/services/robotic-surgery/
- U Cincinnati
- What if 3000 miles away?

Better View

And a very real danger

- https://www.washington.edu/news/2015/05/07/uw-researchers-hack-a-teleoperated-surgical-robot-to-reveal-security-flaws/
- This was a few years ago
  - But we often don't hear about these issues till they are fixed.