Before we start, I want to know what comes into your mind when you see the course title for the first time?
What is a ROBOT?

What image comes into your mind when you think of a robot?
Some images of robots
Robotics and AI Movies

Image from newworldai.com: Top 22 best robotics and AI movies of all the time.
Applications of Robotics

- Undersea (Oberon)
- Distance driving (Stanley)
- Military (Packbot)
Applications of Robotics

- Lawn Care (Cyber Blue)

- Power Line Inspection (WireMonkey)

- Pipe inspection
Robot-Assisted Inspection
Applications for ... Fun??
What is a ROBOT?

Which of these are required characteristics of a robot?

1. Ability to move – legs, wheels, fly, burrow, swim, orbit
2. Ability to sense – eyes, ears, other inputs
3. Ability to manipulate – arms, hands, fingers
4. Ability to mimic – appearance, human tasks
5. Ability to communicate – expressions, sounds, voice, digital, analog
6. Ability to think – mechanical brain, computer, self-awareness
7. Ability to operate – remotely, semi-autonomously
8. Ability to react and respond to different situations
9. Ability to do something useful

Can a software program be considered a robot?
- Is Siri a robot?

How about a mobile sensor?
What is a ROBOT?

Required characteristics of robots

- **Yes** Ability to move – legs, wheels, fly, burrow, swim, orbit
- **Yes** Ability to sense – eyes, ears, other inputs
- **Yes** Ability to manipulate – arms, hands, fingers
- **Yes** Ability to mimic – appearance, human tasks
- **Yes** Ability to communicate – expressions, sounds, voice, digital, analog
- **Yes** Ability to think – mechanical brain, computer, self-awareness
- **Usually** Ability to operate – remotely, semi-autonomously
- **Usually** Ability to react and respond to different situations
- **Usually** Ability to do something useful
There is no all-accepted definition of what a ROBOT is.

And... Robots are evolving!
What is a ROBOT?

• Current common notion of robot:
  ▪ Programmable
  ▪ Mechanically capable
  ▪ Flexible

• Our working definition of robot:

  _Physical_ agent that generates “intelligent” connection between _perception_ and _action_

That is, an autonomous system which exists in the _physical world_, can _sense_ its environment, _reason_, and can _act_ on it to achieve some goals
Human-Centered Robotics

Illustration by Andrew Rae
Human-Centered Robotics
Human-Centered Robotics

The use of robotic systems in human-social environments to help people live safer, easier and more independent lives.

Traditional Robotics

Human-Centered Robotics

Image via Bloomberg.com

Illustration by Andrew Rae
What is a Human-Centered Robot?

Robots that can coexist with humans
Human-Centered Robotics
What is a Human-Centered Robot?

Robots that can coexist with humans

- **Yes**  Ability to move – legs, wheels, fly, burrow, swim, orbit
- **Yes**  Ability to sense – eyes, ears, other inputs
- **Yes**  Ability to manipulate – arms, hands, fingers
  - 4. Ability to mimic – appearance, human tasks
  - 5. Ability to communicate – expressions, sounds, voice, digital, analog
- **Yes**  Ability to think – mechanical brain, computer, self-awareness
  - 7. Ability to operate – remotely, semi-autonomously
- **Usually**  Ability to react and respond to different situations
  - 9. Ability to do something useful
What is a Human-Centered Robot?

Robots that can coexist with humans

- **Yes** Ability to move – legs, wheels, fly, burrow, swim, orbit
- **Yes** Ability to sense – eyes, ears, other inputs
- **Yes** Ability to manipulate – arms, hands, fingers
  1. **Yes** Ability to mimic – appearance, human tasks
- **Yes** Ability to communicate – expressions, sounds, voice, digital, analog
- **Yes** Ability to think – mechanical brain, computer, self-awareness
  2. **Yes** Ability to operate – remotely, semi-autonomously
- **Yes** Ability to react and respond to different situations *(humans & env.)*
- **Yes** Ability to do something useful *(to be assistive)*
What is a Human-Centered Robot?

Robots that can coexist with humans

- Ability to move – legs, wheels, fly, burrow, swim, orbit  
- Yes
- Ability to sense – eyes, ears, other inputs  
- Yes
- Ability to manipulate – arms, hands, fingers  
- Yes
- Ability to mimic – appearance, human tasks  
- Yes
- Ability to communicate – expressions, sounds, voice, digital, analog  
- Yes
- Ability to think – mechanical brain, computer, self-awareness  
- Yes
- Ability to operate – remotely, semi-autonomously  
- Yes
- Ability to react and respond to different situations (humans & env.)  
- Yes
- Ability to do something useful (to be assistive)  
- Yes

Additional characteristics?
What is a Human-Centered Robot?

Robots that can coexist with humans

- Ability to move – legs, wheels, fly, burrow, swim, orbit
- Ability to sense – eyes, ears, other inputs
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- Ability to mimic – appearance, human tasks
- Ability to communicate – expressions, sounds, voice, digital, analog
- Ability to think – mechanical brain, computer, self-awareness
- Ability to operate – remotely, semi-autonomously
- Ability to react and respond to different situations (humans & env.)
- Ability to do something useful (to be assistive)

Human factors: Safety, Privacy, Trust, etc.
Human-Centered Robotics

Robots that can coexist with humans

The use of robotic systems in human-social environments to help people live safer,
easier and more independent lives.

Not necessary to have direct interaction with people
Human-Centered Robotics

Some discussion from NSF’s National Robotics Initiative:

• The co-robot theme of the NRI recognizes the emerging analytical, computational, mechanical, electrical, and cognitive technologies that will make the next generation of robotic systems able to safely co-exist in close proximity to humans in the pursuit of mundane, dangerous, precise or expensive tasks.

• Co-robots will need to establish a symbiotic relationship with their human partners, each leveraging their relative strengths in the planning and performance of tasks.

• Co-robots will be distinguished from robots of the past by their new levels of environmental modeling, situational understanding, and resourcefulness due, in part, to the use of real-world data in real time.

• As research advances, co-robots will operate with ever-increasing levels of intelligence, safety, productivity, and autonomy in unstructured, human-dominated environments. This will ultimately manifest in levels of robot intelligence and adaptability seen only in animals and humans.

• Despite the vastly improved capabilities for broad diffusion, access, and use (and hence, to achieve societal impacts), co-robots must be relatively cheap, easy to use, and available everywhere.
Applications of HCR: Security

https://www.youtube.com/watch?v=8sjt1S9igns
Applications of HCR: Elderly Care

... it is possible to check whether the user is actually drinking from it.

https://www.youtube.com/watch?v=Z1MJPdhniXc
Applications of HCR: Daily Assistance

https://www.youtube.com/watch?v=--wEgmNzs0w
Applications of HCR: Children Education

https://www.youtube.com/watch?v=7T7cIY-MIxc
Challenges of Robotics

None of the following is easy for a robot!

- **Yes**  Ability to move – legs, wheels, fly, burrow, swim, orbit
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- **Yes**  Ability to manipulate – arms, hands, fingers
  4. **Yes**  Ability to mimic – appearance, human tasks
  5. **Yes**  Ability to communicate – expressions, sounds, voice, digital, analog
- **Yes**  Ability to think – mechanical brain, computer, self-awareness
  7. **Yes**  Ability to operate – remotely, program control, autonomously
- **Usually**  Ability to react and respond to different situations **environments**
  9. **Yes**  Ability to do something useful
Additional Challenges for HCR

- Ability to move – legs, wheels, fly, burrow, swim, orbit
- Ability to sense – eyes, ears, other inputs *(Extremely hard to sense people!)*
- Ability to manipulate – arms, hands, fingers
  4. Ability to mimic – appearance, human tasks
- Ability to communicate – expressions, sounds, voice, digital, analog
- Ability to think – mechanical brain, computer, self-awareness
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**Challenges of HCR**

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Challenges of HCR

Additional Challenges for HCR

- Ability to move – legs, wheels, fly, burrow, swim, orbit
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- Ability to react and respond to different situations (humans & env.)
- Ability to do something useful (to be assistive)

Difficult to evaluate HCR performance: A working system is generally not enough; human satisfaction is also essential.

Human factors!!!
Challenges of HCR

Same lady?
Challenges of HCR

Locate her on New York street?
Challenges of HCR

How can a robot navigate in this environment?
Course Objectives

• Get my students motivated!!!
• Introduce my students the state-of-the-art systems and research on human-centered robotics
• Teach my students practical techniques that are essential to build human-centered robots
• Help my students construct a working human-centered robotic system or intelligent machine
• Improve my students’ other skills, including paper writing, presentation, and teamwork

Maybe not during this pandemic…
Topics we’ll Cover

• Robot perception
• Representation/abstraction
• Reasoning/learning
• Decision making
• Several special topics:
  • DARPA challenges
  • Autonomous driving
  • Robot ethics
  • Mapping
  • Others
Related CS Courses

• Human-Robot Interaction / Robot Ethics
  (by Dr. Tom Williams)
• Robot Planning and Manipulation
  (by Dr. Neil Dantam)

• Computer Vision (versus Robot Perception)
• Machine Learning (versus Robot Learning)
• Artificial Intelligence (versus Robot Reasoning)
Mines Robotics Graduate Program

https://gradprograms.mines.edu/robotics-graduate-program/

PROGRAM OVERVIEW

With the prevalence of automation and self-guided technology on the rise, Mines is driving innovation in this growing field, using existing expertise in field robotics to provide professionals with the skills and knowledge to take this technology to the next level.

Mines’ Robotics graduate program offers a core curriculum focused on robotic perception, cognition, action and interaction, with technical electives in computer science, mechanical engineering and electrical engineering.

Students will graduate from the program with the top-notch skills required for work in advanced industries and help turn science fiction into reality.

DEGREE OPTIONS

MASTER’S
- Robotics (Thesis and Non-Thesis)

PHD
- Robotics

CERTIFICATE
- Robotics

APPLY NOW

4% projected job growth 2018-28
$75,487 average robotics engineering salary, glassdoor
Human-centered robotics lab

NOW ACCEPTING APPLICATIONS
Real-Life Transformer Robot