CSCI 473/573
Human-Centered Robotics
Spring 2020
Overview of Syllabus and Class Policies

• Instructor
  ▪ Hao Zhang
    • Assistant Professor, Department of Computer Science
    • Director, Human-Centered Robotics Lab

▪ Office: BB 250
▪ Email: hzhang@mines.edu
▪ URL: http://inside.mines.edu/~hzhang
▪ Office Hours: 1:30 – 2:30 PM Fridays
  or before/after class
  or by appointment (send email)
Overview of Syllabus and Class Policies

• Teaching Assistant
  ▪ Qingzhao Zhu
  ▪ Location: Alamode Lab (BB 136)
  ▪ Email: zhuqingzhao@mymail.mines.edu
  ▪ Office Hours: 2:00 – 4:00 PM Thursdays
    or by appointment (send email)
Overview of Syllabus and Class Policies

• Prerequisites:
  ▪ CSCI 262 (Data Structure)
    • Knowledge of fundamental concepts of computer science (e.g., data structures) and experience of programming in **C++ or Python in Linux** is necessary
  ▪ MATH 201 (Probability and Statistics)
    • Mathematical maturity is also needed to understand computational models

The instructor will not teach programming and will assume sufficient math knowledge
Overview of Syllabus and Class Policies

• Required Textbook:
  ▪ None
  • HCR is a new field in robotics
  ▪ The course is project-based and research-oriented
    • Based on cutting-edge concepts and techniques
    • Focusing on the system level design
  ▪ Many texts, pictures, and slides we use in the lecture are grabbed from online resources or papers, only major resources are provided
Overview of Syllabus and Class Policies

• Schedule and Assignments:
  ▪ Everything will be on the course website
    http://inside.mines.edu/~hzhang/Courses/CSCI473-573/
    Or just google “CSCI 473/573 Mines”

  ▪ If you miss a lecture, it will be your responsibility to check the course website
    (make sure you refresh the webpages)
Overview of Syllabus and Class Policies

• Class Communication
  ▪ Assignments will be submitted to Canvas
  ▪ Grades will be available in Canvas
  ▪ If you need to chat with the instructor,
    • Stop by my office during office hours, or
    • Send me an email or talk with me after classes
  ▪ You may also talk to our TA
Overview of Syllabus and Class Policies

• Evaluation
  ▪ Grading will be based 100% on projects
  ▪ Students in CSCI 473 will be given the same projects, as those taking CSCI 573
    • The quality and quantity of the work expected is higher for CSCI 573 than CSCI 473
    • More questions will be asked for CSCI 573 students in each project

<table>
<thead>
<tr>
<th>Grade</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>90 – 100</td>
</tr>
<tr>
<td>B+</td>
<td>85 – 89.9</td>
</tr>
<tr>
<td>B</td>
<td>80 – 84.9</td>
</tr>
<tr>
<td>C+</td>
<td>75 – 79.9</td>
</tr>
<tr>
<td>C</td>
<td>70 – 74.9</td>
</tr>
<tr>
<td>D</td>
<td>60 – 69.9</td>
</tr>
<tr>
<td>F</td>
<td>0 – 59.9</td>
</tr>
</tbody>
</table>

Final grades will be determined by overall average
Overview of Syllabus and Class Policies

• Class attendance will be taken
  ▪ If you have a good reason to miss class (e.g., sickness, conference travel, job interview), then it is not a problem
  ▪ If you think you have a contagious illness, please don’t come to class. The instructor will help keep you posted on class activities
  ▪ In any case, it is your responsibility to catch up (or keep up) with all course material and announcements covered in class
  ▪ Please participate in class discussions!!!
Overview of Syllabus and Class Policies

• Borderline Final Grades
  ▪ The instructor defines borderline as ~0.75 point
  ▪ Decisions on borderline grades will be based upon class attendance and participation
Overview of Syllabus and Class Policies

• Project Assignments
  ▪ Projects write-ups will be posted on the course website, along with the due dates
  ▪ All projects will involve programming; using C++ or Python in Linux is required (We will discuss why)
Overview of Syllabus and Class Policies

• Late Submission
  ▪ All projects are due to Canvas at the time specified in the write-ups
  ▪ The individual Project 1 and Project 2 have a four-day grace period for each deliverable, and late submission will lose 25% points per day for that specific deliverable.
  ▪ The team-based Final project does NOT have a grace period, and any deliverable submitted five (5) minutes past the due time will receive a grade of zero.
Overview of Syllabus and Class Policies

• Exams: There will be no exams!

• Grading corrections
  • Bring any assignment grading correction requests to the instructor within 1 week of receiving the grade, or before the end of the semester, whichever comes first
  • After that, your grade will not be adjusted.
  • If you find any mistake in grading, please let the instructor know. Your grade will not be lowered.
Overview of Syllabus and Class Policies

• Using computers/phones in class
  ▪ Please be respectful of your colleagues in class, by turning off your phones and using your computers only for taking notes or keeping up with the material covered in class.
  ▪ Checking your email, working on other non-class related materials, web-surfing, etc., are not appropriate activities for class time.
Overview of Syllabus and Class Policies

• Collaboration Policy
  ▪ Discussing ideas is encouraged
  ▪ Reading through the Student Honor Code and the policy existing for all CS courses in the Department of Computer Science

  ▪ Cheating will be dealt with harshly!
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
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
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, tough, 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
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 react and respond to different situations
Yes  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

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

Traditional Robotics

Human-Centered Robotics
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

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

Robots that can coexist with humans

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 (humans & env.)
9. **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
- Ability to sense – eyes, ears, other inputs
- Ability to manipulate – arms, hands, fingers
- 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)

Additional characteristics?
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
- **Yes** Ability to communicate – expressions, sounds, voice, digital, analog
- **Yes** Ability to think – mechanical brain, computer, self-awareness
  7. **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)*

**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
Applications of HCR: Security

https://www.youtube.com/watch?v=8sJtlS9igns
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=7T7clY-Mlxc
Applications of HCR: many others!!!
Challenges of Robotics

None of the following is easy for a robot!

- **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, program control, autonomously
- **Usually**  Ability to react and respond to different situations environments
- **Usually**  Ability to do something useful
## Challenges of HCR

### Additional Challenges for HCR

| Yes | Ability to move – legs, wheels, fly, burrow, swim, orbit |
| Yes | Ability to sense – eyes, ears, other inputs *(Extremely hard to sense people!)* |
| 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, program control, autonomously |
| Yes | Ability to react and respond to different situations *(humans & env.)* |
| Yes | Ability to do something useful *(to be assistive)* |
### Challenges of HCR

#### Additional Challenges for HCR

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Ability to move – legs, wheels, fly, burrow, swim, orbit</td>
</tr>
<tr>
<td>Yes</td>
<td>Ability to sense – eyes, ears, other inputs <em>(Extremely hard to sense people!)</em></td>
</tr>
<tr>
<td>Yes</td>
<td>Ability to manipulate – arms, hands, fingers</td>
</tr>
<tr>
<td></td>
<td>4. Ability to mimic – appearance, human tasks</td>
</tr>
<tr>
<td>Yes</td>
<td>Ability to communicate – expressions, sounds, voice, digital, analog</td>
</tr>
<tr>
<td>Yes</td>
<td>Ability to think – mechanical brain, computer, self-awareness</td>
</tr>
<tr>
<td></td>
<td>7. Ability to operate – remotely, program control, autonomously</td>
</tr>
<tr>
<td>Yes</td>
<td>Ability to react and respond to different situations <em>(humans &amp; env.)</em></td>
</tr>
<tr>
<td>Yes</td>
<td>Ability to do something useful <em>(to be assistive)</em></td>
</tr>
</tbody>
</table>

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
Topics we’ll Cover

• Robot perception
• Representation/abstraction
• Reasoning/learning
• Decision making
• Several special topics:
  • DARPA challenges
  • Cloud robotics
  • 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)
Real-Life Transformer Robot