COSC 4P78

Introduction

Week 1
(Based on Murphy)

Brock University

Introduction to Robotics

Before we can start with this course's *content*, we need to define what to expect.

What this course isn't:

- A comprehensive guide to kinematics, mechatronics, Robot OS, Artificial Intelligence, Machine Vision, or PLCs or Industrial Control

What this course is:

- An Introduction to Robotics

Introduction to Robotics

What will we get from this course?

- Lectures will cover the fundemental theories
- Assignments are for researching assorted topics
- Labs will give *low-level* practical experience
- The project will let you choose to pursue one of the above

Course Procedures

We should take a look at the course outline now, but some highlights:

- Lectures are 2-hours each, other than the in-class final test
- Labs don't start for a couple weeks (you'll get an email notification)
  - You've been divided into two separate lab sections. You need to attend *your* lab.
- The final test is in Week 10
  - It's open book
- The weeks following the test are for consulting/help with the final project

Before we begin

Let's first consider two different robots in media.

- `https://www.youtube.com/watch?v=1sNMHdaJx5c`
- `https://www.youtube.com/watch?v=X7HmltUWXgs&t=32`

Which of these is a good robot design?

No, really, let's talk about this.

So then, what *is* a robot?

Though definitions vary, a robot is simply a mechanical device that fulfills some task, typically by accepting one or more inputs, applying logic rules, and then providing some output that modifies the robot's state and/or the environment.

When discussing robots, there are different levels of *autonomy*. For autonomous robots, there are three *robot primitives* we'll be getting to later: Sense, Think, and Act

- How a robot combines those primitives will define how the robot operates as a whole (again, later)

Why do we use robots?

Applications vary, and they're always expanding.
The automation of manufacturing was an early driving force, and still is.

Besides the precision and repeatability that often accompanies automation, there's also the *3 D's* to consider:

- Dirty
- Dull
- Dangerous

Robots tend to take over for jobs where a human wouldn't want to do it, wouldn't be able to repeat them in the scale necessary, or couldn't perform them safely. (Which of these do you think applies to manufacturing?)

Why do we use robots?
(cont)

Space is a popular venue:

- Satellites
- Probes
- Landers and rovers

Which of these do you think would typically have some degree of *autonomy*? Why might landers be preferable to humans?

And, of course, there's still more:

- Military, agriculture, construction, consumer products, entertainment, search & rescue, etc.

Some of these will blur the lines of what we even consider robots.

History

I'm not a huge fan of detailed history, so let's instead discuss the basics of progression:

- In the 40s and 50s, they started as remote manipulators
  - Effectors and actuators, but entirely human-controlled
  - Mostly for handling hazardous substances, or heavy objects
  - Effectively just acting as a stand-in for a person
- After AI started being developed, it was introduced (in a limited fashion) to robots
  - Basic guidance for vehicles
  - Robots were still mostly developed from the mechanical side
  - Their reliability for repetition and precision made them valuable for manufacturing
- Starting in the 70s, the potential for space exploration gained popularity. Also, computing had advanced to the point that machine vision could start developing

History

And then what happened?

Well, after autonomous robots started becoming more mainstream (more and more in the field, rather than concepts in a lab), their popularity snowballed.

- The 80s saw the first true viability of a “black factory”
- Researchers made great strides in terms of autonomous robots
- (Note that there’s no incongruity with those two points)

And, of course, in the last couple of decades, we’ve seen some impressive additions:

- Self-driving cars (sort of)
- Completely automated homes (kinda)
- Robotic companions (in a way)

On the progression and development of robots...

So that means robots have been evolving, more or less, along a straight line. Just like computers, right?

- Well, yes, but also very much no

As both computing capabilities and AI techniques (not to mention software engineering in general) have advanced, completely new approaches to intelligent robots have arisen.

- In coming weeks, we'll start delving into a few of the different *robotic architectures* (or paradigms) that were used in the early days (and still have significance today)
- Ostensibly, these will simply be using different combinations or sequences of the robotic primitives (again, Sense, Plan, and Act), though they're actually part of larger systems and design philosophies

For now, the short version is: would you rather figure out what you're going to do, and then do it; or try to work out a problem as you go along? And how would you actually implement such a system?

But before we get into the finer details...

Let's just clarify some terms, so we can understand what we'll be discussing later.
First, as hinted earlier, there are different levels of autonomy. For example:

- "RC-ing"
  - You directly control the robot, based on what you see in person (the robot and its environment)
  - e.g. RC cars, Robot Wars, some early bomb disposal robots
  - (Keeps you in the environment, so doesn't help *much* with the "Dangerous" aspect)
- Teleoperation
  - You directly control the robot, based on sensor and environmental information you receive from the robot
  - e.g. drones, better bomb disposal robots
  - (You don't really need to worry about AI)

But before we get into the finer details...

(cont)

- Semi- or full autonomy
    - You might give commands to the robot, or even directly control it (sometimes), but otherwise it determines its own next actions and/or determines how to achieve those commands
    - e.g. rovers
    - (The human doesn't need to do everything)

Note that *teleoperation* and *telepresence* aren't quite the same thing.

Considerations for Teleoperation

Suppose we *did* want to design a robot for teleoperation (or even a lightly-autonomous robot).

What would we need to account for?

- What kind of feedback can we get? What are we missing?
  - Suppose you're doing search and rescue. A human might notice a smell. How much could it matter if a robot offered that?
  - Is a video feed the same thing as sight?
  - How does a robot differ from a human, in terms of tactile response?
- Does distance matter?
- Will the user interface itself matter?
  - e.g. cognitive fatigue, nausea, speed, etc.

Components of a Telesystem

Back in the late 80s, systems were designed that would consist of:

- A local interface
  - A display
  - A control mechanism
- A remote agent
  - Sensors
  - Mobility
  - Effector
  - Power
- Communication between the two

If we were to design a telesystem today, we'd likely include all of that, but what else?

Common concerns for telesystems

Suppose a search and rescue for inside buildings

Many (especially early) systems offer very little feedback.

- It can be difficult to identify that you're "stuck"
- Localization can be difficult within an unknown environment
  - *Especially* if that environment is unstable/changing
- Typically only one perspective for viewing
  - Some landers will have multiple cameras
  - A second robot is also an option (which might require a second operator)
- Communications can easily be blocked
  - In addition to the latency hinted at earlier
- Lighting conditions might be inconsistent or erratic

And one particularly basic concern that you'll often see for robots is *proprioception* (which we'll be discussing a bit more later).

Teleoperation example

Predator drone

Back in the early days of drones:

- 7 people to operate one drone
  - 1 to fly
  - 2 for instruments
  - 1 for landing/take off
  - 3 for sensor processing, maintenance, and routing
- In spite of this, still pretty limited:
  - 7 second latency
  - You could fly up beside one to shoot it down
  - There's only so long the operators could focus continuously

Telesystems

Final thoughts

Of course, telesystems are still viable for lots of tasks; they just have to be tasks suitable for it:

- Unstructured and not repetitive
- Industrial manipulators shouldn't be a option
- Important portions of the task require the human touch, but not indefinitely
- The display/sensor information won't saturate the communications link
- Trained personnel/money aren't an issue

Teleoperation alternatives

Outside of *telepresence*, semi-autonomous systems are often the better choice.

- Supervisory Control
  - Routine (safe) portions of tasks are handled entirely by robot
  - *Shared Control*
    - Human initiates action, adds additional inputs or feedback to help robot with its execution
  - *Traded Control*
    - Human initiates action, but does not interact
- Mixed Initiative (Guarded Control)
  - Robot doesn't let operator injure the robot (without override)
  - "Whoever figures it out first"

That doesn't sound so complicated...

Really, it isn't.

But we're just getting started. Telesystems are immensely valuable, but will always have severe limitations.

We need to add some intelligence, of the artificial variety.
Why?

- Knowledge representation
- Understanding natural languages
- Learning
- Planning/problem solving
- Inference
- Search
- Vision

In the coming weeks

Next week, we'll be looking at how to collect information, and then how to act upon the environment.

After that, we'll be looking at different styles of approaches to translating inputs into outputs.

Questions?

Comments?

- Favourite burgers?

(By the way, do we want to have a *really* quick chat about basic electronics?)