Robotics

Welcome to Intelligent Robotics. Today we'll talk a little about what robotics is as a discipline, and how this course fits into the grand scheme.

1. Read the course policy.
2. Robotics is... the study of robots.
3. OK, wiseguy, what's a robot?
4. Good question:
   (a) "A reprogrammable, multi-functional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks" -Robotics Industry Association.
      - But that just describes industrial manufacturing robots. What about the Terminator, or mobile robots?

   (b) "Any device which replaces human labor" -Soska, 1985
      - Much more general, but too vague. Doesn't a thermostat replace the labor of turning the furnace on and off? Do we really want to include thermostats?

   (c) "The intelligent connection of perception to action" -Brady, 1985
      - I don't even know what that means.
      - It sounds suspiciously as if people are robots.
      - If detecting a mouse click is perception, and changing the contents of a display screen an action, wouldn't this include any smart computer program?
      - What about Robocop? what *was* he?
      - A mechanical device that sometimes resembles a human and is capable of performing a variety of often complex human tasks on command or by being programmed in advance. -anwers.com

   (d) Personally, I like: "A computer controlled multi-function machine whose primary function is to manipulate its external environment." -Crabbe, 2002.
      - Includes non-industrial applications.
      - Is meaningful and precise.

5. In our above discussion, we've seen that there are lots of different types of robots. How shall we categorize them?

6. One common way is to categorize them in terms of their level of autonomy:

   (a) **Autonomy** is the ability of something to control its actions. It roughly mean "self willed".

   (b) At one end of the spectrum are teleoperated robots. These robots are operated by joystick (or other input device) by a remote human controller. A common example is remote surgery robots. These have no autonomy.

   (c) A little to the the right are vehicles that do perform some small actions on their own, but are still considered teleoperated. Most of the micro unmanned military aerial vehicles fall into this category. The aircraft performs some actions to keep it aloft, but all of the major actions still come from the ground.

   (d) In the middle of the spectrum are robots whose tasks are selected by human controllers, but who complete the tasks on their own. Many mobile robots operate this way. A human controller says, "go to location x", and the robot figures out how to get there. These robots are semi-autonomous. A different example is the Air Force's *Global Hawk*. A flight plan is programmed on the ground, the plane takes off and flies to the destination, circles over the target and returns home on command.

   (e) At the extreme end, are robots that have complete control over the actions they take with no input from people. These are rare in the real world (no one wants to trust a robot) but common in robotics labs, where they are the focus of the most research. These robots are fully autonomous. This class will concentrate on fully autonomous robotics.

7. Another way to classify robots is in terms of their mobility.

   (a) Some robots are stationary Industrial manipulators are the primary example of these.

   (b) Others are ground-based. They travel along a firm surface to which they are held by gravity or similar forces.[1]

   (c) Aquatic robots operate either on the surface of, or under water. Obviously, the US Navy has a great deal of interest in these.

   (d) Airborne robots fly. They fly in all the ways other machines fly.

   (e) Space robots work in low or no gravity situations. These are handy for space station construction and maintenance.

8. In this class we're really interested in intelligent robotics. That is, robots that manimpulate the environment in a manner that would be considered intelligent by an observer. This definition can vary based on who the observer is: one person's intelligent robot is another person's stupid little hack. Normally that might be considered a problem with a definition, but in this case accurately reflects the field. That's the nature of a newly developing field.

[1] Some textbook authors refers to these a terrestrial robots. This is a misnomer because they can travel across the surface of any solid planet, moon, or space station.

	Signal	Information	Attribute	Simple Model	Abstract Model	Lifetime
Input Channel	Sensor	Binary	Detection	Maps	Logic	Agent Modeling
Output Channel	Motor	Kinematics	Action Selection	Path Planning	Task Planning	Goal Selection

Figure 1: The Layers of Abstraction framework.

9. One major property of intelligent behavior is to act appropriately given particular situations in the environment. This brings us back to (sort-of) "intelligent connection of perception to action".

10. Intelligent action takes many forms. These can be can be described, as with much of computer science, in terms of layers of abstraction.

11. We should be **really** familiar with it by now, from object orientation to operating systems to computer networks, we see this idea of simplifying away the details all the time.

12. The lowest layers deal directly with physical hardware, and the highest layers with abstract symbols.

13. What are the pieces of that table?

    (a) The pathway describes the direction information is flowing. Is it coming into the robot? then it's input. Is it going to result in a movement? then it's output.

    (b) The abstraction level describes how far removed from the physical hardware is the computation taking place.

    (c) Typically, information comes into the robot at the lowest level of the input pathway. This information is processed and passed up to the higher levels of abstraction, on up the pathway.

    (d) At some point, the information is passed over to the output pathway, where it is processed, decisions are made and passed down the pathways to the bottom, where actions are finally taken.

    (e) Signal layer is where the electrical signals are generated by sensing devices (described in more detail later) and electrical signals are fed into the motor system.

    (f) Information layer is the numeric representation of the electric sensor signals. This is usually a straightforward step up.

    (g) Attribute Layer are attempts to identify WHAT the sensor sensed, and actions are selected from a set of choices.

(h) Model Layer is the combination of multiple sensors into a single model of what the sensors detect. Theses models are used to plan what will happen in the future. In the simple model layer, these models are concrete maps of the environment, and the plans are paths though the maps. At the abstract model level, the models are logical descriptions of the world and the plans are sequences of actions that modify the world.

(i) Lifetime layer. Decisions are made about the longer term behavior of the robot. It is here that other agents are modeled in order to coordinate collective behavior, and the robots are able to consider what tasks they will pursue over their lifetime. "should I change the light bulb or go to the movies." This involves balancing the long-term purposes of the robot.

14. Many people proclaim that there are different incompatible kinds of robotics (Such as behavior-based, intelligent, engineering, planning-based) but in fact each is just an emphasis on particular layers of the abstraction. Not all systems involve all layers, but all systems can be understood in terms of these layers. This will be a central organizing tenet for the class.

15. What is the relation of robotics to other disciplines? You may notice that there are many types of robotics course and rightly wonder what their relation is, and what sort you'll be getting.

    (a) Electrical Engineering usually encompasses issues surrounding the sensor signals, motor signals and sensor information.

    (b) Mechanical Engineering usually encompasses kinematics.

    (c) Signal Processing contains parts of sensor models, sensor fusion, and sequence tracking.

    (d) Artificial Intelligence covers action selection, planning, goal selection, and some parts of sensor models, sensor fusion and sequence tracking.

    (e) In this course, we'll concentrate on the higher end of the table. The courses taught in the systems engineering department concentrate on the lower end. There is some overlap in the middle.