CPS331 Lecture: Robots; Discussion of Brooks last revised November 26, 2018

Objectives:

1. To introduce key issues in robotics
2. To introduce the Sense-Plan-Action architecture for robots
3. To introduce the subsumption architecture for robots

Materials:

1. Materials needed for example based on Russell and Norvig exercise 25.11
   a. Objects to stack
   b. Blindfolds for "brain", "left arm", "right arm".
2. Projectable of Figure 1 from Brooks (1985)
3. Powerpoint on subsumption architecture from UCF EEL 6838
4. Access to UTube videos:
   a. https://www.youtube.com/watch?v=8P9geWwi9e0
   b. https://www.youtube.com/watch?v=C9p8B7-5MTI
   c. https://www.youtube.com/watch?v=YtNKuwiVYm0

I. Introduction

A. The topic of robots is very different from others we have considered this semester - in fact, though robotics is sometimes thought of as a branch of AI, in many ways it is more like a sister discipline with significant areas of overlap.

B. As in other areas (including AI itself!), there is even diversity in the definition of a robot. We will use the following definition (from Russell and Norvig 2nd ed) as "an active artificial agent whose environment is the physical world"

1. This definition includes robots that are controlled by human operators (telepresence) - e.g. the robots being used to cleanup the Fukashima nuclear disaster in Japan.

2. However, we will focus on at least partially-autonomous robots. (We do not preclude "human-in-the-loop" systems, though).

3. As implied by the definition, we will focus on robots whose environment is the physical world, as opposed to pure software robots (softbots).

C. You may recall that, at the start of the course, we spoke about agents and environments. Robot environments have a number of characteristics that create particular challenges.

Recall the characteristics of an environment that we spoke about then. Let's consider what typically characterizes the environment in which a robot operates, looking at a subset of the characteristics we listed then.

(For each one, ask class what is often true of robot environments)

1. Fully observable versus partially-observable - do the agent's sensors provide access to the complete state of the environment (that is everything that is relevant to the agent's decision-making)?

   (Note limitations of sensors)

2. Episodic vs sequential: does time divide into episodes involving the agent perceiving, deciding and acting, with the agent's decision based only on what it perceives in that episode, or do episodes depend on agents' actions in previous episodes - or is time is continuous?

3. Static vs dynamic: Can the environment change while the agent is deciding? (If the environment is static, the agent can sense the environment and then decide what to do, but if it is dynamic the agent needs to keep sensing while deciding).

   (Note that a robot often operates in an environment where other things are going on that may change the state even while the robot is acting.)

4. Known versus unknown: The agents state of knowledge about the "physics" of the environment - i.e. the effect of its actions. Note that this is not the same as whether or not the environment is observable - it has to do with the effects of actions, not the state of the environment.

   (Note that the imprecision of effectors such as motors means that the robot will often have to check to be sure that what happened is precisely what it intended.)

D. Thus, a number of "non-AI" issues are important in robotics - e.g.

1. Various mechanical concerns (e.g. variation in motor speed and hence accuracy of positioning or amount of turn due to battery state and terrain issues.)

2. Sensor-related issues (e.g. dealing with background noise, inconsistent illumination, electronic noise)

E. However, there are a lot of "AI areas" that can be important in robotics - though sometimes in a slighly different form - e.g.

1. Vision

2. Representation of knowledge about the world in which the robot operates.

3. Planning

F. Example - based on problem 25.11 in Russell and Norvig.

1. Four volunteers: eyes, "brain" (blindfolded), "left hand", "right hand"

2. Simple task to perform

3. Brain asks eyes to describe relevant portion of what it sees - but eyes can only describe, not indicate what needs to be done.

4. Brain directs hands to perform task in terms like "move hand forward 3 inches" (or up, down, back, left, right). Left hand and right hand use just one arm each.

II. Architectures for Robots

A. Classically, robots are designed using a CENTRALIZED ARCHITECTURE - sometimes known as "Sense-Model-Plan-Act" or SMPA.

1. PROJECT - Figure 1 from [Brooks 1985]

    a) Such an architecture is based on a functional decomposition of the overall task - the overall task is broken into models based on the various functions needed (perception, modeling, planning ...)

    b) This implies that (at least a portion of) each slice must be implemented before anything can be run

    c) This implies that improving the functionality of any piece may result in changes that have to be propagated through the remaining pieces.

2. This architecture was used for the first autonomous mobile robot - Shakey, developed at SRI in the late 1960's and early 1970's. (Among other things, this project led to the A* algorithm and the creation of STRIPS planning).

3. This architecture is still widely used, including in "human-in-the-loop" systems.

    Play: DARPA Robotics Challenge Finals

    https://www.youtube.com/watch?v=8P9geWwi9e0

B. The paper you read for today is written by the developer of another architectural approach - the SUBSUMPTION or BEHAVIOR-BASED architecture.

1. Such an architecture is based on a decomposition of the overall task in terms of levels of competence.

2. Each levels subsumes the behavior of lower levels.

3. New levels of competence can be added on top of existing levels without altering them.

4. Show powerpoint from USF

5. Show examples of Brooks robots:

   https://www.youtube.com/watch?v=C9p8B7-5MTI

6. (If time) Herbert video

   https://www.youtube.com/watch?v=YtNKuwiVYm0

7. One commercially-interesting system based on this architecture is the Roomba Vaccuum Cleaner!

III. Discussion of Brooks Paper

A. According to Brooks, what is the fundamental problem of "classical AI"?

   Do you agree or disagree? Why?

B. What alternative fundamental hypothesis does he propose?

1. What does he call it?

2. What does Brooks cite as evidence for this hypothesis?

3. How does he deal with objections to this hypothesis

   Do you agree or disagree? Why?

4. Brooks writes "The world is its own best model" What does he mean by this?

   Do you agree or disagree? Why?

5. Why does Brooks call the article "Elephants Don't Play Chess"?