PSYCO 457
Week 5: Braitenberg's Vehicle 2

The Analytic Approach
The Synthetic Alternative
Fabricating A LEGO Vehicle 2
Programming Vehicle 2

Shakey Beginnings

- **Autonomous robots have been a testing ground for much work in artificial intelligence**
- **Historically they employ sense-think-act processing**
  - **Build an internal representation or model of the world**
  - **Use it to plan movements**
  - **Carry out the plan**
- **SRI's Shakey (1966-1972) was one of the most notable of these efforts, guided by Nils Nilsson**

Nils Nilsson

Problems With Planning

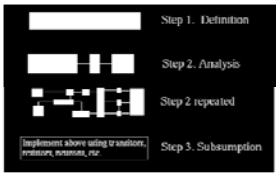
- **The trouble with Shakey was that it simply took too much computational effort to create, and update, a usable model of the world**
  - **"Its most impressive feat – moving a wedge to a block, ascending it, and pushing off a smaller block – was recorded on film piecemeal, requiring multiple takes – and several hours – for each error-prone stage" (Moravec, 1999)**
  - **"Eventually Shakey would get to its goal a few meters from where it started and carry out its task – six or eight hours after it started. Most of the time Shakey, the robot shell, sat idle while its remote brain contemplated a long series of moves to accomplish its ultimate goal" (Brooks, 2002)**

Hans Moravec

Rodney Brooks

Classical Analysis

- **The planning that is central to sense-think-act processing characterizes the methods used by classical cognitive scientists to study cognition**
- **They apply reverse engineering or analytic methods**
- **Functional analysis is a standard example:**
  - **Observe an intact system**
  - **Use observations to decompose the system into inferred subsystems**
  - **How well does the model fit existing data?**



Against Planning

- **Behaviour-based roboticists reacted against the traditional planning or representational approach to building robots**
- **They converted the "sense-think-act" cycle to a "sense-act" cycle**
  - **"The realization was that the so-called central systems of intelligence – or core AI as it has been referred to more recently – was perhaps an unnecessary illusion, and that all the power of intelligence arose from the coupling of perception and actuation systems" (Brooks, 1999)**

Rodney Brooks with an early behavior-based robot

The Parable Of The Ant

- **When embodied perceptual-motor systems were situated in the world, complex behavior was discovered "for free"**
- **Simple robots produced complex behaviors because of their environment**
- **Simon predicted this with his famous *parable of the ant***
  - **"Viewed as a geometric figure, the ant's path is irregular, complex, hard to describe. But its complexity is really a complexity in the surface of the beach, not a complexity in the ant" (Simon, 1996, p. 51)**

Herbert Simon

The Synthetic Approach

- The synthetic approach – or forward engineering – is an alternative to the analytic approach favored by classical cognitive science
  - Synthesize
    - Choose architecture
    - Build a model
  - Observe
    - Look for emergent surprises
    - Interaction between world and agent
- Build the model first – before data!
  - "If we want to achieve wall-following behaviour, we should design not a module for wall-following within the agent, but instead basic processes that together, interacting with the environment, engender this desired behaviour" (Pfeifer & Scheier, 1999).

Rolf Pfeifer

Synthesis Vs. Analysis

- The parable of the ant has important implications for theories in cognitive science
- Braitenberg argues that the synthetic approach will produce simpler theories than will the analytic approach
- The *law of uphill analysis and downhill synthesis:*
  - "It is much more difficult to start from the outside and try to guess internal structure just from the observation of the data. [...] A psychological consequence of this is the following: when we analyze a mechanism, we tend to overestimate its complexity" (Braitenberg, 1984).

Valentino Braitenberg

Getting It

- "Only about 1 in 20 [students] 'gets it' -- that is, the idea of thinking about psychological problems by inventing mechanisms for them and then trying to see what they can and cannot do" (Minsky, 1995, personal communication).
- This class, we will begin to "get it"!

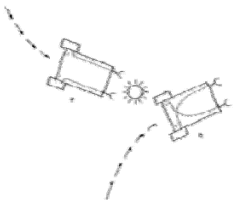
Marvin Minsky

Parable Of The Robot

- Our goal is to build a robot that can generate a complex path like the one above
- To model such behavior, what would be the easiest approach – analytic or synthetic?

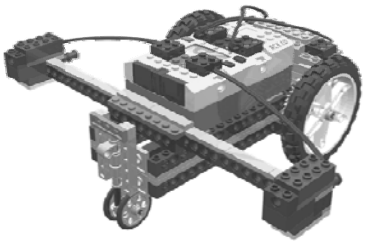
Vehicle 2

- Our robot will be a version of Braitenberg's Vehicle 2
- It will have two light sensors
- It will have two motors
- The speed of one motor will be determined by the amount of light detected by one of the light sensors
- The speed of the other motor will be set using the other light sensor
- What complexities might such a simple machine produce?



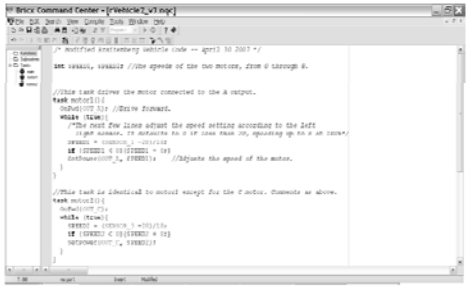
Synthesis: Embodiment

- *For the next while, we will use the detailed instructions in Chapter 4 of Dawson and Dupuis to construct our LEGO Vehicle 2*



Synthesis: Situation

- ***After constructing the robot, we must learn a little NQC programming to bring it to life. This too is described in detail by Dawson and Dupuis in Chapter 4***



Synthesis: Observing

- **After constructing and programming the LEGO Vehicle 2, we can observe its behavior**
- **How can we get this simple robot to make complex paths on its "beach"?**
- **The two videos that accompany this slide – one of the RCX robot, the other of an NXT version of the same machine – provide some insight**