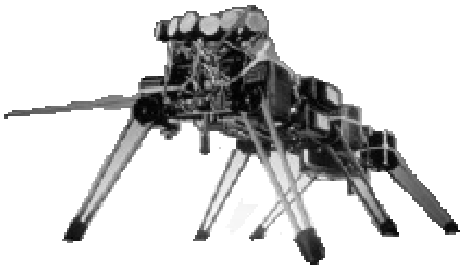
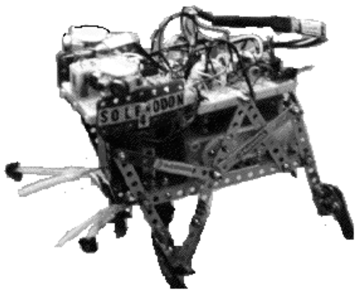
Autonomous Mobile Robotics

Introduction to Autonomy





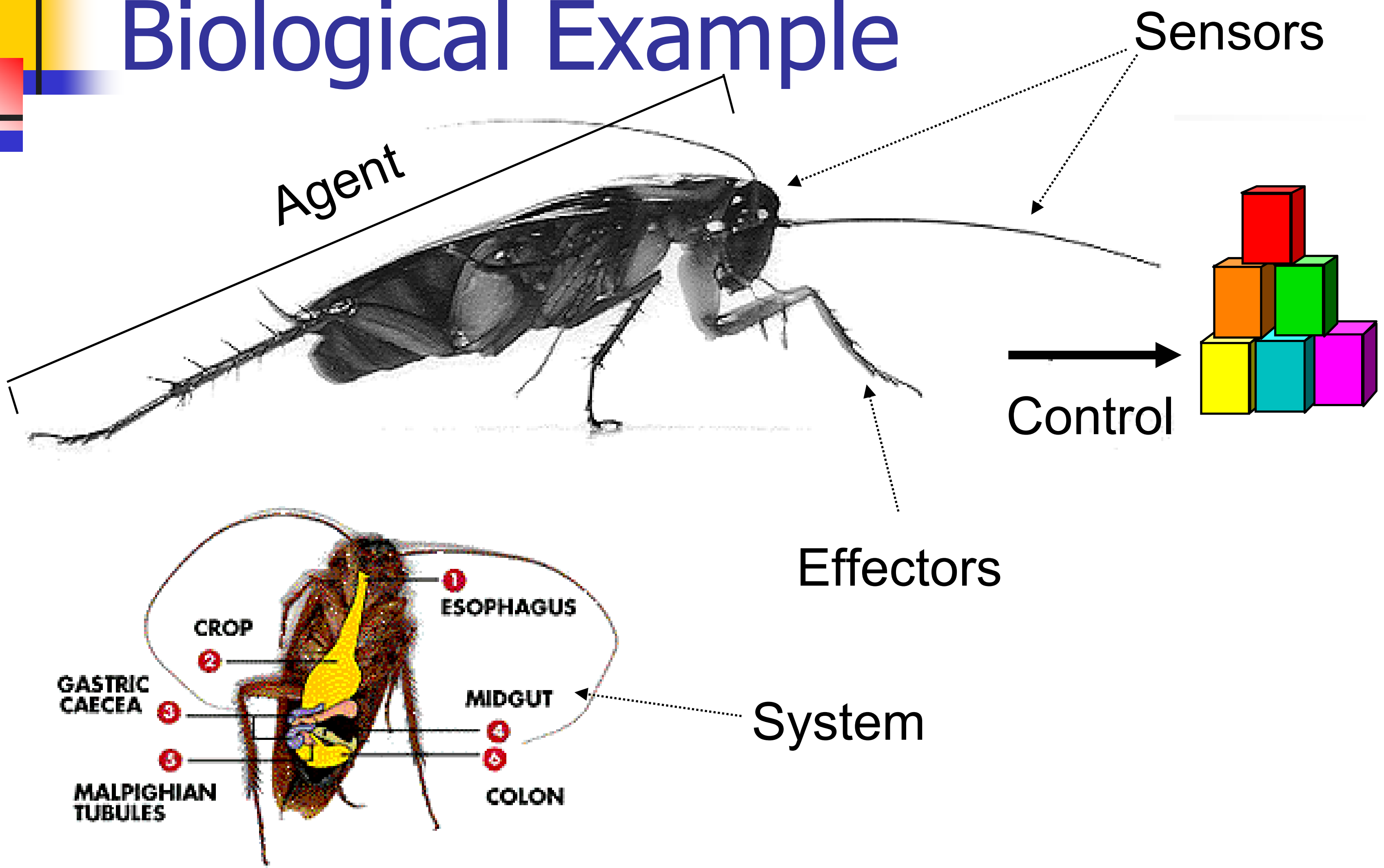
Topics

- Some Definitions
- What is Autonomy?
- An autonomy example with examples
- A bit more about the purpose of this course

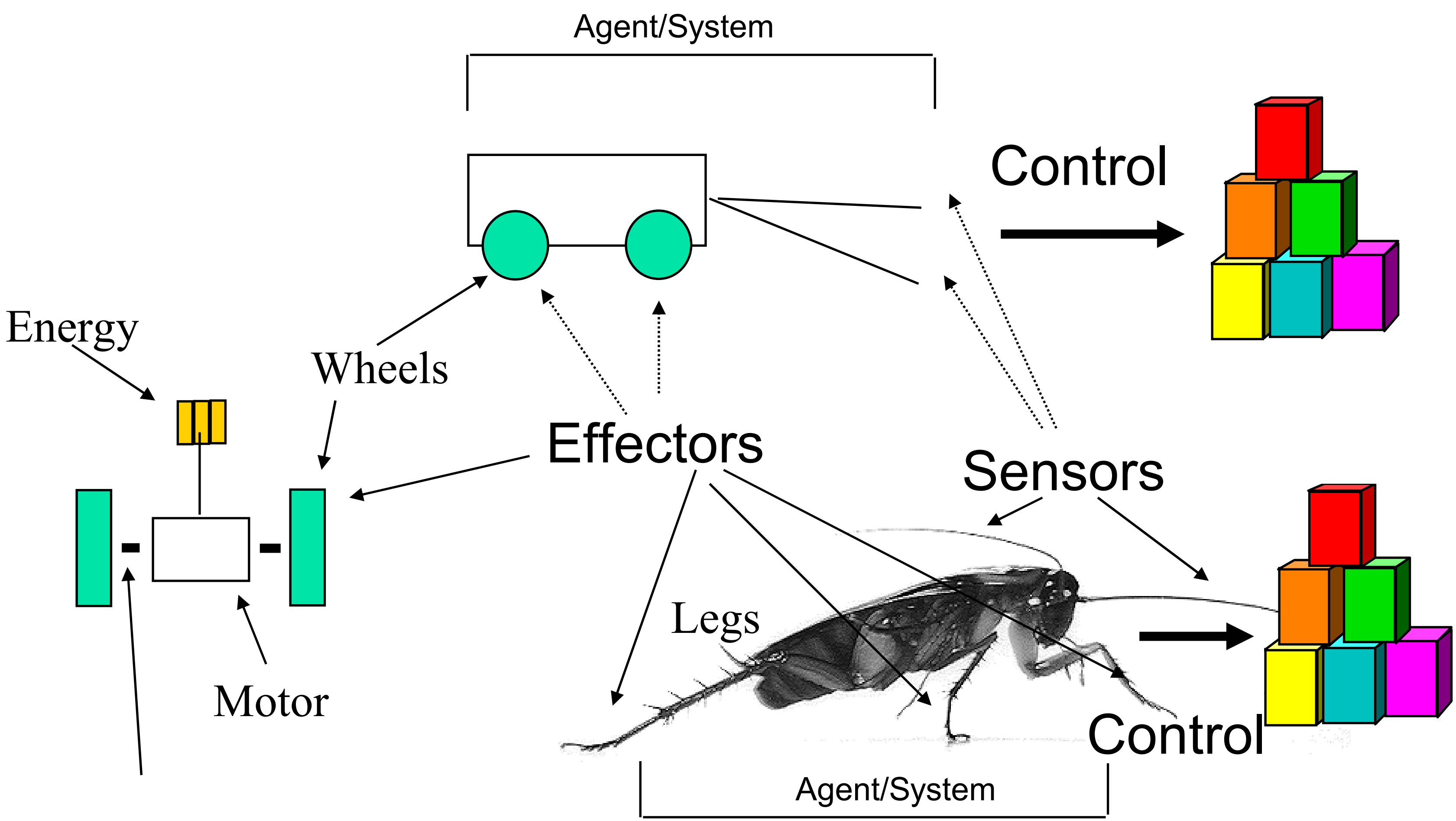
Definitions

- **Autonomy:** ?
- **Sensing:** Sampling the environment.
- **Effecting:** Making changes to the environment.
- **System:** A group of interacting items which form a unified whole.
- **Agent:** Any system which can be viewed as perceiving its environment through <u>sensors</u> and acting upon it through <u>effectors.</u>
- **Control:** The regulation of the behavior of a system to make it perform as desired.

Biological Example



Agent Terminology



What is Autonomy?

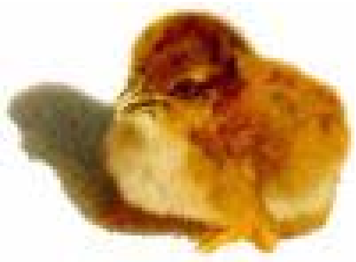
- Philosophical Perspective
- Psychological Perspective
- Biological Perspective

Philosophical Perspective

- The autonomous man, insofar as he is autonomous, is not subject to the will of another. [Wolff 70]
- A person is "autonomous" to the degree that what he thinks and does cannot be explained without reference to his own activity of mind. [Dearden 72]
- I, and I alone, am ultimately responsible for the decisions I make, and am in that sense autonomous." [Lucas 66]

Psychological Perspective

- The chick, which can peck accurately at food shortly after hatching, quickly develops its expertise in behavior because it stems from only a few original tendencies. Its immediate efficiency, however, is “like a railway ticket,...good for one route only.” Whereas, “A being who, in order to use his eyes, ears, hands and legs, has to experiment in making varied combinations of their reactions, achieves a control that is flexible and varied.” [Dewey 63]



Biological Perspective 1

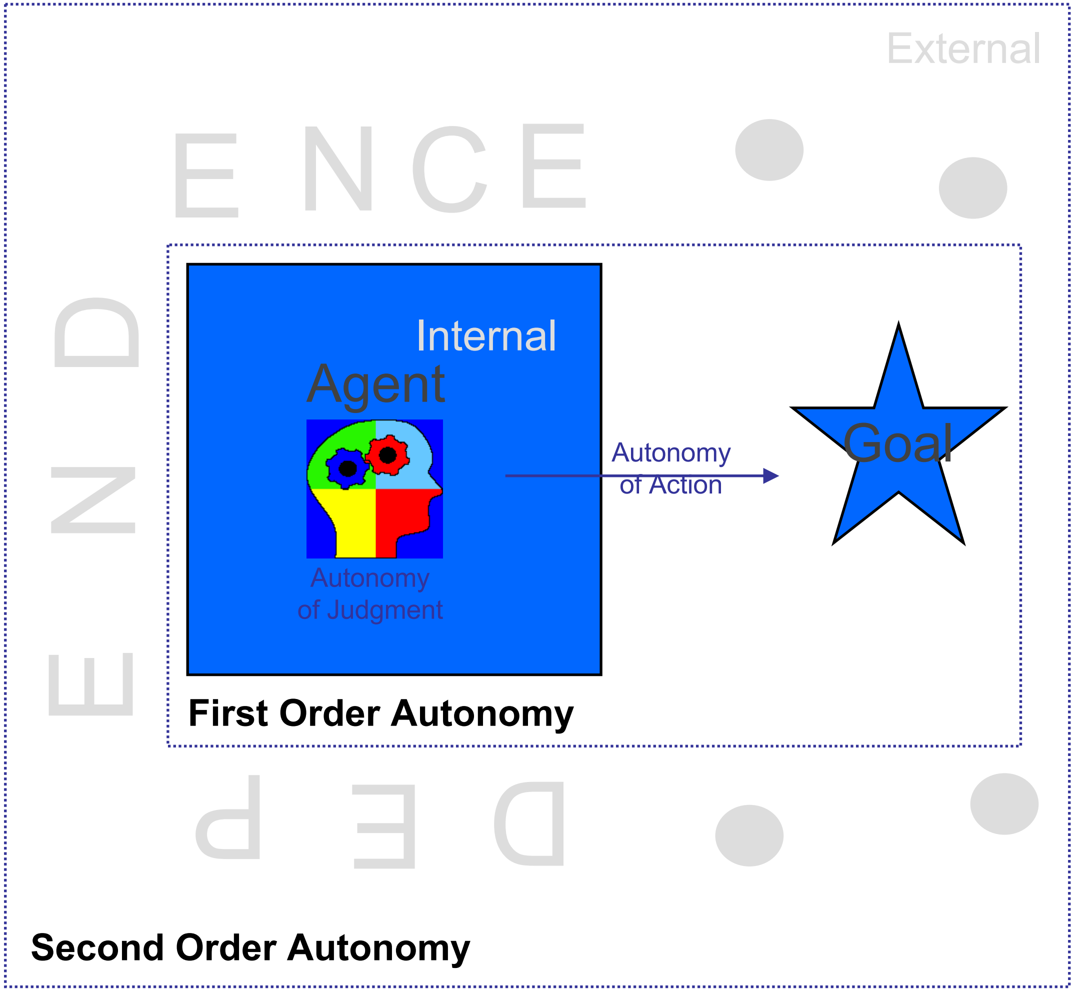
- “Autopoiesis”: defining and describing “living” beings in terms of their mechanical components
- biological systems are comprised of physical components
- robots are comprised of physical components
- a biological life form is defined not by its components but by their interaction
- the same is true of a robot

Biological Perspective 2

- Since humans are biological systems, they are defined by their component interactions as well
- it should be possible to examine the autonomy of a biological system in terms of human autonomy
- This could be applicable to artificial systems as well--like robots!

Discussing Autonomy in Robotics

- **Levels of Autonomy**
  - **First Order Autonomy**
    - degree to which behavioral choices are made *independently*
  - **Second Order Autonomy**
    - changing the nature of behavioral choices
- **Autonomy of Judgment**
  - Degree to which decisions are made internally
- **Autonomy of Action**
  - Degree to which decisions can be acted on
- **Dependence**
  - Reduces autonomy
  - External and Internal

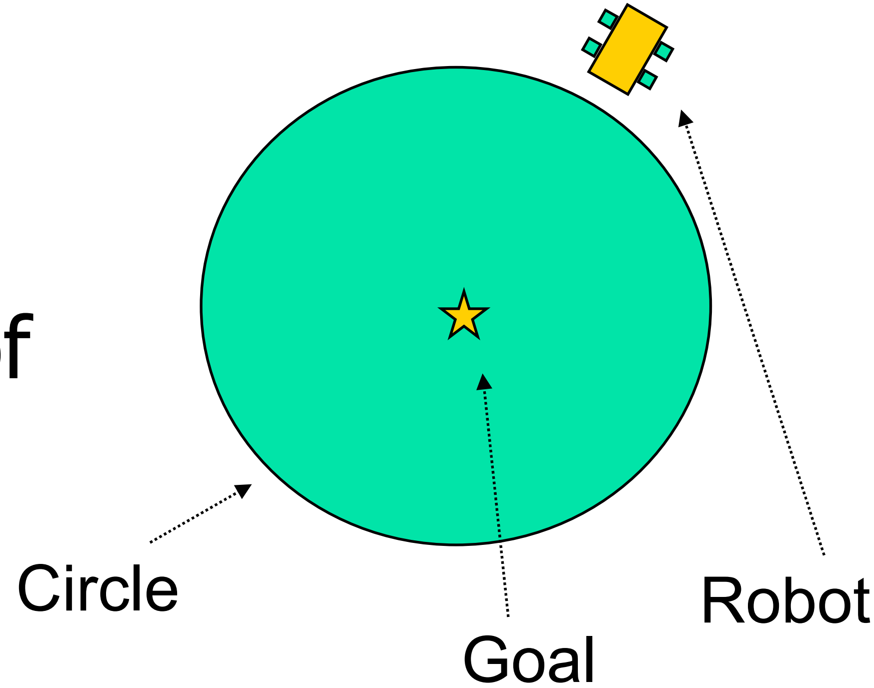


Applying this to a Robot

- Sojourner
  - Aspects of **first order autonomy**, no second order
  - Heavy **Internal dependence** of preprogrammed behavior
  - Heavy **external dependence** of commands sent from Earth
  - **Autonomy of Judgement** limited to limited navigational tasks
  - **Autonomy of Action** limited by available power

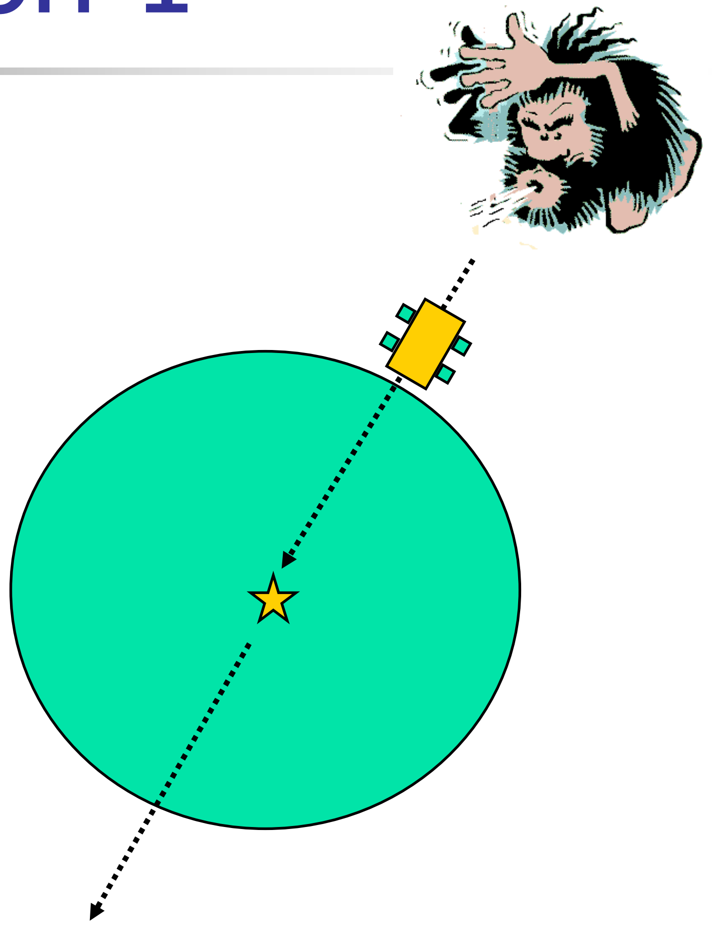
The Autonomy Problem Illustrated

- How would you build an autonomous robot that can move to the goal and push it out of the circle?



Possible Solution 1

- Point the robot at the goal and let it go in hopes of pushing the goal out of the circle.

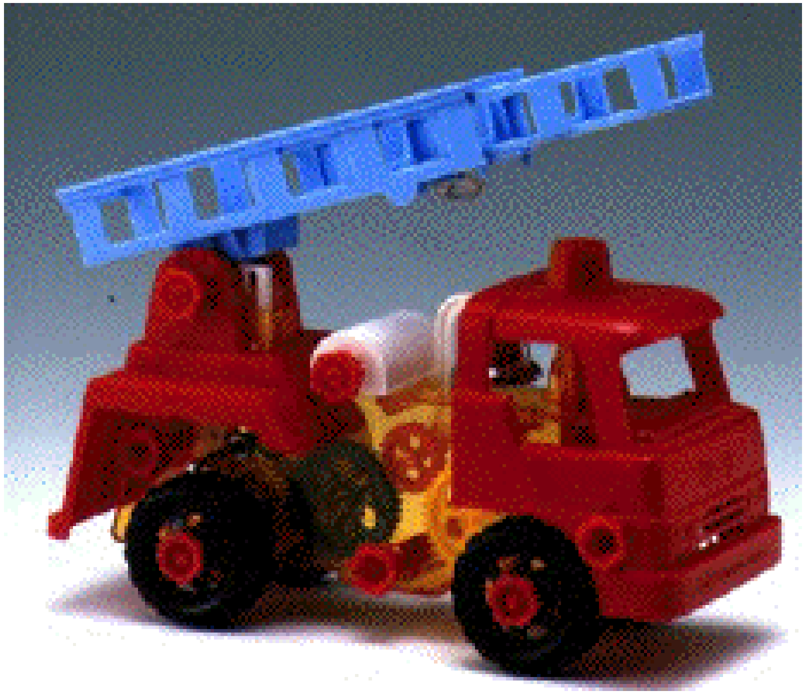


Discussion of Solution 1

- Very limited in terms or even first order autonomy
- dependence on various factors which limit the vehicle’s success
  - friction
  - misalignment with target
  - no correction possible

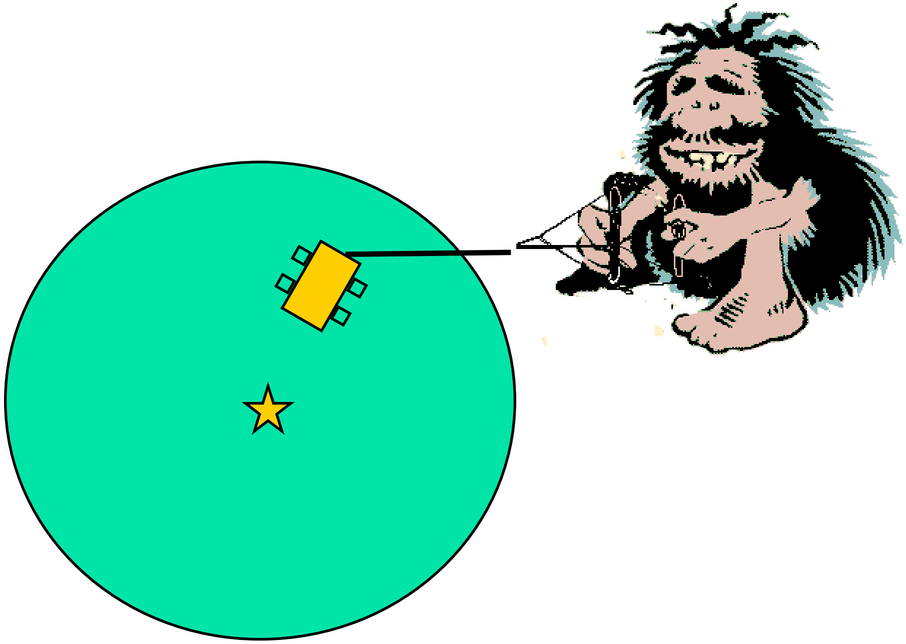
Examples

- Toy wind-up car
- Moves in the direction it is pointed
- Very difficult to accomplish any kind of useful goal



Possible Solution 2

- Hook the robot to a controller and manipulate the controller to steer the robot to accomplish the goal.



Discussion of Solution 2

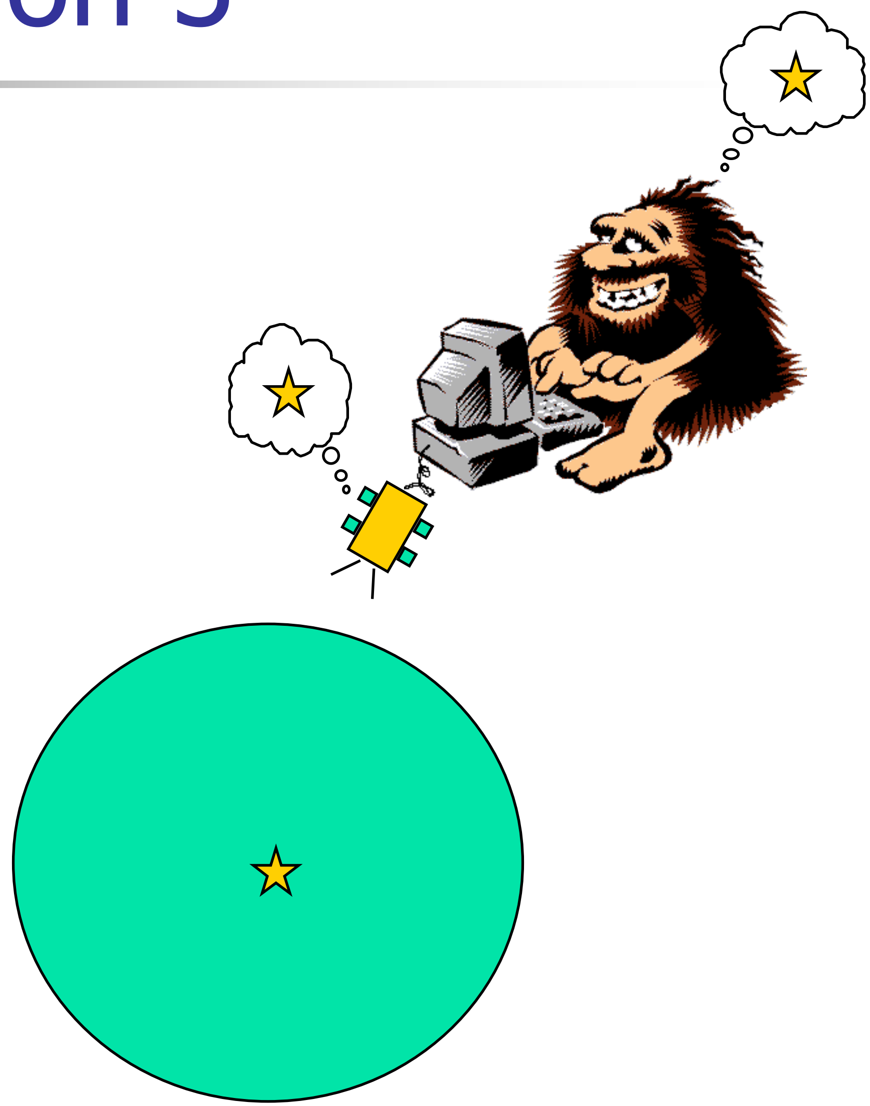
- Hard to call it autonomous in any sense
- Just because it's tethered doesn't mean the task is easy!
  - sojourner was essentially tethered
- A robot might be tethered because it is not desirable or possible to put the controller on-board
  - size restriction, safety concerns, etc.

Example

- Dante II
  - Joint NASA and CMU project
  - Vehicle Designed to explore Volcano in Alaska
  - Mostly tele-operated with an "autonomous mode"
  - Fell over, tether broke, was eventually crushed.

Possible Solution 3

- Create a robot which you "tell" to "push the goal out of the circle.
- The robot than goes and does that!

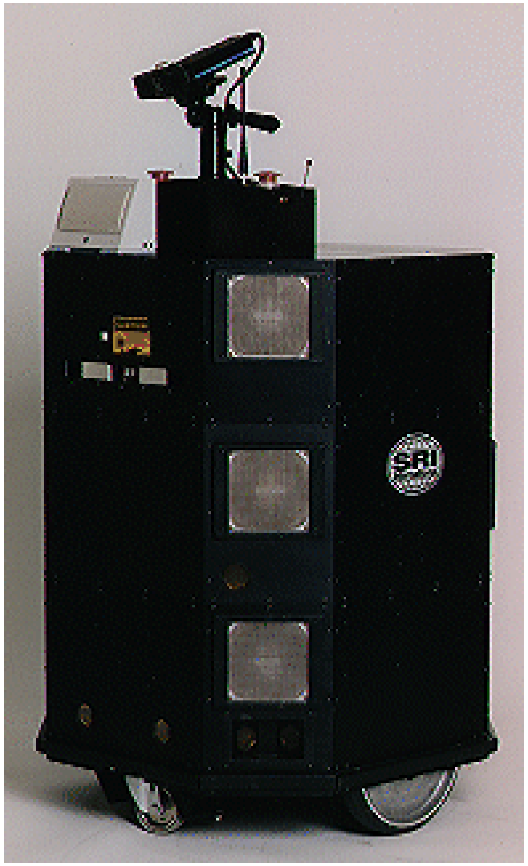


Discussion of Solution 3

- Usually proposed by classical AI types
- Requires representation of the world by an internal model
  - Every object encountered in the world must be placed in the model
  - Decisions are made based on the model
- Very slow but very flexible

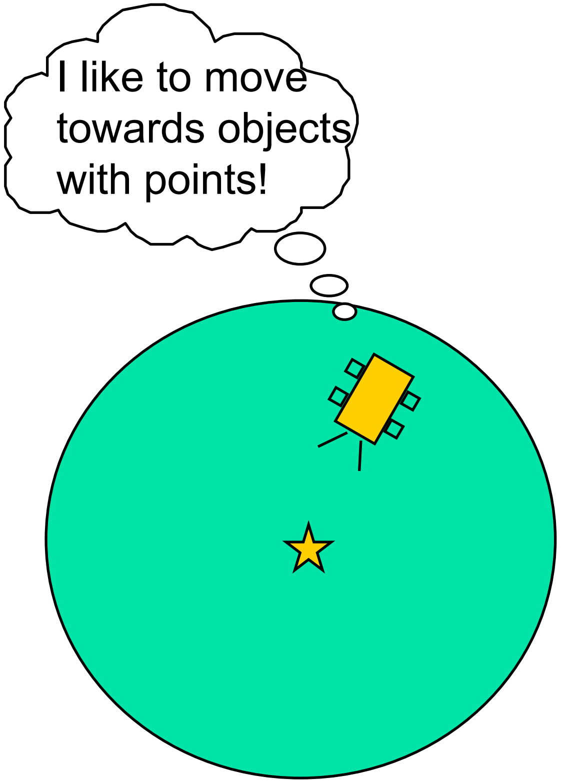
Examples

- "Flakey" the robot
  - SRI's mobile robot, a custom-built platform approx 3 feet high and 2 feet in diameter operating within a limited office environment.



Possible Solution 4

- Instill a set of behaviours which allow the robot to use what it senses to make control decisions to allow it to reach the goal on its own.



Discussion of Solution 4

- Sometimes referred to as “behaviour based robotics”
- No model required as robot uses what it senses to make decisions.
- Very fast but limited in scope

Examples

- "Atilla"
  - MIT AI lab hexapod robot
  - control subsystems interact by sensing the world and controlling the robot's actuators
  - it can learn to walk based on what it senses

The Purpose of this Course

- Explore issues in mobile robotics by building them,
- Develop an understanding of what it means to be autonomous, and
- Learn an appreciation for the extreme difficulty of most autonomy tasks