New Approaches to Robotics

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Overview

- Motivation
- Introduction
- Traditional Approach
- New Approach
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- Discussion

Motivation

How does robotics relate to complex adaptive systems?

Introduction

What is AI?

(AI) tries to make computers do things that, when done by people, are described as having indicated intelligence.

"Hey, stop scanning my cards!"

Introduction

Problem

Reasoning was so slow that systems that were built could not respond to a dynamic real world.

Key Feature

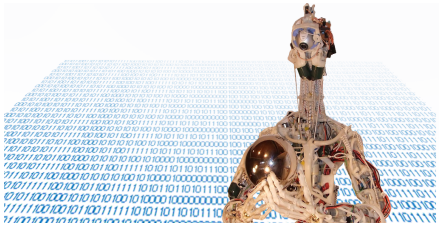
The programs are built with short connections between sensors and actuators, making it plausible, in principle at least, to respond quickly to changes in the world.

Introduction

Two Central IDEAS!

Situatedness : Robots are situated in the world—they do not deal with abstract descriptions

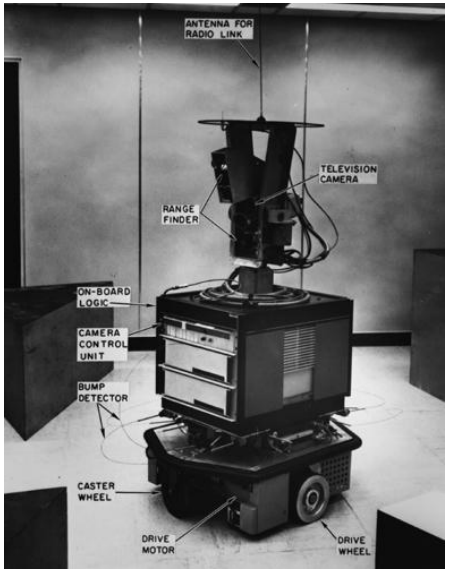
Embodiment :Robots have bodies and experience the world directly



Traditional Approach

“SHAKEY” Robot

- Developed at Stanford Research Institute (now SRI International)
- Navigated from room to room, trying to satisfy a goal given to it on a teletype.
- Navigate around obstacles consisting of large painted blocks and wedges, push them out of the way, or push them to some desired location.
- Other sensors, such as a-bump bar and odometry.



Traditional Approach

“COPY-DEMO” Robot

- Developed at MIT
- Includes a camera system and a robot manipulator arm.
- Programmed to perceive an arrangement of white wooden blocks against a black background.
- It reinforced the idea that a complete three dimensional description of the world could be extracted from a visual image.

Traditional Approach

ROLE of COMPUTER VISION

“ Given a two-dimensional image, infer the objects that produced it, including their shapes, positions, colors, and sizes.”

ROLE of AI

“ Take descriptions of the world and manipulate them based on a database of knowledge about how the world works in order to solve problems, make plans, and produce explanations.”

Traditional Approach

ROLE of ROBOTICS

" Deal with the physical interactions with the world."

Several problems were faced in robotics like:

- Collision-free path (Algorithm to decide the path!)
- Forward Kinematics and Dynamics (What path will the robot follow!)
- Inverse Kinematics and Dynamics (Used to calculate trajectories!)

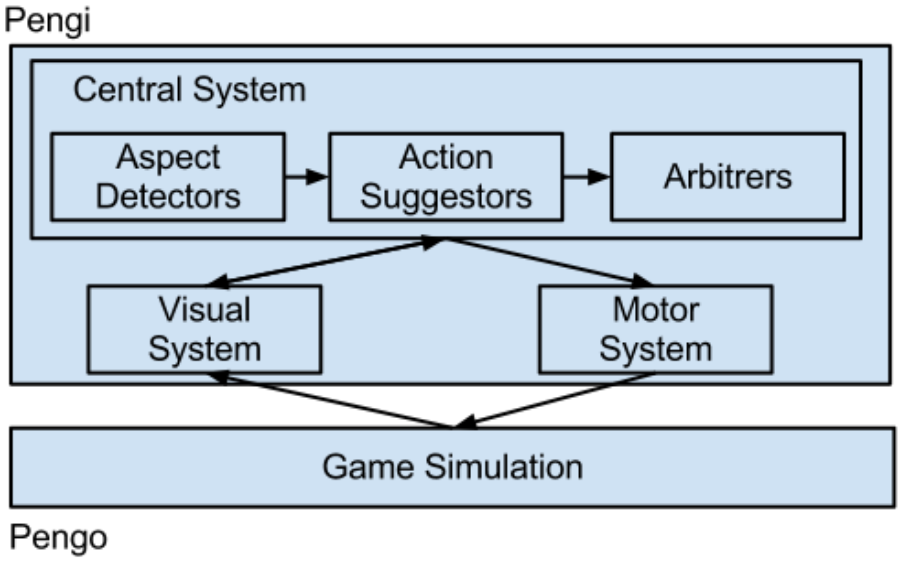
New Approach

Rethinking the general problem of organizing intelligence

- Intelligence should be reactive to dynamic aspects of the environment
- Mobile robots should operate at time scales similar to those of animals and humans
- Intelligence should be able to generate robust behavior given an unpredictable environment, and a changing world

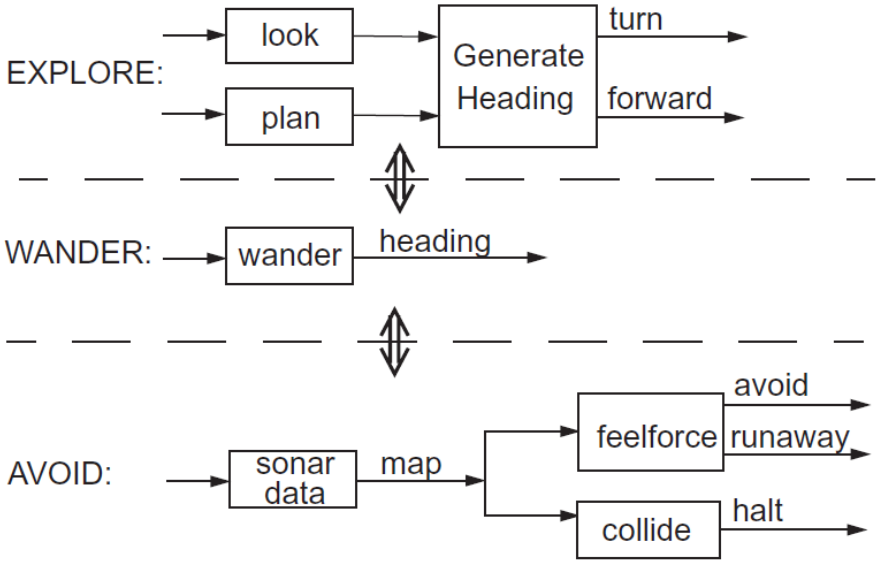
New Approach

- Agre and Chapman: Most of the people activities are routine actions in a dynamic world
  - Agents uses representations of objects that are defined through its interactions with the world.
  - Pengi: A program that plays a video game called Pengo



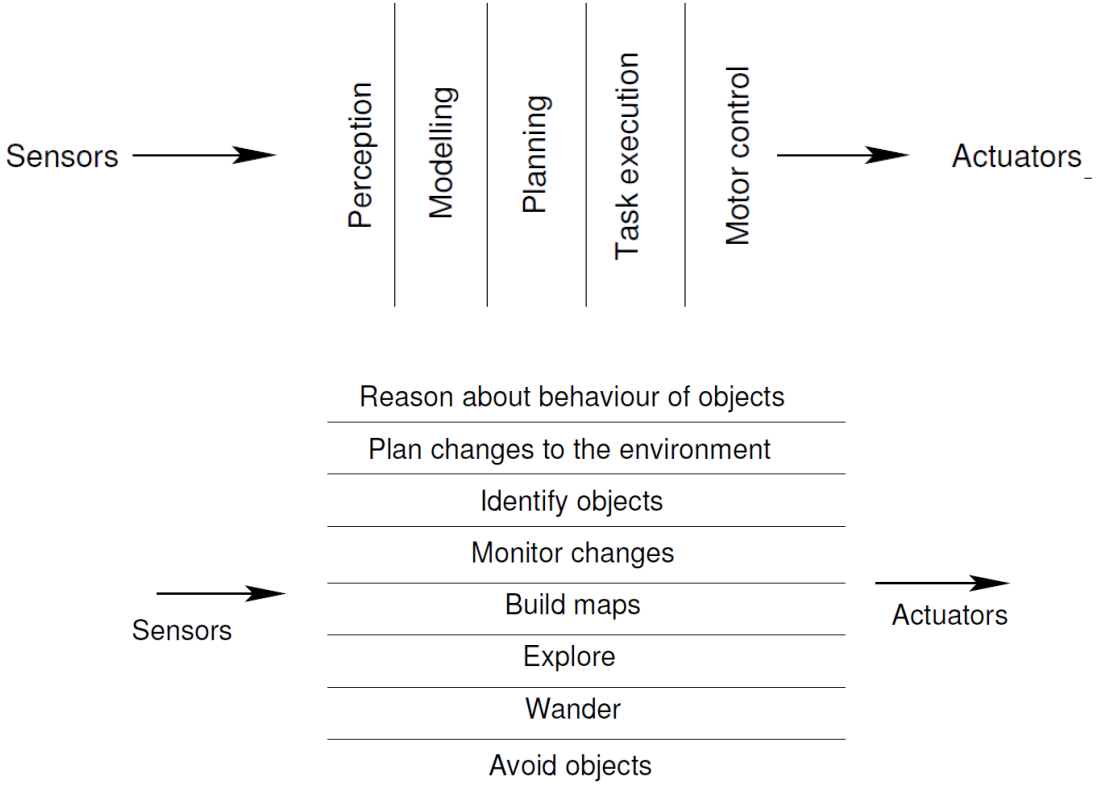
New Approach

- Brooks: Intelligence is the product of a system and its environment.
  - Intelligence emerge from the interactions of architectures of organized simple behaviors



New Approach

- Brooks: Subsumption Architecture



New Approach

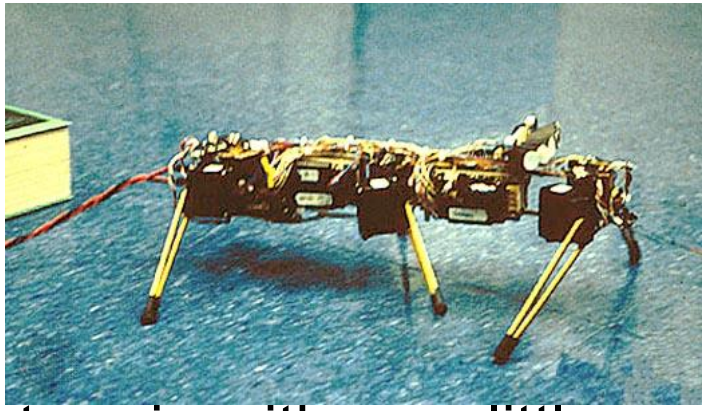
- These architectures were radically different from those in use in the robotics community at the time.
  - No central model of the world explicitly represented within the systems.
  - No implicit separation of data and computation.
  - The separation into perceptual system, central system, and actuation system was much less clear than in previous approaches.

Areas of Work

2 layers

- Non-Reactive higher level layer(For Direction!)
- Lower level Reactive layer(For avoiding Obstacles!)

"Genghis" Robot



- Programmed by Brooks.
- a six-legged robot, Genghis to walk over rough terrain.
- Successfully navigates rough terrain with very little computation.
- (http://www.youtube.com/watch?v=RKeBI0-msGQ)

Areas of Work

Other Areas

- At Hughes, an alternative voting scheme was produced to enable a robot to take advantage of the outputs of many behaviors simultaneously.
- At Brussels a scheme for selectively activating and deactivating complete behaviors was developed by Maes.
- MIT programmed "Toto" to provide a learning mechanism on the six-legged robot Genghis, so that it could learn to coordinate its leg lifting behaviors, based on negative feedback from falling down

Evaluation

- New approach has been difficult to evaluate
  - Proponents argued on Performance
  - Performance is hard to evaluate,
- Criticism to the approach:
  - Unprincipled. Comparisons to traditional academic robotics
  - Will not scale well. Traditional AI.
- What design principles allow systems based in the subsumption architecture to scale to large complex systems?

Evaluation

Traditional vs New approach

- In the new approach robots must learn everything about the world by themselves
- A priori knowledge must be non-specific to the particular location of the robot
- New approach robots operates in more uncertain conditions
- Changes in the environment are difficult to model

Summary

- Traditional academic robotics
  - Uses CAD (Computer Aid Design)-like models of objects
  - Uses modeled physics of the world
  - Verifications done occasionally with robots.
- New Approach
  - Emphasis on the interactions with the world
  - Measure and analyse the systems as they are situated in the real world.
  - Changes in environment conditions affect the behavior of the robots.

Discussion

- How can we find ways to model the interactions with the world in order to make accurate predictions of the performance of the robots?

- Can traditional robots operate in the real worlds in which new approach robots work well?