Intelligence Without Reason

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Definitions

- *Winston 1984*

  "The goals of Artificial Intelligence are both the construction of useful intelligent systems and the understanding of human intelligence."

- *Brooks 1991*

  "Intelligence is the sort of stuff that humans do, pretty much all the time."

Traditional Artificial Intelligence

- *Top down approach*

  It addresses problems through thought and reason.

  It has particular conventions for inputs and outputs when we do planning, problem solving, or knowledge representation.

  Brooks argues that this line of thinking has been influenced by the technological constraints of the available computers.

The Approach of Brooks

- Bottom-up approach

  Some of his framework is based on engineering and some is based on biological inspirations.

  It concentrates on physical systems (mobile robotics).

  He acknowledges dangers in studying biological systems too closely (issue of optimal solutions).

  He believes that by studying animals we may get constraints on how higher level thought in humans could be organized.

Themes

- Robots
- Computers
- Biology
- Ideas
- Thought

Robots

- SRI robot system (Shakey, late sixties)
- Moravec, Stanford (CART system, 1984)
- Giralt, Chatila and Vaisset, France (Hilare, 1984)

Robots

- Characteristics of early efforts

  They dealt with static environments and used off-board computers.

  They employ a framework called sense-model-plan-act (SMPA) by Brooks.

  The implicit idea was to solve first the static case and then deal with the dynamic environment.

Robots

- Agre and Chapman (1987 and 1990)
- Rosenschein and Kaebling (1986 and 1990)
- Brooks (1986, 1990, 1991)

Robots

- Characteristics of later efforts

  They dealt with the problem of organizing intelligence.

  People have routine activities in a dynamic world. An agent can do this by interacting with the world. Internal world models are not needed.

  Agents were built based on these principles from combinatorial circuits plus a little timing circuitry.

Robots

- *The previous approach is often called reactive planning.*
- *The terms behavior-based, robot beings, or artificial creatures have also been used.*

Robots

- *Key aspects of this work:*

  1) Situatedness: The robots are situated in the world.
  2) Embodiment: The robots have bodies.
  3) Intelligence: The robots are observed to be intelligent.
  4) Emergence: The intelligence of the system is derived from the system's interactions with the world.

Computers

- Prehistory

  Alan Turing discussed the creation of a computer to play chess in the 1940's.

  He believed that it will be possible to build a thinking machine due to the fact that it was possible to construct imitations of "any small part of a man."

  After this, we got Turochamp, MacHack-6, Chess 4.0, Belle, Deep Thought,..

Computers

- *Prehistory*

  Turing (1950) asked the question:

  "Can machines think?"

  He also presented the Turing test. A human exchanges English message over a teletype with either a human or a computer at the other end. The objective is to predict who is at the other side of the teletype.

Computers

- Establishment

  Dartmouth Conference (1956) influenced the field. McCarthy, Minsky, Newell, and Simon were present.

  Minsky thought that A.I consists of search, pattern recognition, learning, planning and induction.

  Several researchers talked about problem-solving search systems.

Computers

- *Cybernetics*

  Cybernetics is the study of the mathematics of machines (the emphasis is more on all the possible things that a machine can do).

  Initial emphasis was placed on the control of machines and electronic circuits.

  Much of the research was focused on understanding animals and intelligence.

Computers

- *Abstraction*

  Roberts' system, the copy-demo system, and Shakey operated in very carefully designed environments.

  Due to this careful selection of environmental conditions, high hopes were created.

  However, transition to a real-world environment was impossible.

Computers

- *Knowledge*

  Brooks argues that knowledge representation systems are totally useless. They try to represent "knowledge" about the world. He mentions the example of systems that dealt with penguins being birds. However, penguins cannot fly.

Computers

- *Robotics*

    Autonomous Land Vehicle Projects

    1) SMPA approach (Waxman, Srinivasan, Ambler project)

    2) Martin Marietta's robot

    3) CMU's NAVLAB

Computers

- Computer Vision

  Brooks argues that computer vision tries to reconstruct the static external world as a 3-D world model.

  He argues that this is not feasible.

  He also argues that this is not what the human vision does.

Computers

- *Parallelism*

Parallel computers are different than Von Neumann computers.

Perceptrons (linear threshold devices) were the first attempts.

Back propagation (as a learning algorithm) revived the field.

Computers

- Parallelism

Brooks says that:
"One problem for neural networks becoming situated or embodied is that they do not have a simple translation into time varying perception or action pattern systems."

Big help for A.I. (through parallel computation) was the Connection Machine developed by Hillis.

Biology

- ## *Ethology*

  Ethology (the study of animal behavior) has influenced Brooks.

  Tinbergen (1951) supported an hierarchical structure of animal intelligence.

  Modern ethology supports theories of motivational competition, disinhibition, and dominant and sub-dominant behaviors.

Biology

- Psychology

Brooks says that:
"The way in which our brains works is quite hidden from us."

To support this statement, he uses the example of optical illusions (e.g., leopard's moving spots).

Marr's model is also ill-equipped to deal with optical illusions.

Biology

- Psychology

  Researchers often study damaged brains in order to get insight.

  A.I. believes that there is a central storage system (in the brain) where concepts, goals, intentions, desires, categories etc. are linked together.

  Cases of split brain patients contradict the previous assumption.

Biology

- Neuroscience

  Researchers such as Dennett and Moravec view the brain as an electrical machine with electrical inputs and outputs to the sensors and actuators of the body.

  Brooks claims that the brain has a more serious coupling due to the existence of hormones.

  There is debate even about the role of a neuron (a single functional unit or a collection of many independent smaller units).

Biology

- Neuroscience

  Computational speed of neuronal systems is 1 KHz (pretty low).

  Wehner believes that evolution plays a big role.

  Animals can survive with very little neurological processing by choosing the right sensors.

Ideas

- *Situatedness*

  “The world is its own best model.”

- *Embodiment*

  “The world grounds regress.”

Ideas

- Intelligence

  "Intelligence is determined by the dynamics of interaction with the world."

- Emergence

  "Intelligence is in the eye of the observer."

Thought

- *Principles of the Brooks' framework:*

  1) The goal is to study complete integrated intelligent agents.

  2) Agents are mobile robots found around in a laboratory.

  3) The robots should operate even when changes happen in the laboratory environment.

  4) Computation is done through augmented finite state machines.

Thought

- Principles of the Brooks' framework:

5) Messages sent are small numbers (8 or 16 bits).

6) Sensors are connected through asynchronous two-sided buffers.

7) There is neither a central world model, nor a central locus of control.

8) There is no separation into perception and actuation systems.

Thought

- Principles of the Brooks' framework:

9) Layers are used to increase the behavioral competence of the system (they are based on evolutionary development).

10) There is no hierarchical arrangement.

11) The layers or behaviors run in parallel.

12) All the computations are done on-board.

13) Any specification can be easily compiled into a silicon circuit.

Thought

- *Reactivity*

Brooks mentions two robots:

1) Allen (1986) which combined reactive with non-reactive capabilities.

2) Herbert (1989) pushed more the reactive component of the framework.

Thought

- *Representation*

Brooks supports representations which are partial models of the world.

He rejects explicit representations of goals within the system.

Mataric (1990) introduced <u>active-constructive representations</u> to subsumption for a sonar-based robot (Toto).

Thought

- *Complexity*

How does the behavior-based approach scale to arbitrary large and complex systems?

Brooks evades the question. He says that one should look to precedents and trends.

The largest system he mentions has ~ 25 actuators and over 150 sensors.

Thought

- *Learning*

Brooks believes that the robots should learn both from their "genes" and their "experiences".

Four classes can be learnt:
1) Representations which help at a task
2) Calibration numbers
3) Ways of behavior interaction
4) New behavioral modules.

Thought

- *Behavior-Based Approach*

Three challenges:

1) Dynamics of how the individual behavior couples with the environment through sensors and actuators.

2) The number of behaviors that can be integrated into a single robot.

3) The interaction of multiple robots.

Thought

- Behavior-Based Approach

    For each behavior, the issues are:

    1) Convergence: Prove that a specific behavior can indeed execute a task successfully.

    2) Synthesis: Find a behavior specification to fit a task.

    3) Complexity: Deal with real world environments.

Thought

- *Behavior-Based Approach*

For each behavior, the issues are:

4) Learning: Learn new behaviors.

Thought

- *Behavior-Based Approach*

  For multiple behaviors in a single robot, the issues are:

  1) <u>Coherence</u>: The robot should appear to be coherent in its actions and goals.

  2) <u>Relevance</u>: The activation of the behaviors should be related to the activities of the robot.

  3) <u>Adequacy</u>: The behavior selection mechanism should select the behavior that satisfies the goals of the robot designer.

Thought

- Behavior-Based Approach

  For multiple behaviors in a single robot, the issues are:

  4) <u>Representation</u>: Some behaviors may share partial representations of the world.

  5) <u>Learning</u>: The robot's performance is improved as a result of experience.

Thought

- Behavior-Based Approach

  For multiple behavior-based robots, the issues are:

  1) <u>Emergence</u>: Having a set of behaviors programmed into a set of robots, we would like to predict the global behavior of the system.

  2) <u>Synthesis</u>: Given a task, find a program for the set of robots in order to execute the task.

  3) <u>Communication</u>: Performance vs. the amount of explicit communication.

Thought

- *Behavior-Based Approach*

  For multiple behavior-based robots, the issues are:

  4) <u>Cooperation</u>: Some behaviors may share partial representations of the world.

  5) <u>Interference</u>: Protocols should exist for handling robot interference.

  6) <u>Density Dependence</u>: The system's performance may depend on the robots and the resources.

Thought

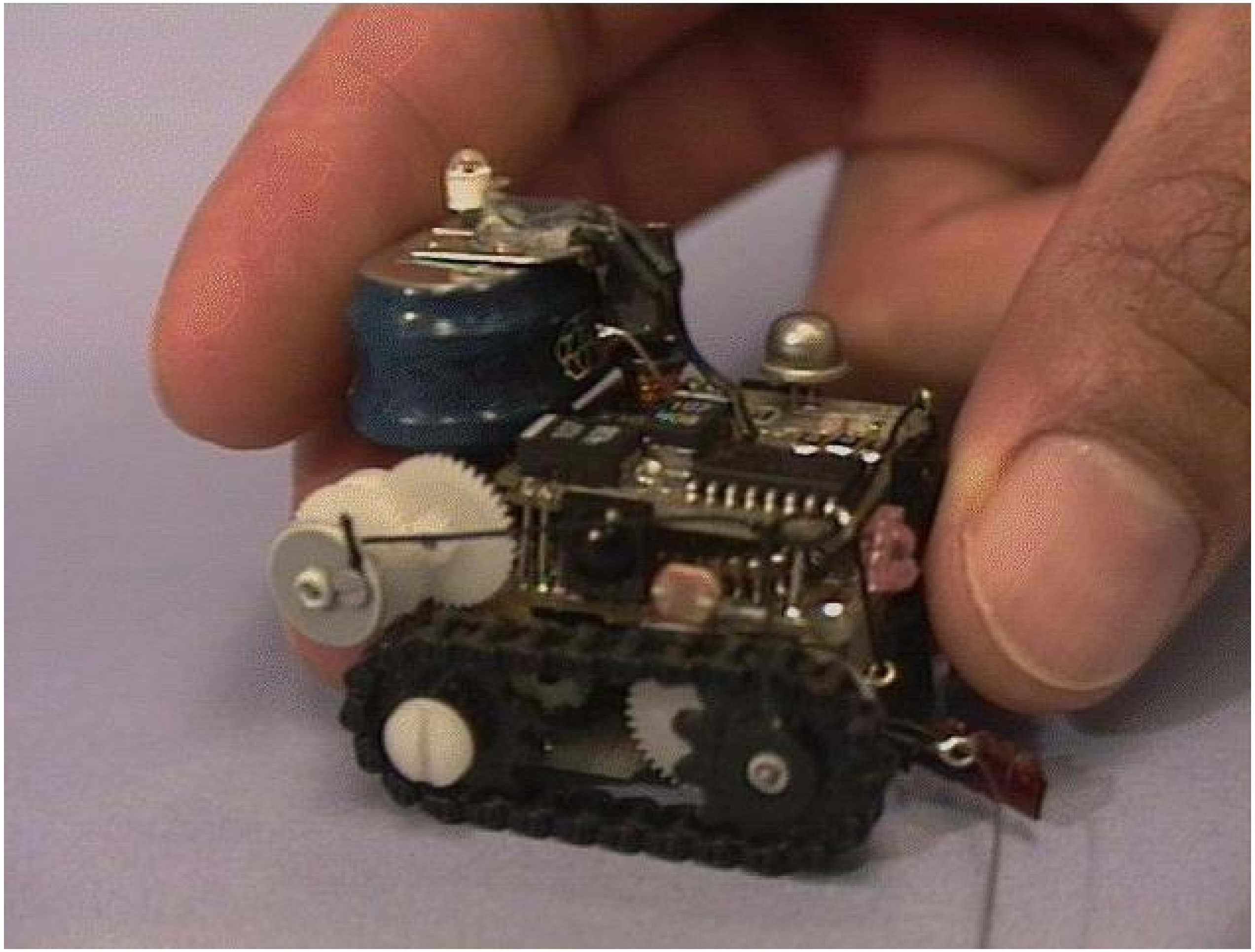
- *Behavior-Based Approach*

  For multiple behavior-based robots, the issues are:

  7) Individuality: The robots should be interchangeable. Another issue is the number of classes.

  8) Learning: The robots can learn individual or cooperative strategies.

His Current Work



Ant or Microbot

Conclusion

"We are a long way from creating Artificial Intelligences that measure up to the standards of early ambitions for the field."