

Agents and Knowledge Representation and Reasoning

An Introduction

Agents in the Real World

- # Mitsubishi Concordia, Java-based mobile agent system.
<http://www.merl.com/projects/concordia>
- # Copernic Agents for Internet Searching.
<http://www.copernic.com>
- # IBM - Aglets
<http://www.trl.ibm.com/aglets/>
- # Earlier, General Magic's Messaging Agents and Apple Newton's Agent Software

Agents in the Academic World

AAAI 2002 Workshops

- Agent-Based B2B Electronic Commerce
- Agent-Based Systems for Information Retrieval
- Coalition Formation in Dynamic Multiagent Environments
- Game Theoretic and Decision Theoretic Agents
- Cognitive Robotics
- Multi-Agent Modeling and Simulation of Economic Systems
- Autonomy, Delegation, and Control: From Inter-Agent to Groups

Agents in the Academic World (Cont)

- # The Fifth International Conference on Autonomous Agents 2001, Montreal
- # ATAL '01 Eighth International Workshop on Agent Theories, Architectures, and Languages. Seattle, 2001
- # AAMS 2002, Bologna, Italy - First International Joint Conference on Autonomous Agents and Multi-Agent Systems, July 2002.

Agents in the Academic World (cont)

- # *Artificial Intelligence*. January 1995. Volume 72, Numbers 1-2. Special Issue. Computational Research on Interaction and Agency
- # *Communications of the ACM*. July 1994. Special Issue on Intelligent Agents.

Agents in the Academic World (Cont)

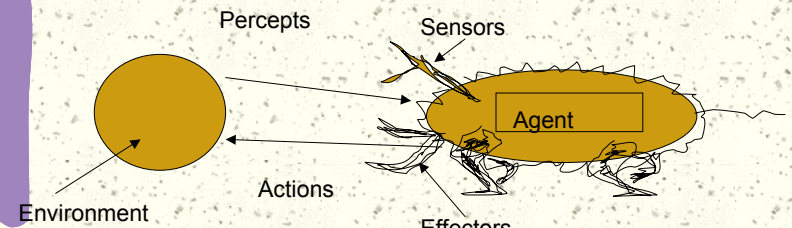
- # *Artificial Intelligence: A Modern Approach*, by Stuart Russell and Peter Norvig. Prentice Hall 1995. (2003 Second Edition)
- # *Artificial Intelligence: A New Synthesis*, by Nils J. Nilsson. Morgan Kaufmann 1998.
- # *Heterogeneous Agent Systems*, by V.S. Subrahmanian et al. MIT Press 2000.

What is an Agent?



Intelligent Agents (Russell and Norvig)

- # An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors



Example: Rodney -- A UNIX Softbot

- # Oren Etzioni et al.
- # Notify me if my disk utilization exceeds 80%
- # Let me know when Neal logs into his workstation.
- # Show me any posts containing the string "bicycle" that appear on the market bulletin board this week.

Rodney (cont)

- # Compress all files that haven't been accessed for a week.
- # Print my file on a nearby printer that is not busy, and tell me where to find it when the printing is finished.
- # Locate Neal Mitchell

Softbots

- # A softbot's effectors are commands transmitted to the external environment in order to change its state. (e.g. UNIX shell commands such as `mv` or `compress`)
- # A softbot's sensors are commands that provide the softbot with information about its external world (e.g. `pwd` or `ls`)

Softbots (cont)

- # Dynamic, real-world environment
- # Filtering electronic mail
- # Sending routine messages such as meeting reminders, talk announcements etc.
- # Scheduling meetings
- # Performing system maintenance tasks

Interface Agents

- # Computer programs that employ artificial intelligence techniques in order to provide assistance to a user dealing with a particular application ... The metaphor is that of a personal assistant who is collaborating with the user in the same work environment. (Maes '94)
- # Pattie Maes -- MIT Media Lab

Intelligent Web Search Agents

- # Numerous Examples and Applications
- # Sophisticated Knowledge Based Search Engines.

DAI: Distributed AI

- # Les Gasser
- # Collection of Interacting Knowledge-Based Processes
- # Coordinating a collection of agents to jointly take actions or to solve problems
- # Applications: expert systems, collaborative problem solving, scheduling, design

Agents

- # People
- # Robots
- # Softbots
- # Programs

Agency

- # Definition due to Phil Agre '95, AIJ
- # **Autonomy:** Agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state.

Agency (cont)

- # **Social Ability:** Agents interact with other agents (and possibly humans) via some kind of agent-communication language.

Agency (cont)

- # **Reactivity:** Agents perceive their environment (which may be the physical world, a user via a graphical user interface, a collection of other agents, the Internet, or perhaps all of these combined), and respond in a timely fashion to changes that occur in it.

Agency (cont)

- # **Pro-Activeness:** Agents do not simply act in response to their environment, they are able to exhibit goal-directed behavior by taking the initiative.

A Stronger Notion of Agency

- # A Computer system that is either conceptualized or implemented using concepts that are more usually applied to humans. These concepts are mentalistic notions such as knowledge, belief, intention, obligation etc.
- # (Woolridge and Jennings '95, Shoham '93)

What is A.I.

- # Using principled characterizations of interactions between agents and their environments to guide explanation and design. (Philip Agre 1995).

What is AI? (cont)

- # ... the study and construction of rational agents.
- # Acting rationally means acting in such a way as to achieve one's goals given one's beliefs.
- # An agent is just something that perceives and acts.
- # (Russell and Norvig 1995)

What is AI? (cont)

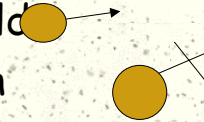
- # In this approach, AI is viewed as the study and construction of rational agents.
- # (Russell and Norvig 1995)

KR Hypothesis (Brian Smith)

- # Any mechanically embodied intelligent process will be comprised of structural ingredients that a) we as external observers naturally take to represent a propositional account of the knowledge that the overall process exhibits, and b) independent of such external attribution, play a formal but causal and essential role in engendering the behavior that manifests that knowledge.

Propositions

- # Statements about the world that are either true or false, right or wrong.
- # Symbols stand for things in the world
- # Men
- # Women



Propositions (cont)

- # "John loves Mary" stands for the proposition that JOHN LOVES MARY.
- # "John" is a symbol standing for JOHN.
- # ETC

Reasoning

- # Manipulation of Symbols encoding propositions to obtain new propositions.
- # From "John is Mary's Father"
- # We can infer that "John is an adult male."

Implicit and Explicit Knowledge

- # KB is a set of sentences
- # $KB \models \alpha$
- # Explicit Knowledge -- KB
- # Implicit Knowledge $\{\alpha \mid KB \models \alpha\}$

Example

- # Due to Brachman and Levesque (unpublished notes)
- # Is there a green block directly on top of a non-green block?



Knowledge Affects Action

- # Do action A if sentence P is in KB.
- # Vs
- # Do action A if world believed in Satisfies P.

Example

- # "Patient x is allergic to medicine m."
- # "All people allergic to m are also allergic to n."
- # "Is it ok to prescribe n for x"

Knowledge Based Systems

- # Separate Knowledge Base
- # Expert Systems -- Knowledge Base vs Shell

What Tasks demand KB Systems

- # Language Understanding, planning, diagnosis, "expert systems"
- # game-playing, vision
- # speech, motor control.

Intentional Stance

- # Ascription of beliefs, intentions, abilities, wants, or desires to a machine or organism.
- # When is this useful?
- # How does it relate to KR hypothesis?

Work on Agents

- # Agent Architectures (Symbolic vs NonSymbolic Processing)
- # Agent Languages
- # Agent Theories
- # Applications

Agent Theories

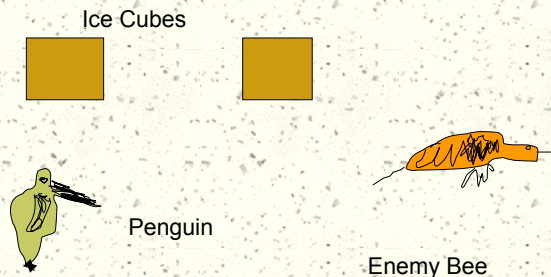
- # Logics
- # Specifying Agents
- # Intentional Stance
- # Many unresolved issues, Which Logics? Which Mental Attributes?

Robotics as the Foundation for AI (Brooks -- MIT)

- # Subsumption Architecture.
- # At each step we should build complete intelligent systems that we let loose in the real world with real sensing and real action.
- # The agents should be embodied as mobile robots ... the new approach can be extended to cover the whole story, both with regards to building intelligent systems and to understanding human intelligence.

Reactive Architectures

- # Pengi: Philip Agre and David Chapman
- # Plays Pengo --- Visual Routines



Situated Automata

- # Rosenschen and Kaelbling
- # All Symbolic Manipulation Done at Compile Time
- # A Logical Specification is compiled into an automata.

Touring Machines

- # Innis Ferguson
- # Multiple Layers
- # Reactive Layer
- # Planning Layer
- # Modelling Layer

Agent Languages

- # A system that allows one to program hardware or software computer systems in terms of some of the concepts developed by agent theorists.
- # Shoham -- Agent O, Agent Oriented Programming
- # Thomas PLACA

Some Applications

- # Supply Chain Management
- # Avoiding Aircraft Accidents
- # Data Integration
- # Personalized Visualization
- # Army War Reserves Logistics

Summary and Conclusions

- # BEWARE of the many uses of the word "Agents."
- # "Agents" provide interesting applications for many ideas that are being developed in AI.
- # But there is no easy solution to the difficult problems involved in KR -- Knowledge Representation and Reasoning"