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• Arthur Samuel at IBM wrote programs to play checkers (1950s)
  – initially, they played at a strong amateur level
  – however, they used some (simple) machine learning techniques, and soon outperformed Samuel

Source: IBM Research
Search/CSPs: Chess

• In 1996 and 1997, Gary Kasparov, the world chess grandmaster played two tournaments against Deep Blue, a program written by researchers at IBM

Source: IBM Research
• Deep Blue’s Results in the first tournament:
  – won 1 game, lost 3 and tied 1
    • first time a reigning world champion lost to a computer
    • although Kasparov didn’t see it that way…

Source: CNN
Search/CSPs: Chess

• Deep Blue’s Results in the second tournament:
  – second tournament: won 3 games, lost 2, tied 1

May 11th, 1997
Computer won world champion of chess
(Deep Blue) (Garry Kasparov)

(Reuters = Kyodo News)
Search/CSPs: Crossword Puzzles

Summary statistics:
- 95.3% words correct (miss three or four words per puzzle)
- 98.1% letters correct
- 46.2% puzzles completely correct

Daily Puzzles
370 puzzles from 7 sources.

Proverb Daily Results

Source: Michael Littman
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Planning: Logistics

• Dynamic Analysis and Replanning Tool (Cross & Walker)
  – logistics planning and scheduling for military transport
  – used in the 1991 Gulf War by the US
  – problems had 50,000 vehicles; different starting points and destinations

Source: DARPA
Planning: Spacecraft Control

NASA: Deep Space One spacecraft
• operated autonomously for two days in May, 1999:
  – determined its precise position using stars and asteroids
    • despite a malfunctioning ultraviolet detector
  – planned the necessary course adjustment
  – fired the ion propulsion system to make this adjustment

Source: NASA
Planning: Autonomous Delivery Robot

• Roams in an office environment making deliveries
  – observations: cameras, range finders, microphone, …
  – prior knowledge: map, people in the world

Source: Pantalis Elinas, UBC
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“Day after day since 1984, teams of programmers, linguists, theologians, mathematicians and philosophers have plugged away at a $60-million project they hope will transform human existence: teaching a computer common sense.

“They have been feeding a database named Cyc over a million truths and generalities about daily life so it can automatically make assumptions humans make, such as:
– Creatures that die stay dead.
– Dogs have spines.
– Scaling a cliff requires intense physical effort.

“Though some critics question the potential of this painstaking effort, the inventors believe Cyc will form the brains of computers with supercharged reasoning abilities - which could help us work more efficiently, make us understand each other better and even help us predict the previously unforeseeable.”

Quoted from: Independent Online
Logic: Cyc

Cyc Ontology & Knowledge Base

Cyc contains:
- 10,000 Predicates
- 100,000 Concepts
- 1,400,000 Assertions

Represented in:
- First Order Logic
- Higher Order Logic
- Context Logic
- Micro-theories

Domain-Specific Facts and Data

Domain-Specific Knowledge
(e.g., Bio-Warfare, Terrorism, Computer Security, Military Tactics, Command & Control, Health Care, ...)

Source: Cycorp
“CycSecure scans a computer network to build a formal representation of the network, based on Cyc’s pre-existing ontology of networking, security, and computing concepts:

- information about what computers are on the network, what programs are installed or running on those computers, what privileges the running programs have, what users are logged into the computers, etc.

This formal representation also allows users to interact directly with the model of the network, allowing testing of proposed changes.”

Excerpted from: Shepard et al., 2005
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Reasoning under Uncertainty: Diagnosis

Source: Onisko et al., 99
Reasoning Under Uncertainty

- Texture classification using SVMs
  - foliage, building, sky, water

Source: Mike Cora, UBC
Reasoning under Uncertainty

• Track a hand and estimate activity:
  – drawing, erasing/shading, other

Source: Kevin Murphy, UBC
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Planning Under Uncertainty

Localization: office robot with laser rangefinder

Source: Sebastian Thrun
Planning Under Uncertainty

Simultaneous Localization & Mapping: Mine mapping

Source: Sebastian Thrun
Planning Under Uncertainty

SLAM in 3D: Helicopter Mapping

Source: Sebastian Thrun
Planning Under Uncertainty

Helicopter control: MDP, reinforcement learning

Source: Andrew Ng
Planning Under Uncertainty

Autonomous driving: DARPA Grand Challenge

Source: Sebastian Thrun

Dr. Sebastian Thrun
Stanford Racing Team Leader & Director
Stanford Artificial Intelligence Lab
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Multiagent Systems: Poker

- In full 10-player games Poki is better than a typical low-limit casino player and wins consistently; however, not as good as most experts.
- New programs being developed for the 2-player game are quite a bit better, and we believe they will very soon surpass all human players.

Source: *The University of Alberta GAMES Group*
Multiagent Systems: Robot Soccer

Source: RoboCup web site
Multiagent Systems: Trading Agents

Source: Swedish Institute of Computer Science
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