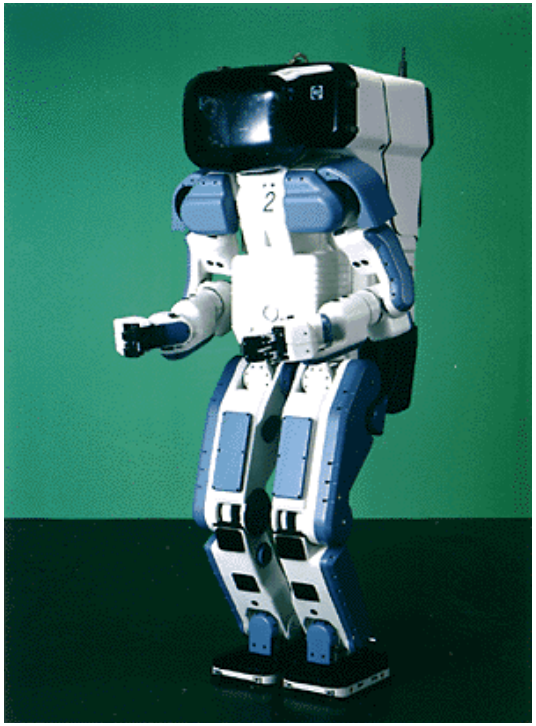
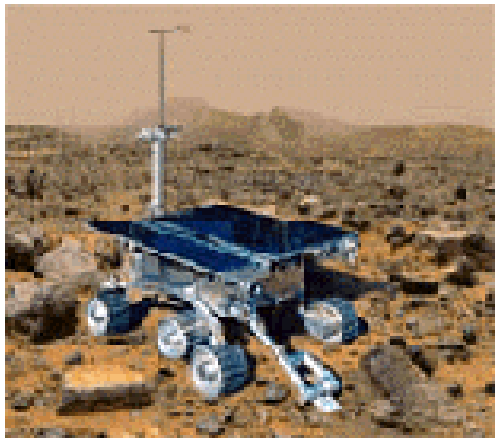
Robotics and AI

Introduction

Why study AI?



Labor



Science

Google

YAHOO!

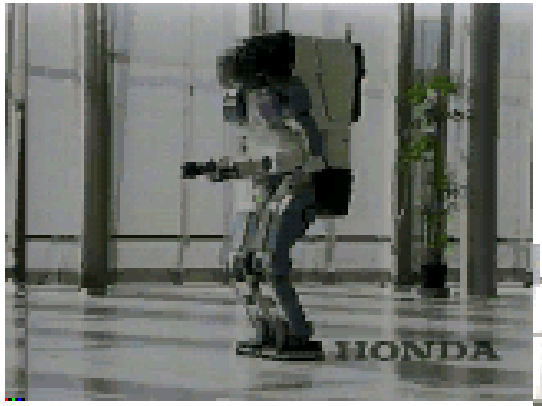
Search engines

Medicine/
Diagnosis

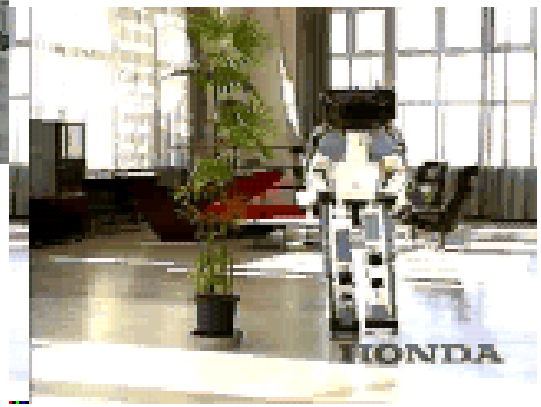
Appliances

What else?

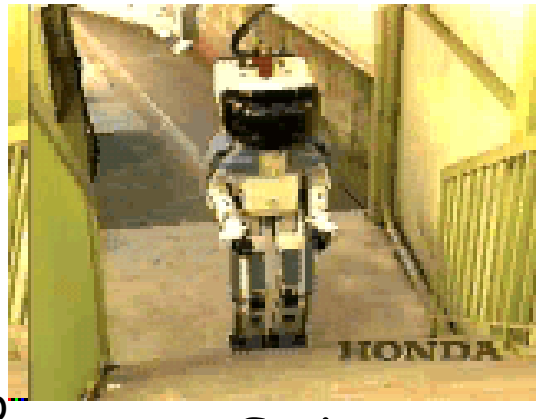
Honda Humanoid Robot



Walk



Turn

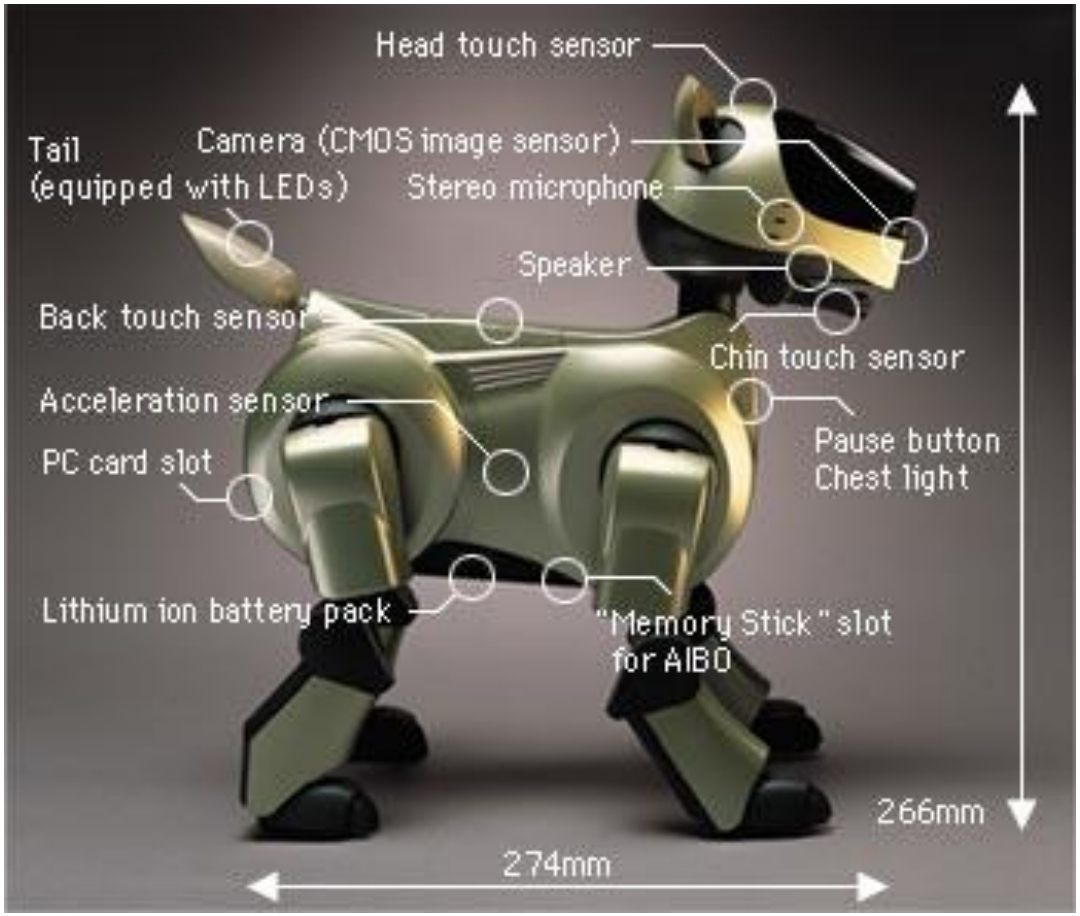


Stairs

http://world.honda.com/robot/

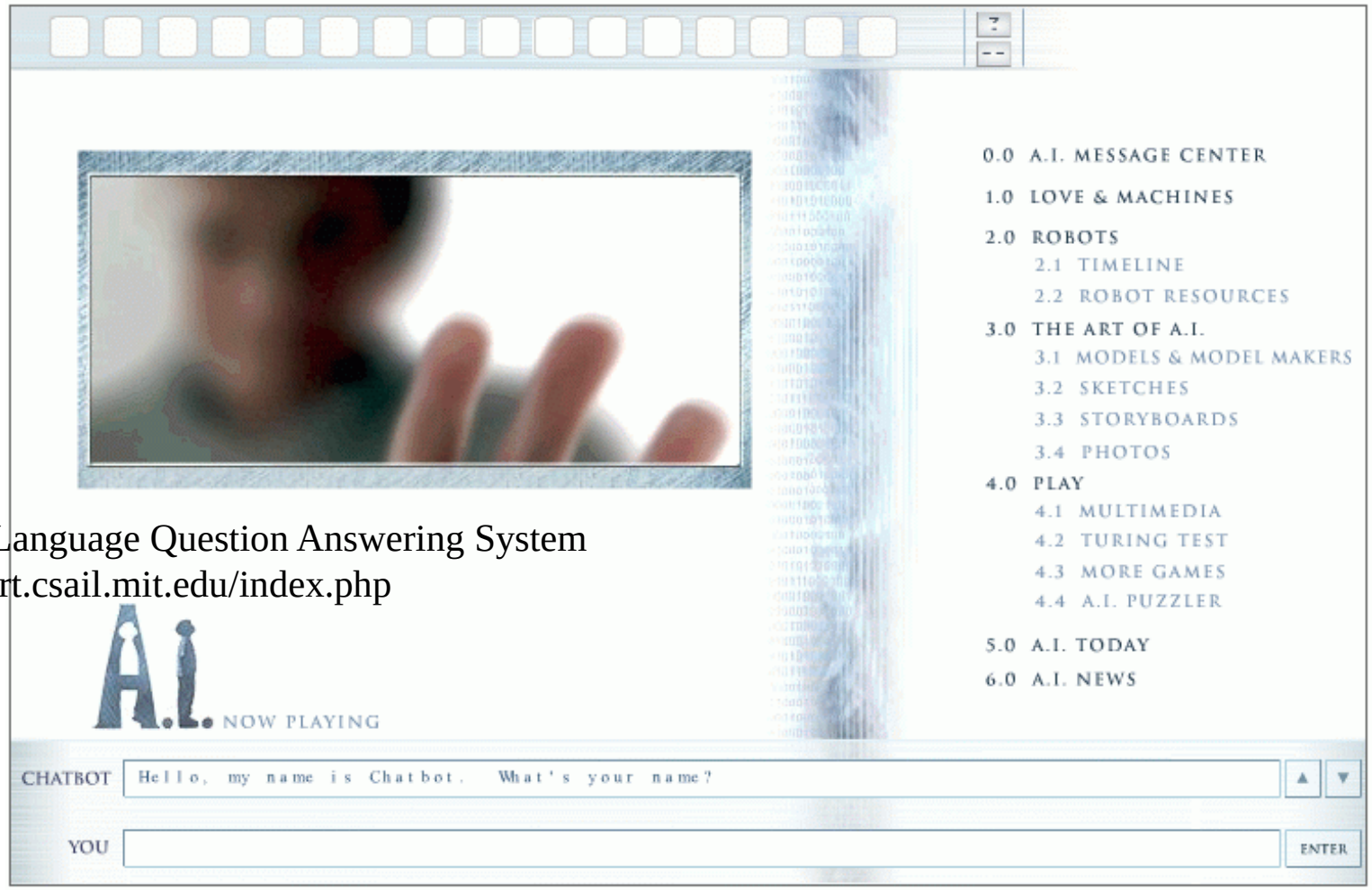
https://www.honda.com/mobility/say-hello-to-asimo

Sony AIBO



http://www.aibo.com
Robot Dog

Natural Language Question Answering



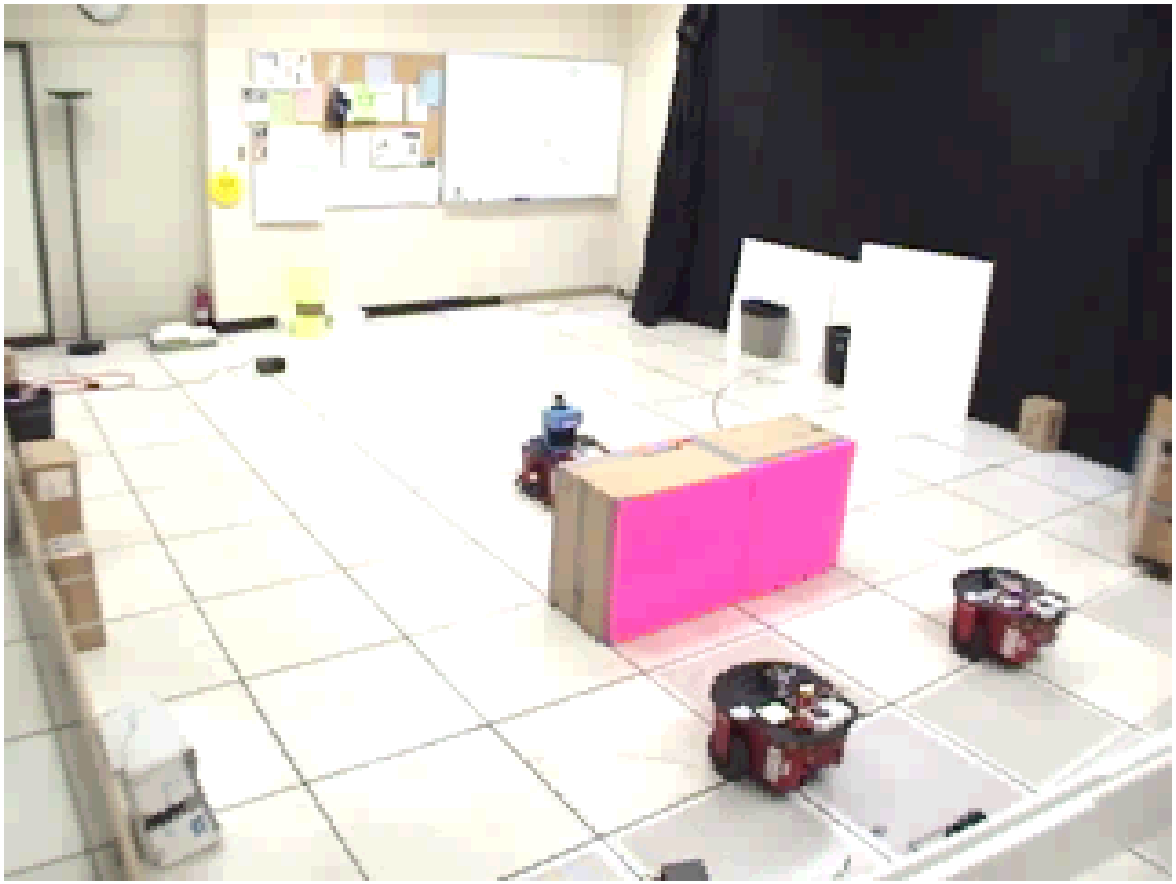
Natural Language Question Answering System
http://start.csail.mit.edu/index.php

http://aimovie.warnerbros.com

http://www.ai.mit.edu/projects/infolab/

MIT InfoLab Group develops intelligent interactive software system

Robot Teams



USC robotics Lab

What is AI?

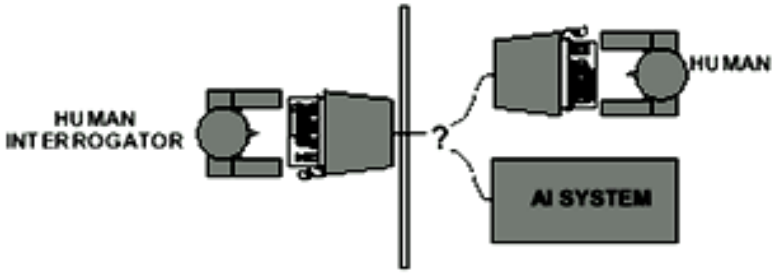
"The exciting new effort to make computers think ... *machines with minds*, in the full and literal sense" (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (Bellman, 1978)	"The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act" (Winston, 1992)
"The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990) "The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

Figure 1.1 Some definitions of AI. They are organized into four categories:

Systems that think like humans.	Systems that think rationally.
Systems that act like humans.	Systems that act rationally.

Acting Humanly: The Turing Test

- Alan Turing's 1950 article *Computing Machinery and Intelligence* discussed conditions for considering a machine to be intelligent
  - "Can machines think?" ←→ "Can machines behave intelligently?"
  - The Turing test (The Imitation Game): Operational definition of intelligence.



- Computer needs to posses:Natural language processing, Knowledge representation, Automated reasoning, and Machine learning

- Are there any problems/limitations to the Turing Test?

What tasks require AI?

- "AI is the science and engineering of making intelligent machines which can perform tasks that require intelligence when performed by humans …"

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- Tasks that require AI:
  - Solving a differential equation
  - Brain surgery
  - Inventing stuff
  - Playing Jeopardy
  - Playing Wheel of Fortune
  - What about walking?
  - What about grabbing stuff?
  - What about pulling your hand away from fire?
  - What about watching TV?
  - What about day dreaming?

Acting Humanly: The Full Turing Test

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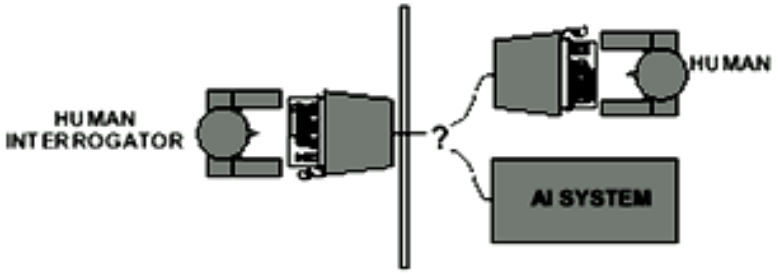

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- Problem: 1) Turing test is not reproducible, constructive, and amenable to mathematic analysis. 2) What about physical interaction with interrogator and environment?
- Total Turing Test: Requires physical interaction and needs perception and actuation.

What would a computer need to pass the Turing test?

- Natural language processing: to communicate with examiner.
- Knowledge representation: to store and retrieve information provided before or during interrogation.
- Automated reasoning: to use the stored information to answer questions and to draw new conclusions.
- Machine learning: to adapt to new circumstances and to detect and extrapolate patterns.
- Vision (for Total Turing test): to recognize the examiner's actions and various objects presented by the examiner.
- Motor control (total test): to act upon objects as requested.
- Other senses (total test): such as audition, smell, touch, etc.

Thinking Humanly: Cognitive Science

- 1960 "Cognitive Revolution": information-processing psychology replaced behaviorism

- Cognitive science brings together theories and experimental evidence to model internal activities of the brain
  - What level of abstraction? "Knowledge" or "Circuits"?
  - How to validate models?
    - Predicting and testing behavior of human subjects (top-down)
    - Direct identification from neurological data (bottom-up)
    - Building computer/machine simulated models and reproduce results (simulation)

Thinking Rationally: Laws of Thought

- Aristotle (~ 450 B.C.) attempted to codify "right thinking"
  What are correct arguments/thought processes?
- E.g., "Socrates is a man, all men are mortal; therefore Socrates is mortal"

- Several Greek schools developed various forms of logic:
  notation plus rules of derivation for thoughts.

- Problems:
  1) Uncertainty: Not all facts are certain (e.g., *the flight might be delayed).*
  2) Resource limitations: There is a difference between solving a problem in principle and solving it in practice under various resource limitations such as time, computation, accuracy etc. (e.g., *purchasing a car)*

Acting Rationally: The Rational Agent

- Rational behavior: Doing the right thing!
- The right thing: That which is expected to maximize the expected return
- Provides the most general view of AI because it includes:
  - Correct inference ("Laws of thought")
  - Uncertainty handling
  - Resource limitation considerations (e.g., reflex vs. deliberation)
  - Cognitive skills (NLP, AR, knowledge representation, ML, etc.)
- Advantages:
  1) More general
  2) Its goal of rationality is well defined

How to achieve AI?

- How is AI research done?
- AI research has both theoretical and experimental sides. The experimental side has both basic and applied aspects.
- There are two main lines of research:
  - One is biological, based on the idea that since humans are intelligent, AI should study humans and imitate their psychology or physiology.
  - The other is phenomenal, based on studying and formalizing common sense facts about the world and the problems that the world presents to the achievement of goals.
- The two approaches interact to some extent, and both should eventually succeed. It is a race, but both racers seem to be walking. [**John McCarthy]**

Branches of AI

- **Logical AI**
- **Search**
- **Natural language processing**
- **pattern recognition**
- **Knowledge representation**
- **Inference** From some facts, others can be inferred.
- **Automated reasoning**
- **Learning from experience**
- **Planning** To generate a strategy for achieving some goal
- **Epistemology** This is a study of the kinds of knowledge that are required for solving problems in the world.
- **Ontology** Ontology is the study of the kinds of things that exist. In AI, the programs and sentences deal with various kinds of objects, and we study what these kinds are and what their basic properties are.
- **Genetic programming**
- **Emotions???**
- …

AI Prehistory

Philosophy	logic, methods of reasoning
	mind as physical system
	foundations of learning, language, rationality
Mathematics	formal representation and proof
	algorithms
	computation, (un)decidability, (in)tractability
	probability
Psychology	adaptation
	phenomena of perception and motor control
	experimental techniques (psychophysics, etc.)
Linguistics	knowledge representation
	grammar
Neuroscience	physical substrate for mental activity
Control theory	homeostatic systems, stability
	simple optimal agent designs

AI History

1943	McCulloch & Pitts: Boolean circuit model of brain
1950	Turing's "Computing Machinery and Intelligence"
1952–69	Look, Ma, no hands!
1950s	Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
1956	Dartmouth meeting: "Artificial Intelligence" adopted
1965	Robinson's complete algorithm for logical reasoning
1966–74	AI discovers computational complexity Neural network research almost disappears
1969–79	Early development of knowledge-based systems
1980–88	Expert systems industry booms
1988–93	Expert systems industry busts: "AI Winter"
1985–95	Neural networks return to popularity
1988–	Resurgence of probabilistic and decision-theoretic methods Rapid increase in technical depth of mainstream AI "Nouvelle AI": ALife, GAs, soft computing

AI State of the art

- Have the following been achieved by AI?
  - World-class chess playing
  - Playing table tennis
  - Cross-country driving
  - Solving mathematical problems
  - Discover and prove mathematical theories
  - Engage in a meaningful conversation
  - Understand spoken language
  - Observe and understand human emotions
  - Express emotions
  - …

AI Technique

- What?
- Knowledge
  - Voluminous
  - Hard to categorize
  - Constantly changing
  - Differs from data

- AI Technique : method that makes use of knowledge (represented as
  - Captures generalization
  - Understood by people
  - Modifiable
  - Can bu used in multiple places

- *AI problem is independent of AI technique.*

Tic Tac Toe (X- O)

Program 1:

1	2	3
4	5	6
7	8	9

Program 2 :

Tic Tac Toe (X- O)

Program 3 :

8	3	4
1	5	9
6	7	2

Program 4 :

Question Answering

Marry went shopping for a new coat. She found a red one she really liked. When she got it home she discovered that it went perfectly with her favorite dress.

Q1) What did Marry go shopping for?
Q2) What did Marry find that she liked?
Q3) Did Marry buy anything?

- Program 1
  - Input in string
  - Datastructure
    - Set of template that match common Qs
      - What did X Y
  - Algorithm
    - Compare All pattern of Qs, match with verb and substitute, Apply all patterns and find answer.

    Fails for 3rd.....

- Program 2
  - Input in char form
  - Datastructure
    - Use Event , Thing and their properties.
  - Algorithm
    - Convert input and Qs in strctured form,Match,return

flexible

Fails for 3rd.....

- Program 3
  - Input in char form
  - Datastructure
    - Structured representation of background knowledge, object ,action,situation like script
  - Algorithm
    - Convert input and Qs in strctured form using knowledge and model.

flexible

AI Techniques

- Search
- Use of Knowledge
- Abstraction