Chapter 1
Fundamentals

a) Review – AI and its history
b) Philosophical remarks
c) Application fields of AI
d) Procedure for solving an AI problem

History of Applications

- Game Playing
  - From 1952 checkers
  - Later chess (1997 won against Kasparow)
  - 2011: Watson, Jeopardy; 2016 AlphaGO;
- Analysis of molecular structures
  - DENDRAL
  - Knowledge based system
- Diagnosis of infections
  - MYCIN
  - Knowledge based system with fuzzy logic
  - In 1991 diagnosis programs reached level of doctors
    - Lymph-node pathology, expert scoffs at the system's response
    - Program explained reasons / doc finally agreed and admits his error

History of Applications

- First commercial expert system R1, 1982
  - Automatic configuration of newly ordered computers
  - Saved 40 million per year after four years
  - Many enterprises had their own (A)AI group

- Internet (World Wide Web)
  - Search
  - Recommender
  - Construction
  - Agents and bots - usual terms

- Logistic planning
  - Dynamic analysis and replanning tool (DART), army, 1991
  - Planned 50,000 items – “30 years of investment paid off”

History of Applications

- Autonomic Control
  - ALVINN controls van and follows street
  - Could navigate 98% of a trip with 2,850 km
  - DARPA Grand challenge (2005) Urban (2007)
  - Now: Google Car conquers the streets

- Autonomic Scheduling
  - Remote-Agent-Program of NASA, 2000
  - Global aims from earth, locally divided and solved
- Speech and Handwriting Recognition
  - Integrated in today's operating systems

Application Areas (Map)

handwriting recognition

pattern recognition

computer vision

search

data mining

speech recognition

image recognition

document retrieval

reasoning

language technology

statistical learning

fuzzy logic

human computer interaction

decision making

communication

intelligent agents

logic

predicting

collaborative intelligence

planning

problem solving

robotic

knowledge representation

simulated reality

cognitive systems

knowledge engineering

augmented reality

expert systems

game playing

sonar

recommender systems

knowledge systems

question answering

knowledge management

information management

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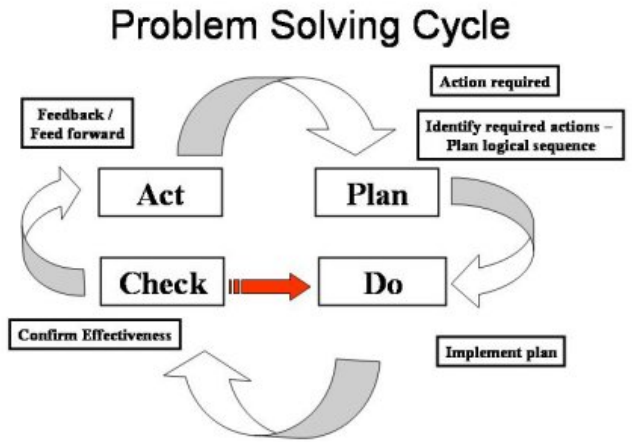
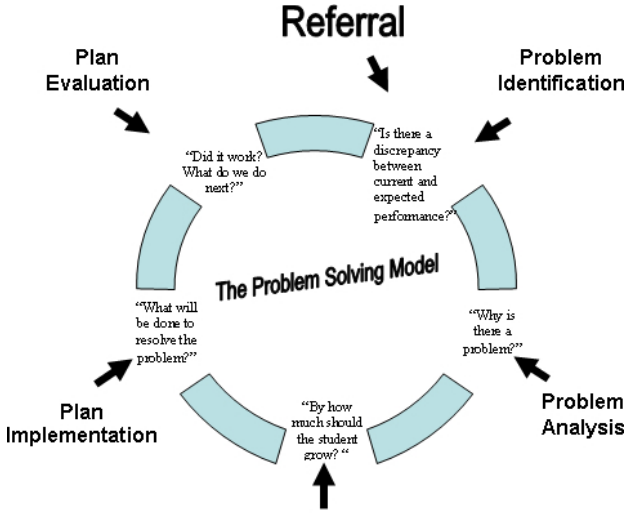
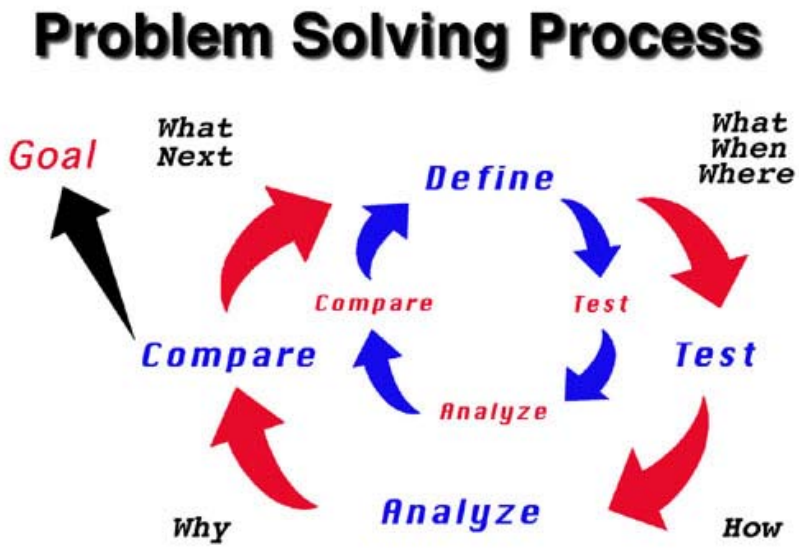
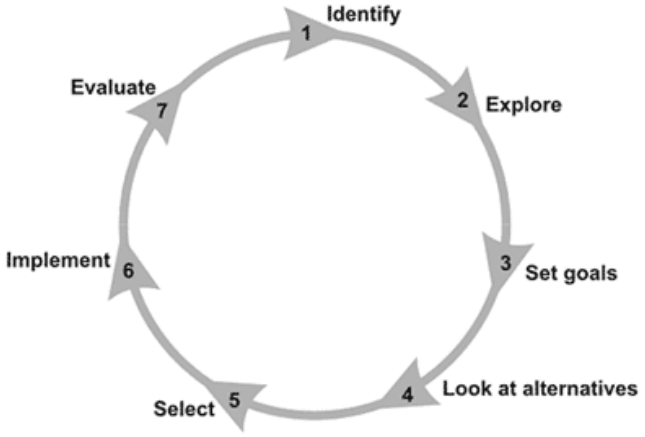
Many Strategies for Problem Solving







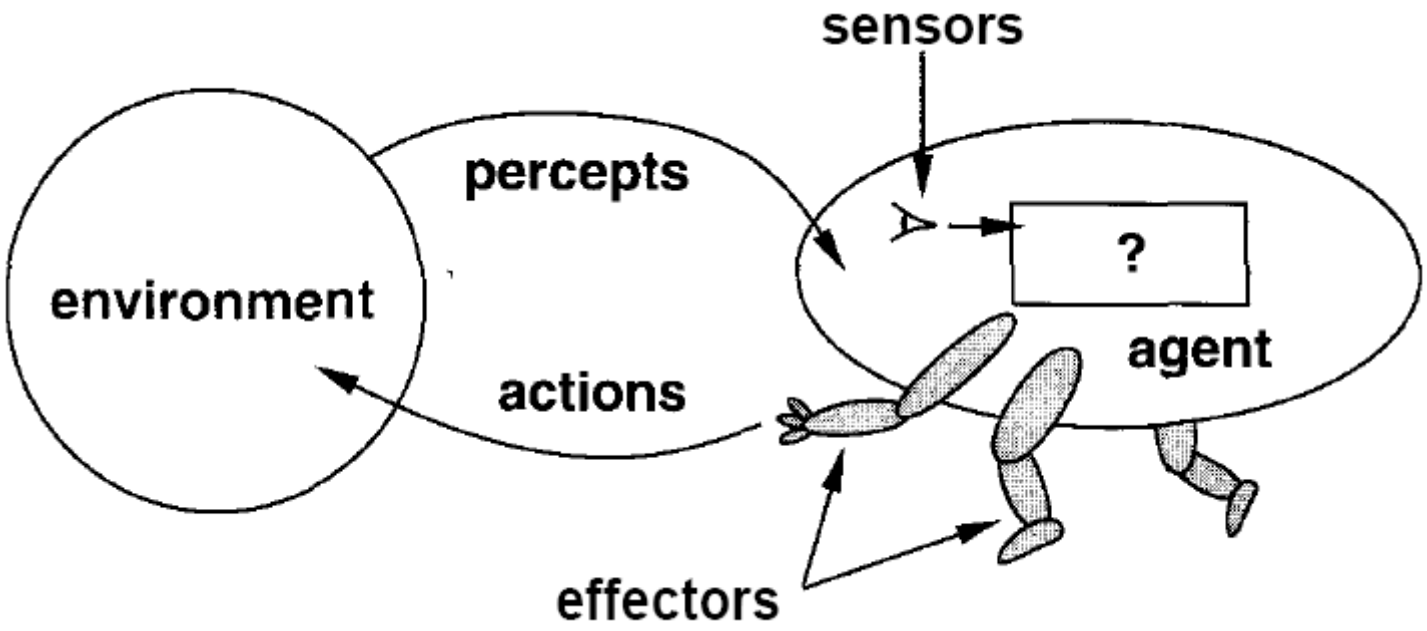


Procedure for Solving an AI Problem

1. Classify the problem
2. Analyze the data
3. Divide the problem into sub-tasks
4. Develop/apply methods for handling subtasks
5. Evaluate different methods
6. Select best methods for solving subtasks
7. Combine individual solutions to the overall solution
8. (Evaluate overall solution)

Agent

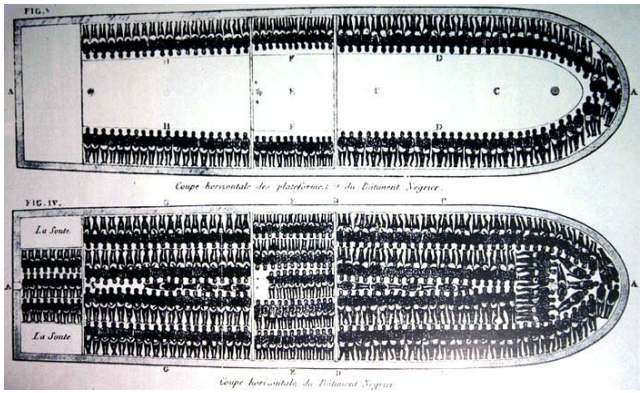
- System which perceives and acts accounted as an agent
- A rational agent should always choose the actions which maximize the performance, given a percept sequence
  - Note: nothing said about intelligence at this point



Agents – From Simple to Complex

- Simple reflex-agents
  - If … then …
- Agents that keep track of the world
  - Maintain an internal state

- Goal-based agent
  - Try to reach a goal
  - (Conference in Hilton Hotel Edminton/Alberta) General Problem Solver Example



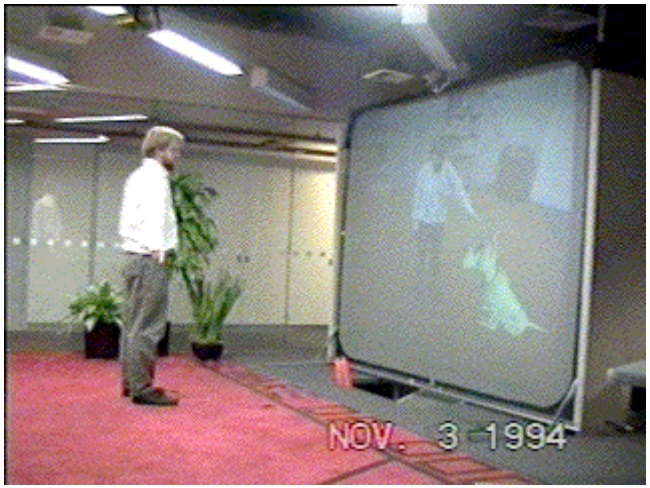
- Utility-based agents
  - Find the safest/fastest/cheapest etc. way

Job of AI

- Design the agent program:
  - Function that implements the agent mapping from percepts to actions.
  - Run on a defined architecture – maximizing the benefit from recources

$$agent = architecture + program$$

- It has to be determined
  - Percepts and actions
  - What goals, performance measure
  - Sort of environment
    - (real or artificial – ALIVE, MIT, 1994)



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Classifying the Problem

- We have to determine the characteristics of the agent's environment
- Accessible vs. inaccessible
  - Always access to the complete state of the environment
  - Agent does not need to maintain any internal state

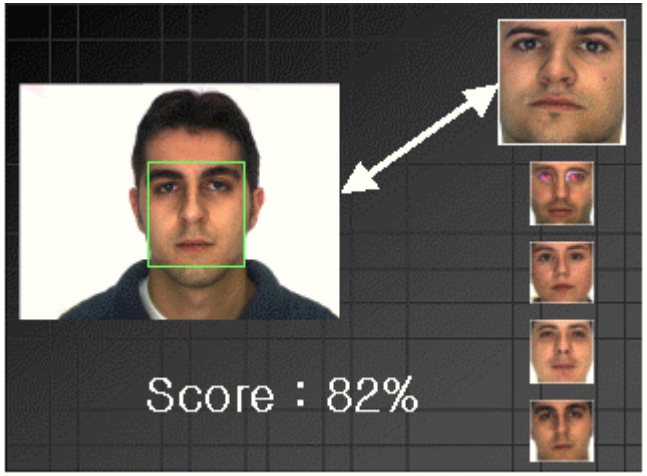
*

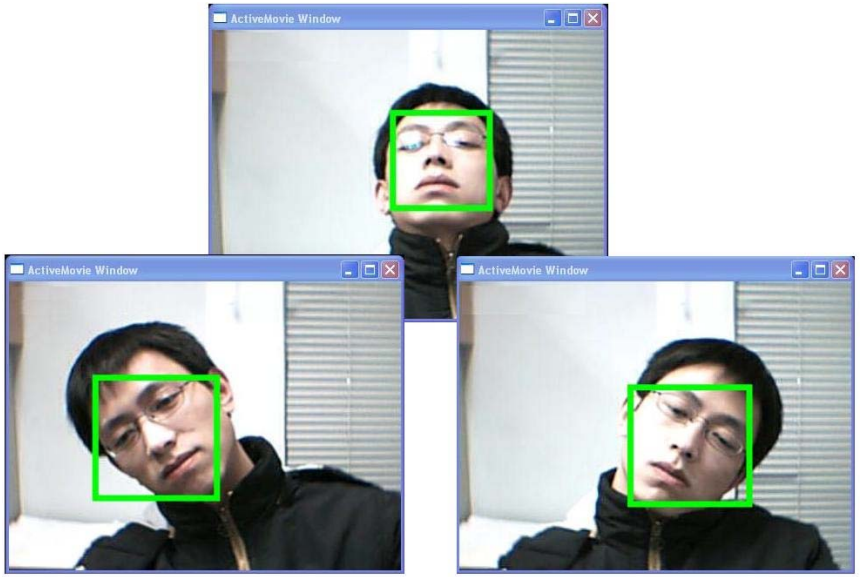
Classifying the Problem

- Deterministic vs. nondeterministic (=stochastic)
  - Does the next state of environment depend on the agents' actions?
  - No problem if deterministic and accessible
  - If inaccessible, it seems like it is nondeterministic
    - In complex environments (new dirt in vacuum cleaner environment)
    - Strategic: everything but the actions of other agents is deterministic

Classifying the Problem

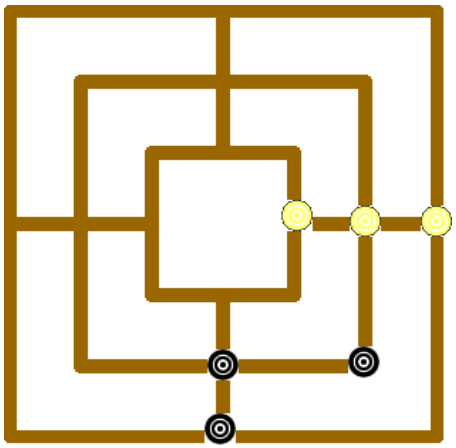
- Episodic vs. nonepisodic (=sequential)
  - Episodic: perceiving, then acting – quality of the action depends on the episode itself
  - Episodic environments are simpler





- Static vs. dynamic
  - Does the environment change while the agent deliberates?
  - Static environments are easier
    - Agent does not need to keep track of the world
  - Semi-dynamic: environment does not change, but the score

- Discrete vs. continuous
  - Limited number of distinct clearly defined percepts and actions



Classifying the Problem

- Single-agent vs. multi-agent
  - Is the influence of other agents important for the performance?
  - Competing agents vs. cooperative agents

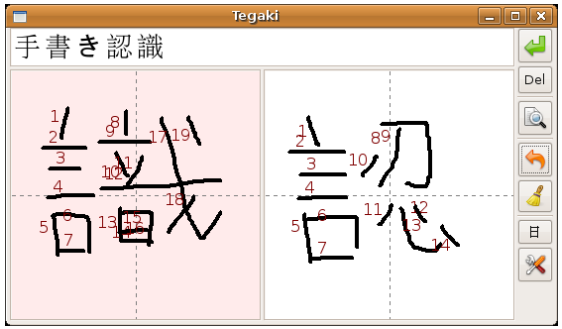
Classifying the Problem

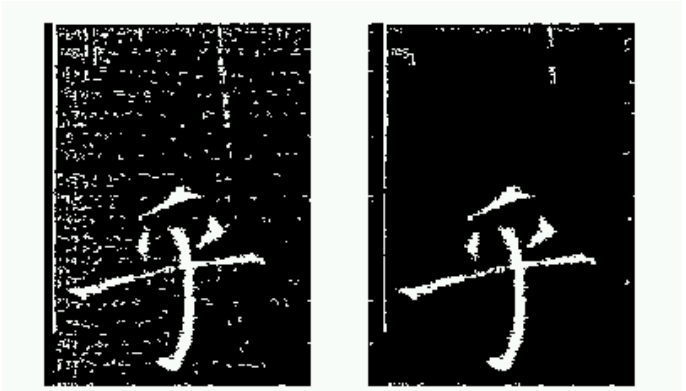
Environment	Accessibility	Deterministic	Episode	Static	Discrete	Agents
crosswords						
chess						
poker						
backgamm.						
taxi driving						
diagnostic						
image rec.						
simple robot						
controller						
AI teacher						

The most complex environment is inaccessible, nondeterministic, sequential, dynamic, continuous, with multiple agents

Analyze the Data

- Facts and knowledge vs. examples
  - Use of *a priori* knowledge
- How much data (percepts) are available
  - Significant amount
  - Representative
  - Possibly add more percepts
- Quality
  - Noise
  - Reliability





Divide the Problem into Subtasks

- This is difficult and often not considered
- Depends on the specific task to be solved
- Basic idea: try to find subtasks where the environments are easier to handle
- Note: sometimes, division leads to more difficult tasks

- This depends on the combination

Develop/Apply Methods for Handling Subtasks

- Study related work
- Which methods fits best?

- Generalize the problem
  - Example: face recognition benefits from pattern recognition
- Gather knowledge from experts in the field
- Ask multiple persons

Evaluate Different Methods

- Define examples, test cases
  - Test them
  - Ask experts if this is correct
- Use evaluation data, validation data

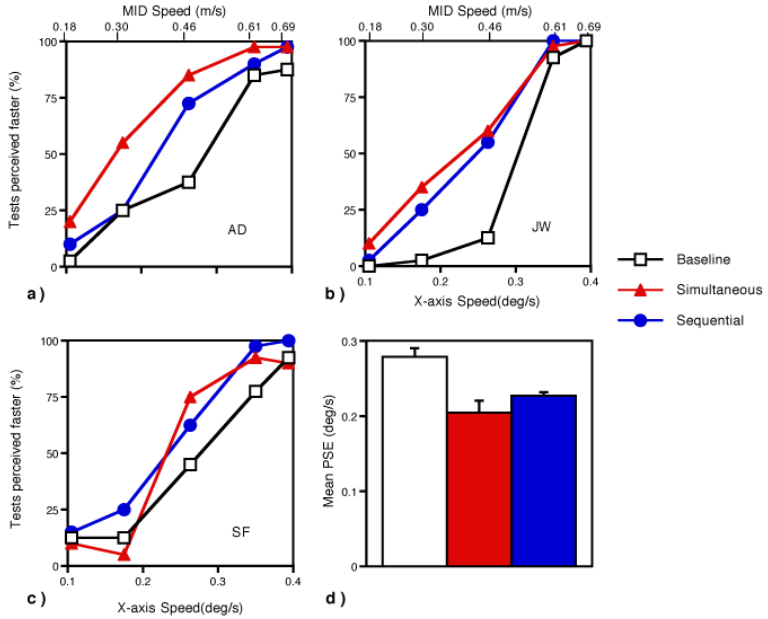
- Define a good evaluation function

$$\mathbf{Q-Score} = \sqrt{\frac{\sum_{k=1}^{m}\left(\sum_{i=1}^{n_k}\sum_{j=i+1}^{n_k}\left(x_{ki}-x_{kj}\right)^2\right)}{\sum_{k=1}^{m}\frac{n_k\times\left(n_k-1\right)}{2}}}$$

- Consider different aspects
  - Performance
  - Calculation time
  - Resources needed

Select Best Methods for Solving Subtasks

- Compare the methods properly
- Make your choice objective
  - Unbiased
  - Consider statistically significance (more later)



Combine Individual Solutions to the Overall Solution

- Put everything together
- What to pass to the next subtask?
  - A single result
  - Several alternates
  - Alternates with probabilities
  - Complexity may be time-consuming
- Apply the overall solution
  - Fix the bugs ☺
- Finally: Evaluate the solution

What is the general AI problem?

The General AI Problem

- Develop a machine where human experts cannot decide if it is a machine or a human being
  - Turing test (scheduled to be solved in 2000)
    - Communication via terminal
    - Answer questions and talk to the evaluating expert
    - Experts decides after 5 minutes if human or machine
    - If more than 30% of experts fail, the test is successful
  - Total Turing test (Russell & Norvig)
    - Uses Video signal
  - Ultimate Turing test (gedankenexperiment)
    - Lets the computer directly interact with the expert
    - Stage 1: no direct physical interaction allowed
    - Stage 2: no limitations
  - Truly Total Turing Test
    - Machine must evolve its own manifestations

How to solve the general AI problem?

Solve the General AI Problem

1. Classify the problem

   inaccessible, non-determenistic, sequential, dynamic, continuous, with multiple agents

2. Analyze the data

   noisy, few *a priory* knowledge

3. Divide the problem into sub-tasks
   - Natural language processing
   - Knowledge representation
   - Automated reasoning
   - Machine learning
   - Computer vision
   - Robotics

4. Develop/apply methods for handling subtasks …