ARTIFICIAL INTELLIGENCE & EXPERT SYSTEMS

Introduction

ABOUT THE COURSE

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Course Web Site : aksis.istanbulc.edu.tr

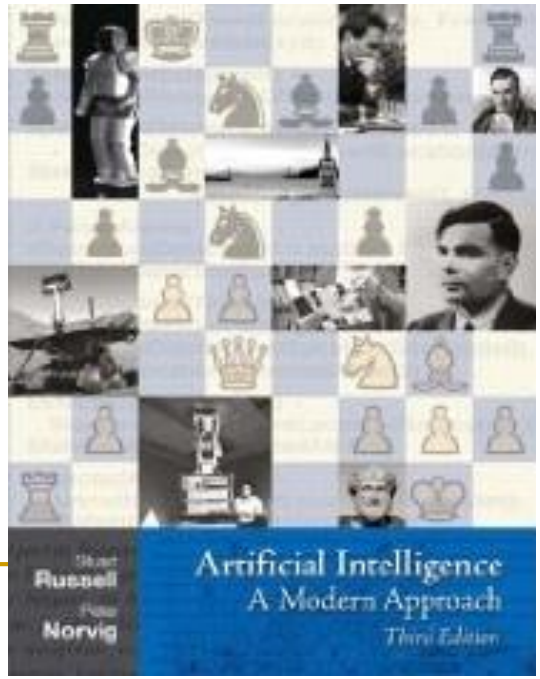
- The web site will be the primary source of more detailed information, lecture notes, announcements, etc.
- Check the site often
- Updates about assignments, clarifications etc. will also be posted on the web site.

TEXT-BOOKS

Required:

S. Russell and P. Norvig *Artificial Intelligence: A Modern Approach* Prentice Hall, 2010, **Third Edition**

- **This is a good introductory text on AI, well written and with very broad coverage.**
- **Lecture notes will be posted on line.**



Textbook Website :

http://aima.cs.berkeley.edu/

ARTIFICIAL INTELLIGENCE & EXPERT SYSTEMS

Grading: Project & Assignments & Labs (30%),
Midterm exam (30%),
Final exam (40%)

Subareas of AI

- Perception: vision, speech understanding, etc.
- Machine Learning, Neural networks
- Robotics
- Natural language understanding
- Reasoning and decision making **(our focus)**
  - **Decision making** *(search, planning, decision theory)*
  - **Knowledge representation**
  - **Reasoning** *(logical, probabilistic)*

Course Topics

- Introduction and Agents (chapters 1,2)
- Search
  - Heuristic Search (Chapter 3,4)
    - Search spaces
    - Heuristic guidance
  - Backtracking Search (Chapter 5)
    - “Vector of features”representation
  - Game tree search (Chapter 6)
    - Working against an opponent.

Course Topics

- Knowledge Representation (Chapter 7-10)
  - First order logic for more general knowledge.
  - Knowledge represented in declarative manner.
- Planning (Chapter 11-12)
  - Predicate representation of states.
  - Planning graphs
  - Reachability heuristics.
- Uncertainty (Chapter 13-16)
  - Probabilistic reasoning, Bayes networks
  - Utilities and influence diagrams.

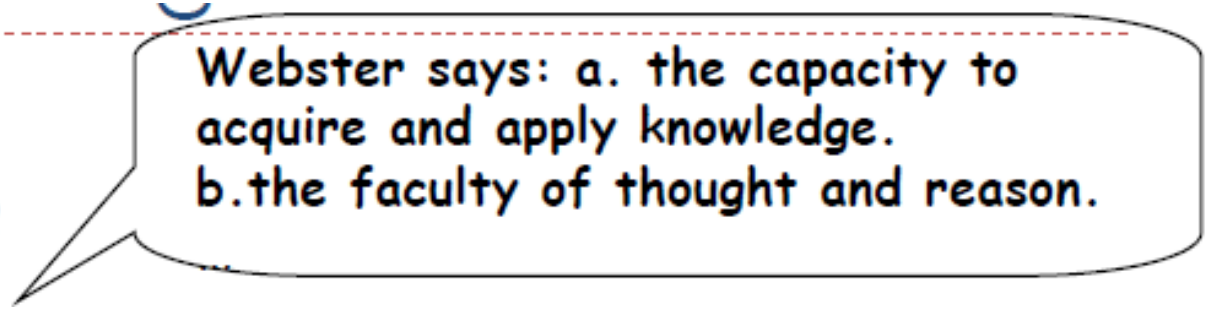
What is AI?

- **Definition 1:** AI is concerned with creating intelligent computer systems.
  - What is intelligence?
- **Definition 2:** AI is the study of systems that act in a way that to any observer would appear intelligent. [Coppin]
  - Dependent on observer.

- *Intelligence* is the ability of a system to act appropriately in an uncertain environment, when an appropriate action is that which increases the probability of success, and success is the achievement of behaviour subgoals that support the system's ultimate goal.
- **Artificial Intelligence** is the part of computer science that attempts to make computers act like human beings

What is AI?

- **Definition 3:** AI involves using methods based on intelligent behaviour of humans (or animals) to solve complex problems.
- **Definition 4:** AI is concerned with making computers more useful and useable.
  - What's the difference to general CS?
- **Definition 5:** AI is what AI researchers do.



What is AI?

- making computers that think?
- the automation of activities we associate with human thinking, like decision making, learning ... ?
- the art of creating machines that perform functions that require intelligence when performed by people ?
- the study of mental faculties through the use of computational models ?

What is AI?

- the study of computations that make it possible to perceive, reason and act ?
- a field of study that seeks to explain and emulate intelligent behaviour in terms of computational processes ?
- a branch of computer science that is concerned with the automation of intelligent behaviour ?
- anything in Computing Science that we don't yet know how to do properly ? (!)

What is AI?

- Definitions for AI, vary along two dimensions :
  - thought processes and reasoning
  - behavior
- We can also group these definitions in terms of
  - human performance

  and
  - rationality

What is AI?

Views of AI fall into four categories:

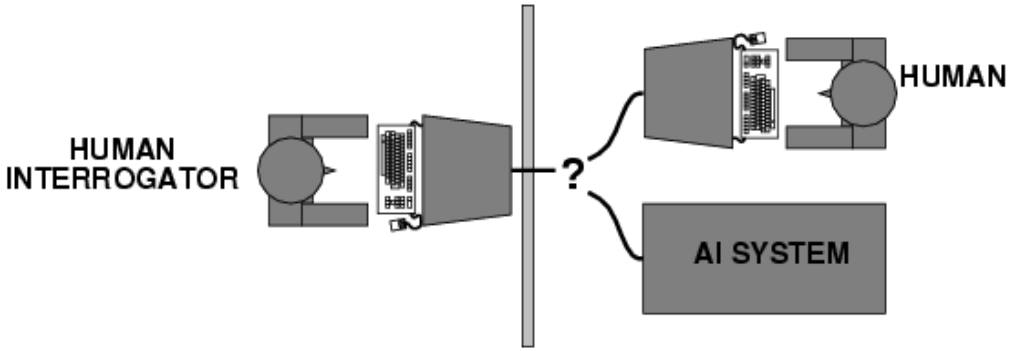
Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

The textbook advocates "acting rationally“

A system is rational if it does the “right thing”, given what it knows.

Acting humanly: Turing Test

- Turing (1950) "Computing machinery and intelligence":
- "Can machines think?" → "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game



Acting humanly: Turing Test

- An interrogator is communicating with group of people and a computer.
- The interrogator is not told whether he communicates with a real person or a computer.
- If 30% of the times the computers are able to fool the interrogator that it's a real person, then the computer passed the Turing test.
- Predicted that, a machine might have a 30% chance of fooling a person for 5 minutes.

TURING TEST

The computer would need to possess the following capabilities:

- **natural language processing** to enable it to communicate successfully in English (or some other human language);
- **knowledge representation** to store information provided before or during the 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.

Acting Humanly: The Full Turing Test

- Problem:
  - 1. Turing test is not reproducible, constructive, and amenable to mathematical analysis.
  - 2. What about physical interaction with interrogator and environment?
- Total Turing Test: Requires physical interaction and needs perception and actuation.
  - includes a video signal so that the interrogator can test the subject's perceptual abilities

Total Turing Test

- Includes two more issues:
  - *Computer vision*
    - to perceive objects (seeing)
  - *Robotics*
    - to move objects (acting)

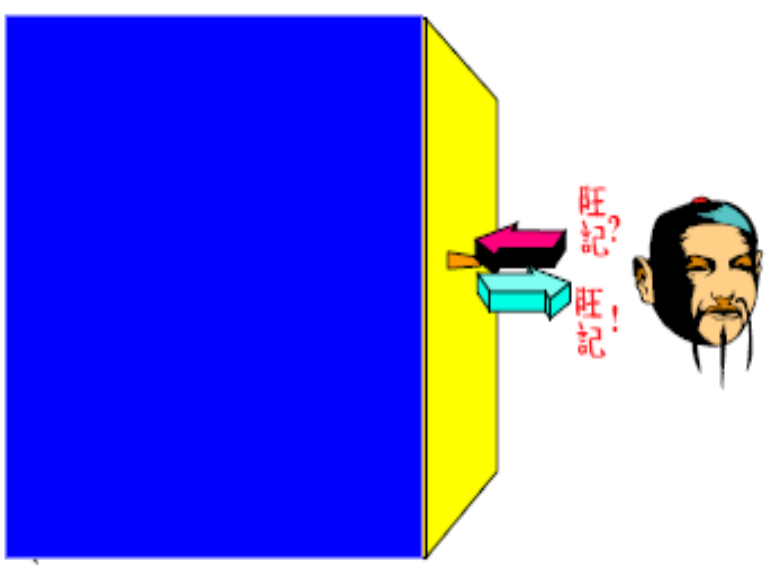
Acting Humanly: The Full Turing Test

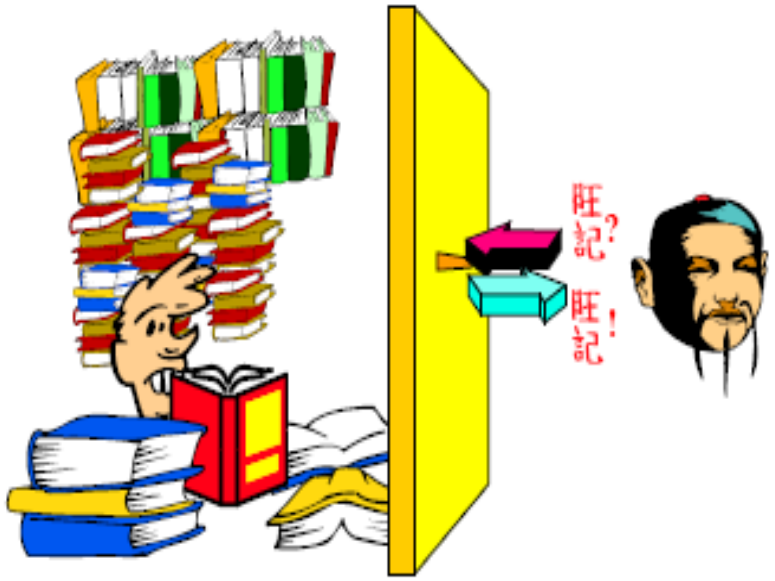
- Turing provided some very persuasive arguments that a system passing the Turing test is intelligent.
- However, the test does not provide much traction on the question of how to actually build an intelligent system.

The Chinese Room

- A person P1 communicates in Chinese with another person P2 by passing written notes back and forth.
- P2 does not know Chinese.
- P2 has a room full of books that tell him what to do for each character in the note (similar to a Turing Machine program).
- Assuming that all the rules in the books are correct, does P2 speak Chinese?

The Chinese Room





The Chinese room argument comprises a thought experiment and associated arguments by John Searle (1980), which attempts to show that a symbol-processing machine like a computer can never be properly described as having a "mind" or "understanding", regardless of how intelligently it may behave.

Thinking humanly: cognitive modeling

- 1960s "cognitive revolution": information-processing psychology
- Requires scientific theories of internal activities of the brain
- -- How to validate? Requires

  1) Predicting and testing behavior of human subjects (top-down) OR

  2) Direct identification from neurological data (bottom-up)
- Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI

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”

These *laws of thought* govern the operation of mind – initiation the field *logic*

Several Greek schools developed various forms of *logic*: *notation* and *rules of derivation* for thoughts.

Thinking rationally: "laws of thought"

- Logic can’t express everything (e.g. uncertainty)
- Logical approach is often not feasible in terms of computation time (needs ‘guidance’)

Thinking rationally: "laws of thought"

- Problems:

  1) Uncertainty: Not all facts are certain

(e.g., *the flight might be delayed).*

  2) Resource limitations:

  - Not enough time to compute/process

  - Insufficient memory/disk/etc

  -etc.

Acting rationally: rational agent

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Provides the most general view of AI
- Doesn't necessarily involve thinking – e.g., blinking reflex – but thinking should be in the service of rational action

Acting rationally: rational agent

- Logic → only *part* of a rational agent, not *all* of rationality
  - Sometimes logic cannot reason a correct conclusion
  - At that time, some *specific (in domain) human knowledge* or information is used

Acting rationally: rational agent

- Study AI as rational agent –

2 advantages:

- It is more general than using logic only
  - **Because: LOGIC + Domain knowledge**
- It allows extension of the approach with more scientific methodologies

Rational agents

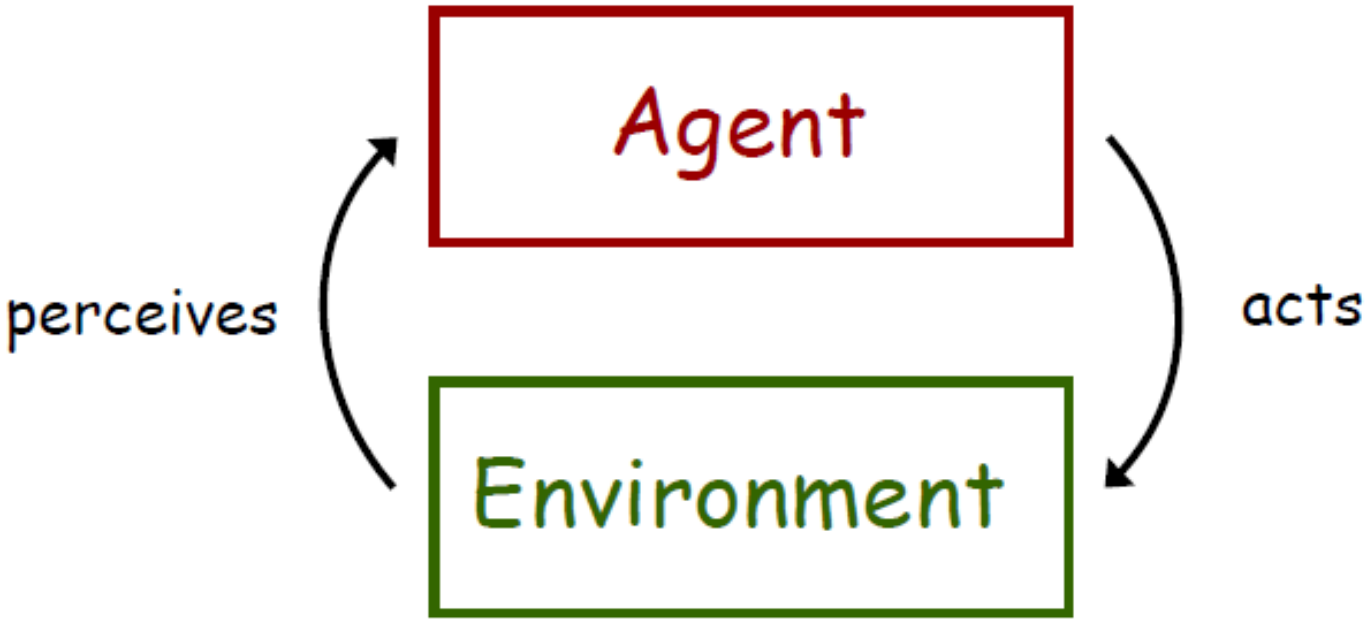
- An agent is an entity that perceives and acts
- **This course is about designing rational agents**
- Abstractly, an agent is a function from percept histories to actions:

$$[f: \mathcal{P}^* \rightarrow \mathcal{A}]$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Computational limitations make perfect rationality unachievable

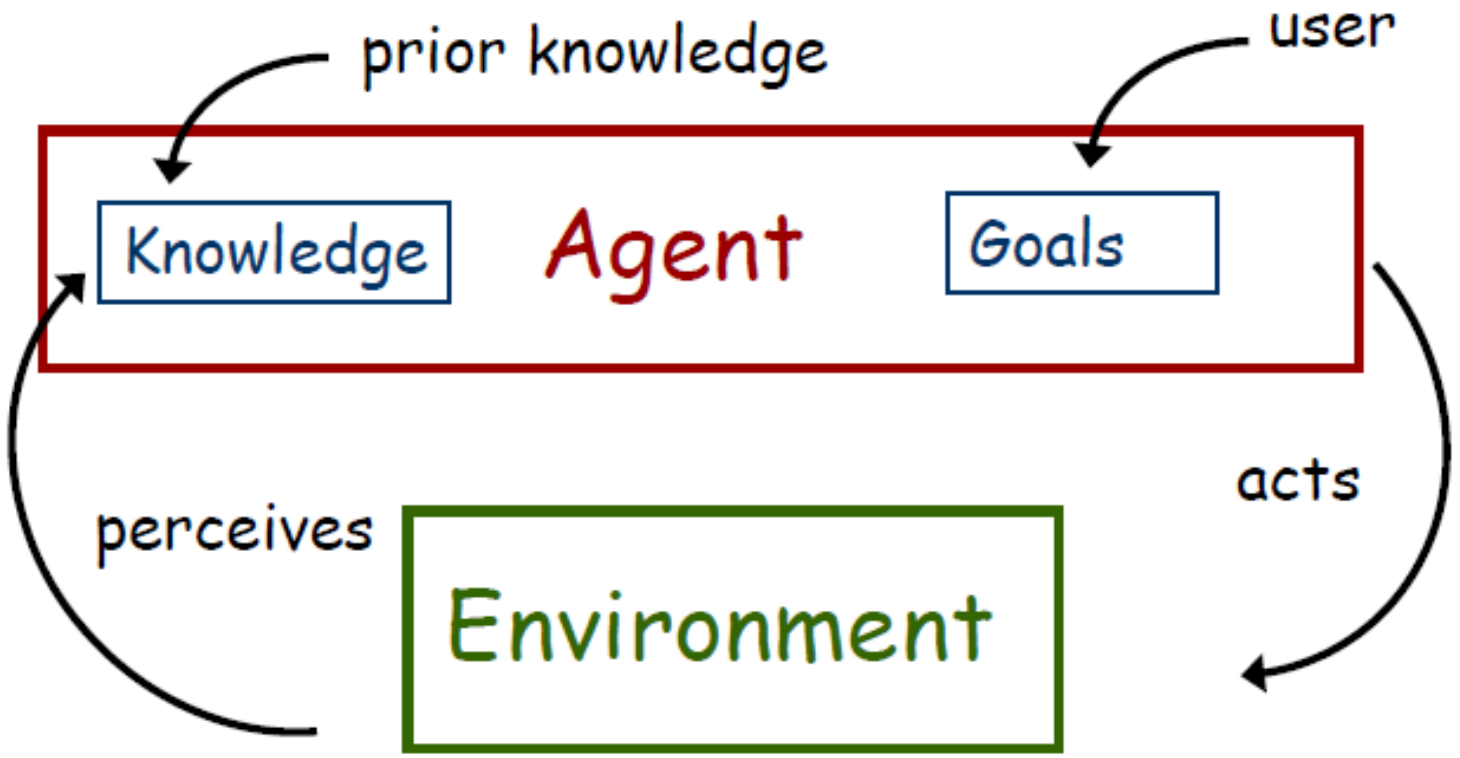
  → design best program for given machine resources

Agent Schematic (I)



- This diagram oversimplifies the internal structure of the agent.

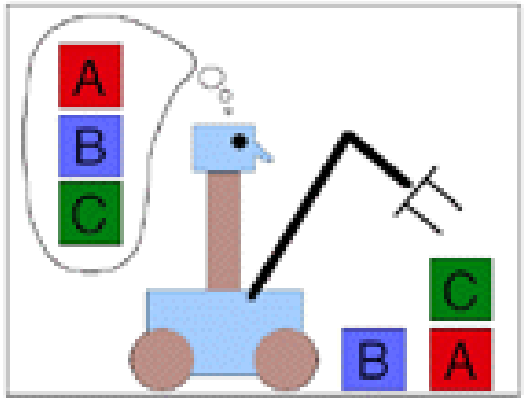
Agent Schematic (II)



- Require more flexible interaction with the environment, the ability to modify one's goals, knowledge that be applied flexibly to different situations.

Goals of AI

- To make computers more useful by letting them take over dangerous or tedious tasks from human
- Understand principles of human intelligence



The main topics in AI

Artificial intelligence can be considered under a number of headings:

- Search (includes Game Playing).
- Representing Knowledge and Reasoning with it.
- Planning.
- Learning.
- Natural language processing.
- Expert Systems.
- Interacting with the Environment
  (e.g. Vision, Speech recognition, Robotics)

We won't have time in this course to consider all of these.

Some Advantages of Artificial Intelligence

- more powerful and more useful computers
- new and improved interfaces
- solving new problems
- better handling of information
- relieves information overload
- conversion of information into knowledge

The Disadvantages

- increased costs
- difficulty with software development - slow and expensive
- few experienced programmers
- few practical products have reached the market as yet.

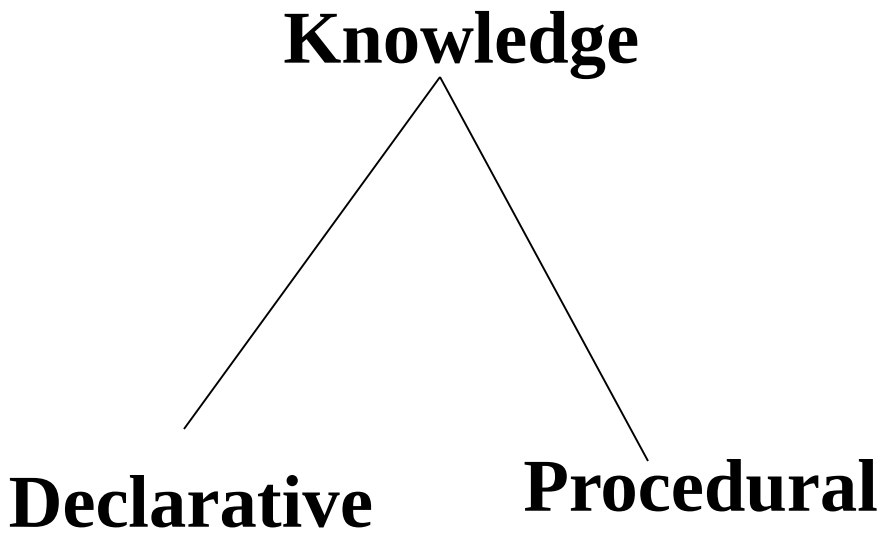
Search

- ***Search* is the fundamental technique of AI.**
  - Possible answers, decisions or courses of action are structured into an abstract space, which we then search.
- Search is either "blind" or “informed":
  - blind
    - we move through the space without worrying about what is coming next, but recognising the answer if we see it
  - informed
    - we guess what is ahead, and use that information to decide where to look next.

- We may want to search for the first answer that satisfies our goal, or we may want to keep searching until we find the best answer.

Knowledge Representation & Reasoning

- The second most important concept in AI
- If we are going to act rationally in our environment, then we must have some way of describing that environment and drawing inferences from that representation.
  - how do we describe what we know about the world ?
  - how do we describe it *concisely* ?
  - how do we describe it so that we can get hold of the right piece of knowledge when we need it ?
  - how do we generate new pieces of knowledge ?
  - how do we deal with *uncertain* knowledge ?



- **Declarative knowledge deals with factoid questions (what is the capital of India? Etc.)**
- **Procedural knowledge deals with “How”**
- **Procedural knowledge can be embedded in declarative knowledge**

Planning

Given a set of goals, construct a sequence of actions that achieves those goals:

- often very large search space
- but most parts of the world are independent of most other parts
- often start with goals and connect them to actions
- no necessary connection between order of planning and order of execution
- what happens if the world changes as we execute the plan and/or our actions don't produce the expected results?

Learning

- If a system is going to act truly appropriately, then it must be able to change its actions in the light of experience:
  - how do we generate new facts from old ?
  - how do we generate new concepts ?
  - how do we learn to distinguish different situations in new environments ?

Interacting with the Environment

- In order to enable intelligent behaviour, we will have to interact with our environment.
- Properly intelligent systems may be expected to:
  - accept sensory input
    - vision, sound, …
  - interact with humans
    - understand language, recognise speech,
      generate text, speech and graphics, …
  - modify the environment
    - robotics

Homework

Read Pg (1 – 31) From the book