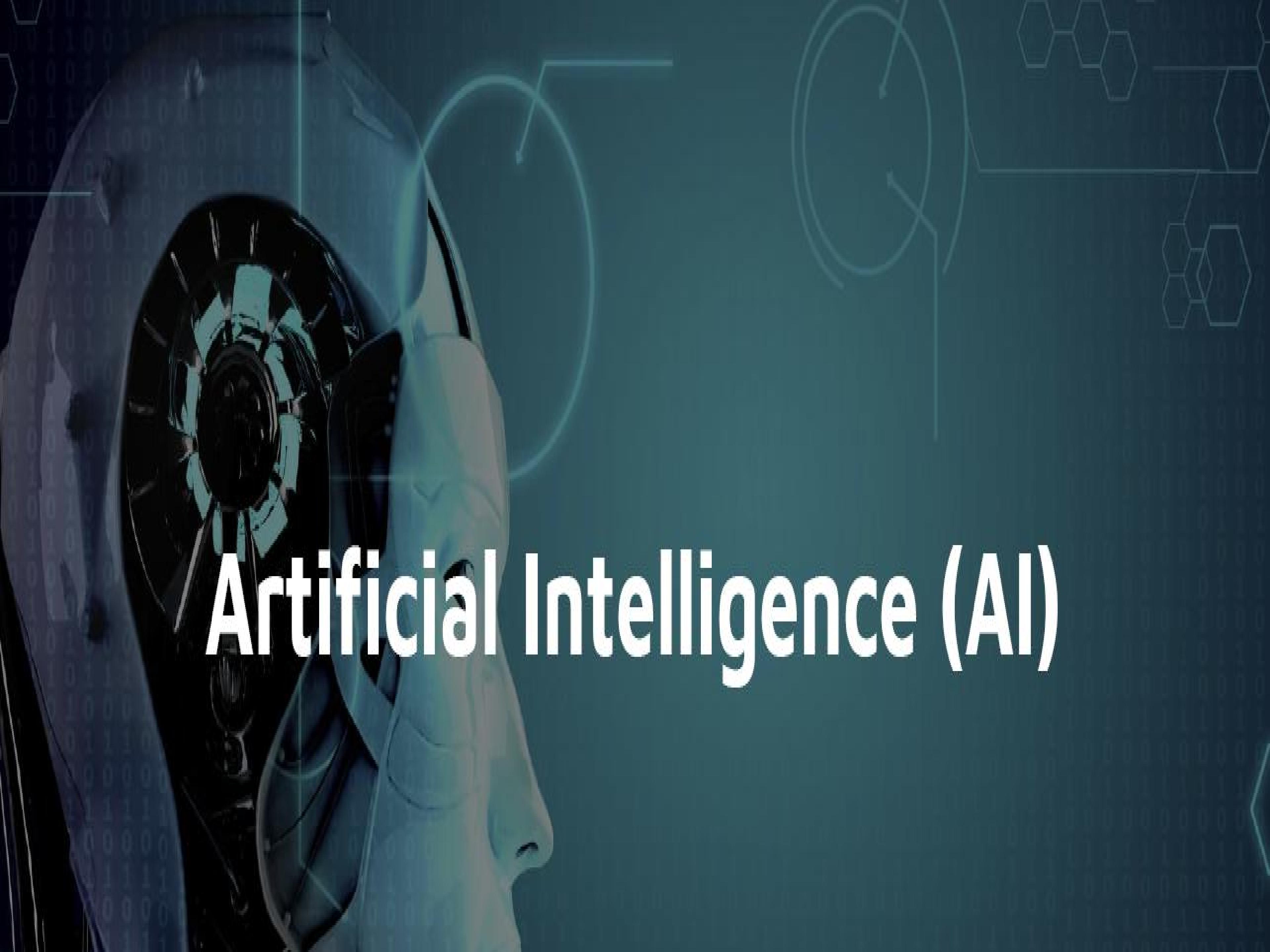

Artificial Intelligence (AI)

- Subject Name: Artificial Intelligence
- Code : CO44001
- Faculty name: Mrs.Sonika Shrivastava

B.E IV Year
CO 44001:Artificial Intelligence (Syllabus)

- UNIT 1. Introduction to AI: Definition and Terminologies, Silicon Model, Biomodel, Cognitive Model, Introduction to logic, Problems, Problem Spaces, and Search, Production Systems, Problem Characteristics.
- UNIT 2. Search techniques: Breadth first, Depth-first, Generate and Test, Hill Climbing, Best first Search, Problem Reduction, AND/OR graphs, Constraints Satisfaction.
- UNIT 3. Knowledge Representation and Mappings, Knowledge Representation issues. Predicate Logic, Resolution, Representing Knowledge using Rules, Reasoning under Uncertainty, Non monotonic Reasoning, Statistical Reasoning, Probability, Bayesian logic, Certainty factors, Dempster Shafer reasoning, Semantic Nets, Frames, Conceptual dependency, Scripts.
- UNIT 4. Introduction to: Game Playing, Planning, Understanding, Natural Language Processing, Learning, Common Sense, Perception, Lisp, Prolog, and Expert System.
- UNIT 5. Basic Concepts of: Neural networks, Fuzzy Logic, Genetic Algorithm

TEXT BOOKS RECOMMENDED:

1.Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall Series in AI, 3rd edition 2015.

2. Kevin Knight , Elaine Rich , B. Nair ,”ARTIFICIAL INTELLIGENCE”, Third Edition Paperback – 2017

3. David Poole, Alan Mackworth, Artificial Intelligence: Foundations for Computational Agents, Cambridge Univ. Press, 2010.

REFERENCE BOOKS:

1. Charniak E. & D. McDermott, “Introduction to Artificial Intelligence”, Addison-Wesley, 1985.

2. Schalkoff, “Artificial Intelligence: An Engineers Appraoch”, McGraw-Hill, 1992.

3. Keith Weiskamp& Terry Hengl, “Artificial Intelligence Programming with Turbo Prolog”, John Wiley & Sons, 1998.

COURSE OUTCOMES:

After Completing the course student should be able to:

- 1. Compare Artificial Intelligence with Human Intelligence and improving traditional information processing by designing state space for real world problems
- 2. Understanding the working of various searching algorithms for Artificial Intelligence area and implementing efficient ones.
- 3. Learn to represent knowledge through different Representation Techniques and application of reasoning on knowledge base to derive inferences.
- 4. To understand the basic concept of Fuzzy logic and neural network with its applications in the real world.

Course Material and Assignments

- Join Google classroom
- Artificial Intelligence (CO44001)(2020-2021)

  Class code: 2ef2q7q

What is Artificial Intelligence?

Artificial Intelligence is the development of computer systems that are able to perform tasks that would require human intelligence.

Examples of these tasks are visual perception, speech recognition, decision-making, and translation between languages.

AI Definitions

- It is the methodology that systemize and automates to build machine which shows intelligence.

- A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes.

AI Definitions

- “The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil)
- “The study of how to make computers to do things at which, at the moment, people are better.” (Rich and Knight)

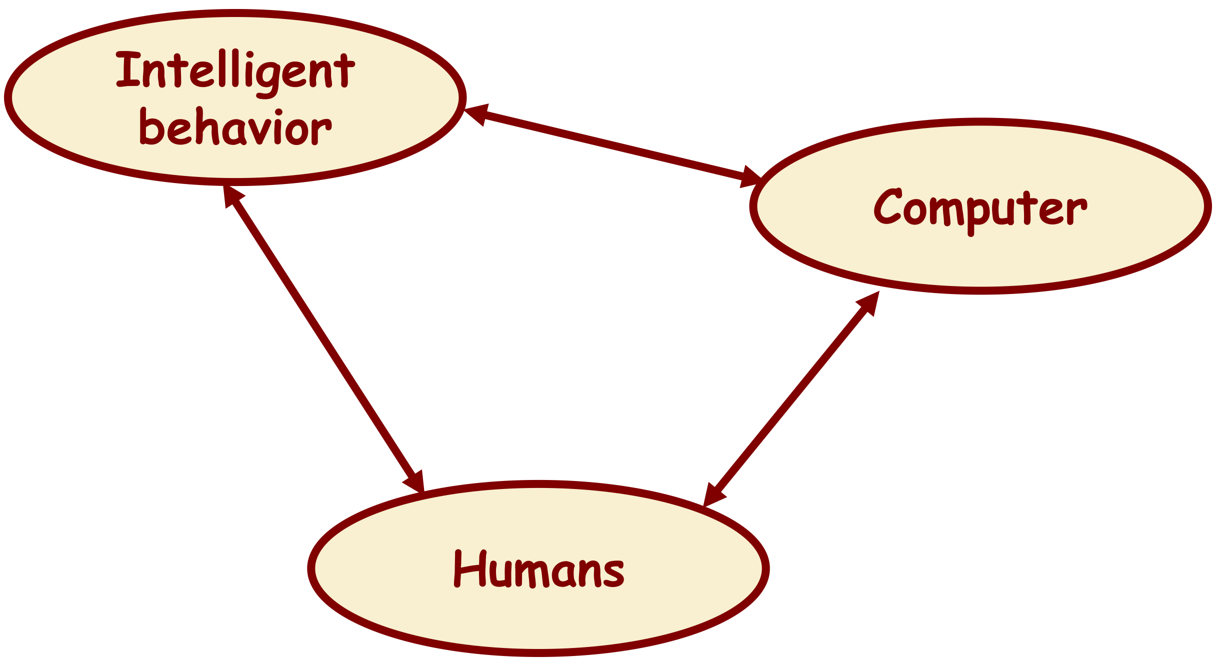
Goals of AI

Artificial Intelligence as a branch of computer science began in the 1950s. Its two main goals were:

1) To study human intelligence by modeling and simulating it on a computer.
2) To make computers more useful by solving complex problems like humans do.

Exaplanation of AI

- AI is an attempt to create or build human reasoning and intelligent behavior by computational methods.



Dimensions of AI

	HUMAN	RATIONAL
THINK	Systems that think like humans	Systems that think rationally
ACT	Systems that act like humans	Systems that act rationally

Different Approaches to AI

- Philosophy, ethics, religion
  - What is intelligence?
- Cognitive science, neuroscience, psychology, linguistics
  - Understand natural forms of intelligence
  - Learn principles of intelligent behavior
- Engineering
  - Can we build intelligent devices and systems?
  - Autonomous and semi-autonomous systems for replicating human capabilities, enhancing human capabilities, improving performance, etc.

• 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.
• Economics	utility, decision theory
• Neuroscience	neurons as information processing units.
• Psychology/ Science	how do people behave, perceive, process Cognitive information, represent knowledge.
• Computer engineering	building fast computers
• Control theory	design systems that maximize an objective function over time
• Linguistics	knowledge representation, grammar

The Foundation of AI

- ***Philosophy***
  - Can formal rules be used to draw valid conclusions?
  - How does the mind arise from a physical brain?
  - Where does knowledge come from?
  - How does knowledge lead to action?

The Foundation of AI

- Mathematics formalizes the three main area of AI: *computation*, *logic*, and *probability*
  - Computation leads to analysis of the problems that can be computed
    - *complexity theory*
  - Probability contributes the *"degree of belief"* to handle *uncertainty* in AI
  - *Decision theory* combines *probability theory* and *utility theory* (bias)

The Foundation of AI

- Psychology
  - How do humans think and act?
  - The study of human reasoning and acting
  - Provides reasoning models for AI
  - Strengthen the ideas
    - humans and other animals can be considered as information processing machines

The Foundation of AI

- Computer Engineering
  - How to build an efficient computer?
  - Provides the artifact that makes AI application possible
  - The power of computer makes computation of large and difficult problems more easily
  - AI has also contributed its own work to computer science, including: time-sharing, the linked list data type, OOP, etc.

The Foundation of AI

- **Control theory and Cybernetics**
  - How can artifacts operate under their own control?
  - The artifacts adjust their actions
    - To do better for the environment over time
    - Based on an objective function and feedback from the environment
  - Not limited only to linear systems but also other problems
    - as language, vision, and planning, etc.

The Foundation of AI

- Linguistics
  - For understanding natural languages
    - different approaches has been adopted from the linguistic work
  - Formal languages
  - Syntactic and semantic analysis
  - Knowledge representation

History of AI

- Foundation Father
- In the Dartmouth conference: 1956
  - John McCarthy (Stanford)
  - Marvin Minsky (MIT)
  - Herbert Simon (CMU)
  - Allen Newell (CMU)
  - Arthur Samuel (IBM)

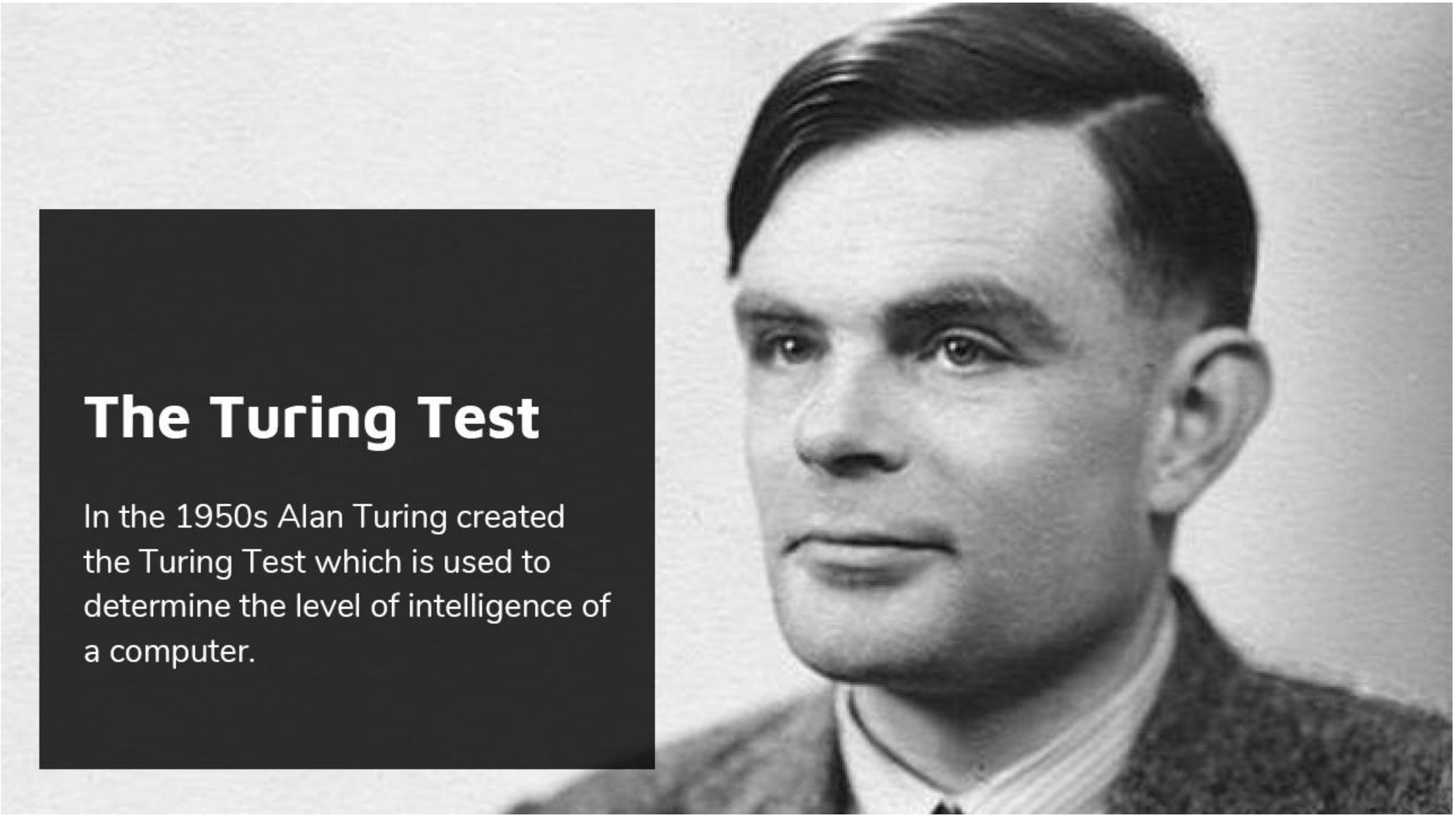
Periods in AI

- Early period - 1950’s & 60’s
  - Game playing
    - brute force (calculate your way out)
  - Theorem proving
    - symbol manipulation
  - Biological models
    - neural nets
- Symbolic application period - 70’s
  - Early expert systems, use of knowledge
- Commercial period - 80’s
  - boom in knowledge/ rule bases

Periods in AI cont'd

- period - 90's and New Millenium
- Real-world applications, modelling, better evidence, use of theory, ...?
- Topics: data mining, formal models, GA's, fuzzy logic, agents, neural nets, autonomous systems
- Applications
  - visual recognition of traffic
  - medical diagnosis
  - directory enquiries
  - power plant control
  - automatic cars

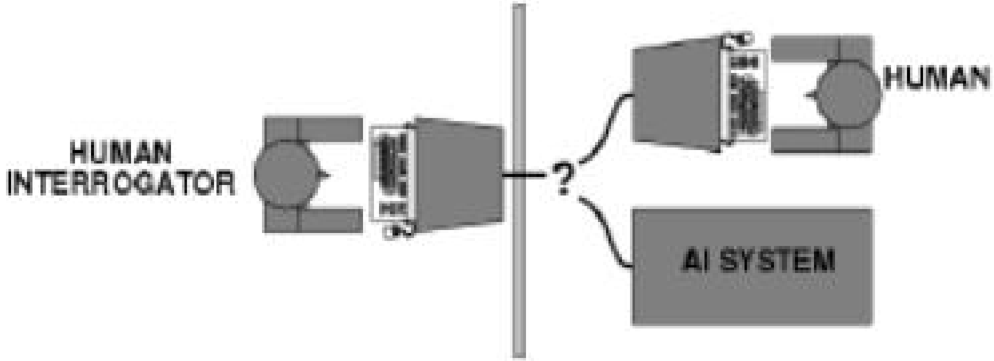
Turing Test



The Turing Test
In the 1950s Alan Turing created the Turing Test which is used to determine the level of intelligence of a computer.

The Turing Test

- A. Turing, "Computing machinery and intelligence," 1950
- Can machines think? → Can we tell if a conversation is by a machine and not a human?
- text in, text out
- Operational test for intelligent behavior: aka the **Imitation Game**



- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Suggested major components of AI: knowledge rep., reasoning, natural language processing, learning

Findings of Turing Test

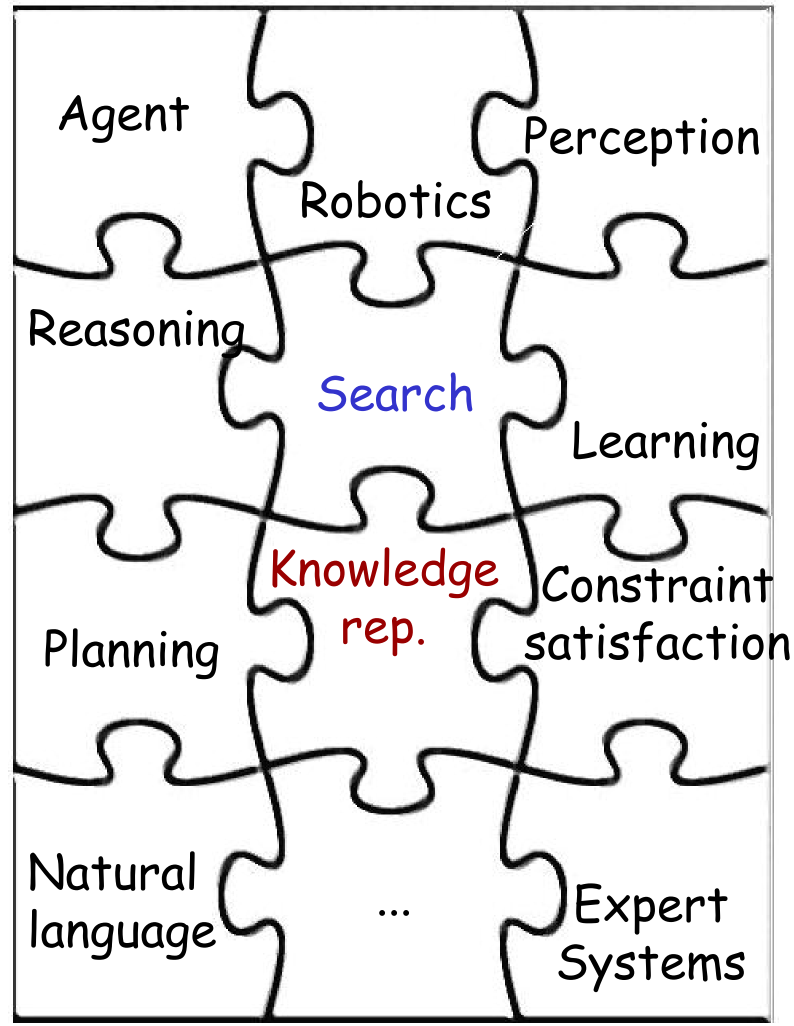
- The Turing Test approach
  - a human questioner cannot tell if
    - there is a computer or a human answering his question, via teletype (remote communication)
  - The computer must behave intelligently
- Intelligent behavior
  - to achieve human-level performance in all cognitive tasks

Findings of Turing Test

- These cognitive tasks include:
  - *Natural language processing*
    - for communication with human
  - *Knowledge representation*
    - to store information effectively & efficiently
  - *Automated reasoning*
    - to retrieve & answer questions using the stored information
  - *Machine learning*
    - to adapt to new circumstances

Main Areas of AI

- Knowledge representation (including formal logic)
- Search, especially heuristic search (puzzles, games)
- Planning
- Reasoning under uncertainty, including probabilistic reasoning
- Learning
- Agent architectures
- Robotics and perception
- Natural language processing



Symbolic and Sub-symbolic AI

- Symbolic AI is concerned with describing and manipulating our knowledge of the world as explicit symbols, where these symbols have clear relationships to entities in the real world.
- Sub-symbolic AI (e.g. neural-nets) is more concerned with obtaining the correct response to an input stimulus without ‘looking inside the box’ to see if parts of the mechanism can be associated with discrete real world objects.
- This course is concerned with symbolic AI.

Table 1: Domains in Symbolic AI (1950s to 1980s)

Domain	Description
Problem Solving	Broad, general domain for solving problems, making decisions, satisfying constraints and other types of reasoning. Subdomains included expert or knowledge-based systems, planning, automatic programming, game playing and automated deduction. Problem solving was arguably the most successful domain of symbolic AI.
Machine Learning	Automatically generating new facts, concepts or truths by rote, from experience, or by taking advice.
Natural Language	Understanding and generating written human languages (e.g., English or Japanese) by parsing sentences and converting them into a knowledge representation such as a semantic network, and then returning results as properly constructed sentences easily understood by people.
Speech Recognition	Converting sound waves into phonemes, words and ultimately sentences to pass off to Natural Language Understanding systems, and also speech synthesis to convert text responses into natural sounding speech for the user.
Vision	Converting pixels in an image into edges, regions, textures and geometrical objects in order to make sense of a scene, and ultimately recognize what exists in the field of vision.
Robotics	Planning and controlling actuators to move or manipulate objects in the physical world.

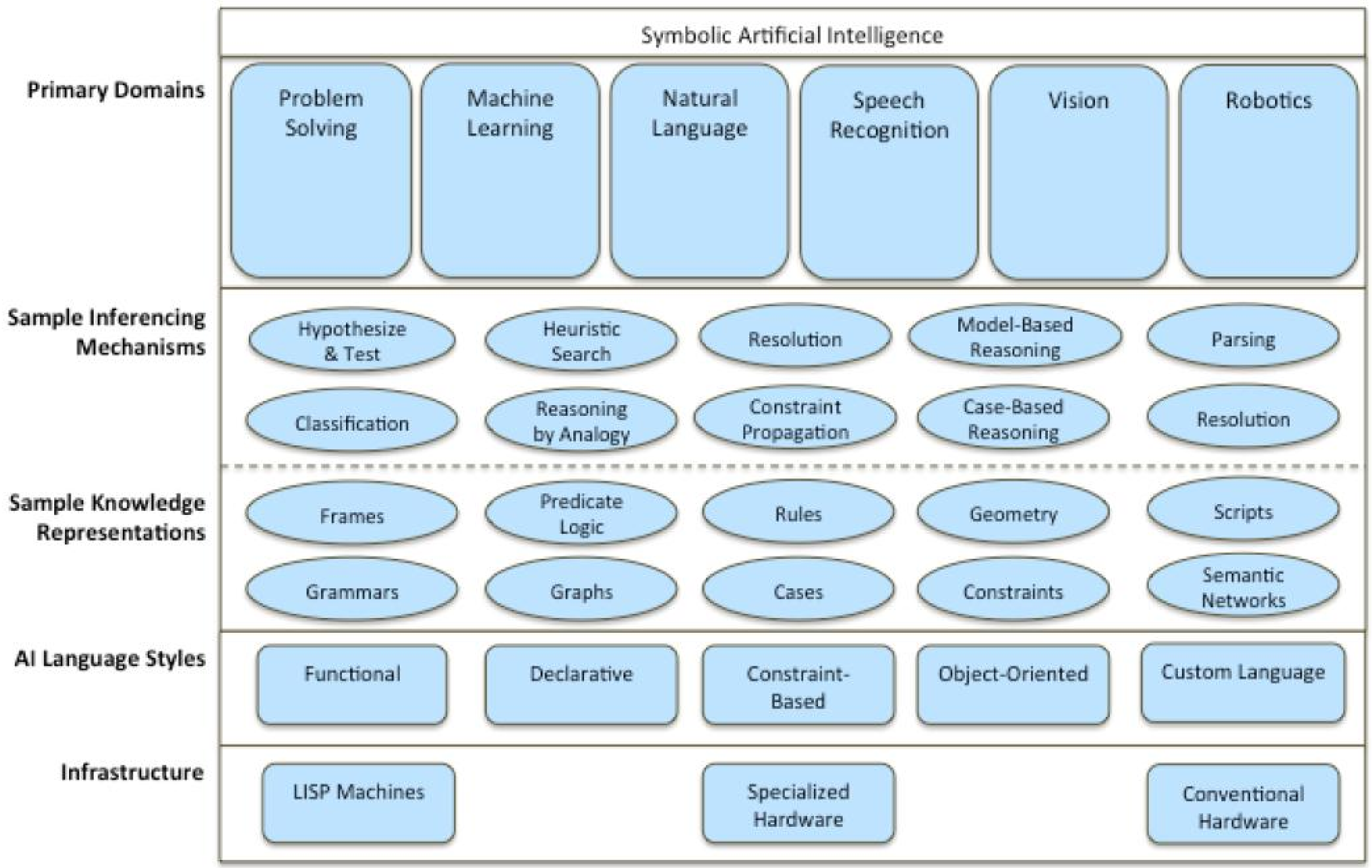


Figure 1: Overview of Symbolic Artificial Intelligence

Some Successful AI Applications

1. Language translation services (Google)
2. Translating Telephone (Skype)
3. News aggregation and summarization (Google)
4. Speech recognition (Nuance)
5. Song recognition (Shazam)
6. Face recognition (Recognizr, Google, ...)
7. Image recognition (Google)
8. Question answering (Apple Siri, IBM Watson, ...)
9. Chess playing (IBM Deep Blue)
10. 3D scene modeling from images (Microsoft Photosynth)
11. Driverless cars (Google)
12. Traffic prediction system (Inrix)

Natural Language

- Speech technologies (e.g. Siri)
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems
- Language processing technologies
  - Question answering
  - Machine translation

"Il est impossible aux journalistes de rentrer dans les régions tibétaines"

Bruno Philip, correspondant du "Monde" en Chine, estime que les journalistes de l'AFP qui ont été expulsés de la province tibétaine du Qinghai "n'étaient pas dans l'illégalité".

Les faits Le dalaï-lama dénonce l'"enfer" imposé au Tibet depuis sa fuite, en 1959

Vidéo Anniversaire de la rébellion

"It is impossible for journalists to enter Tibetan areas"

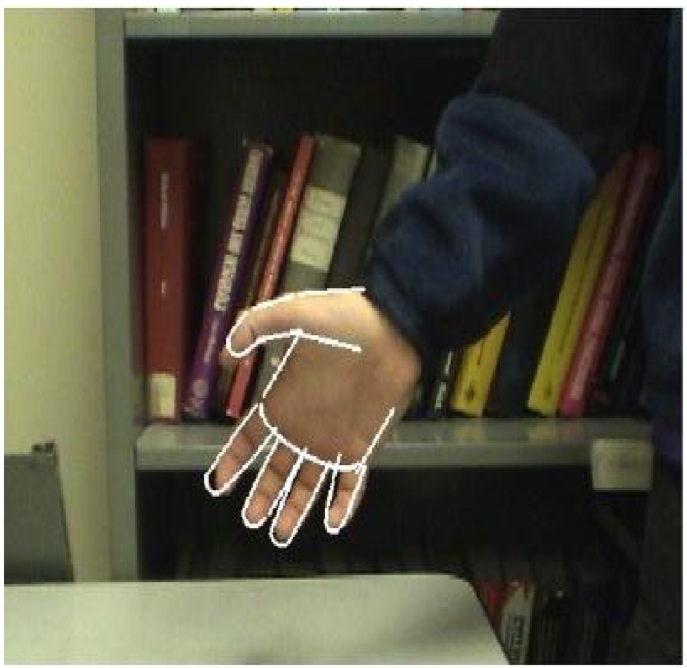
Philip Bruno, correspondent for "World" in China, said that journalists of the AFP who have been deported from the Tibetan province of Qinghai "were not illegal."

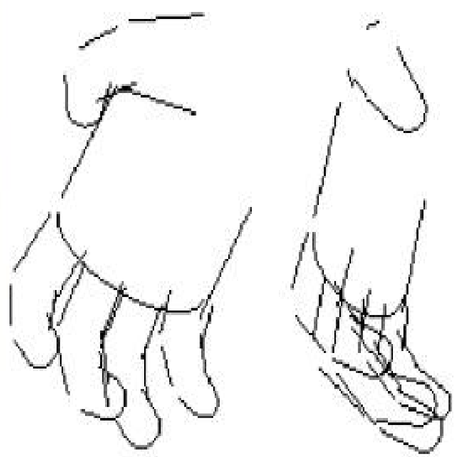
Facts The Dalai Lama denounces the "hell" imposed since he fled Tibet in 1959

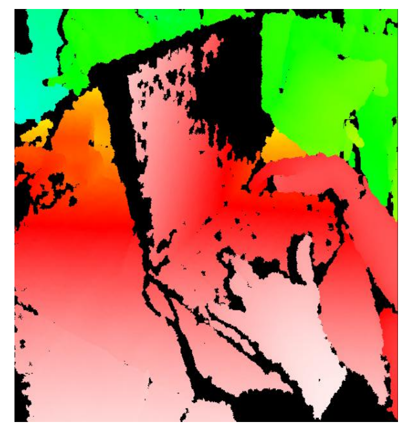
Video Anniversary of the Tibetan rebellion: China on guard

Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification



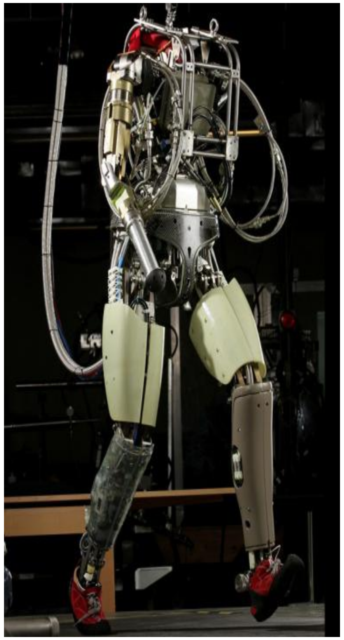




Images from Erik Sudderth (left), wikipedia (right)

Robotics

- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!



Logic

- Logical systems
  - Theorem provers
  - NASA fault diagnosis
  - Question answering

- Methods:
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers (huge advances!)

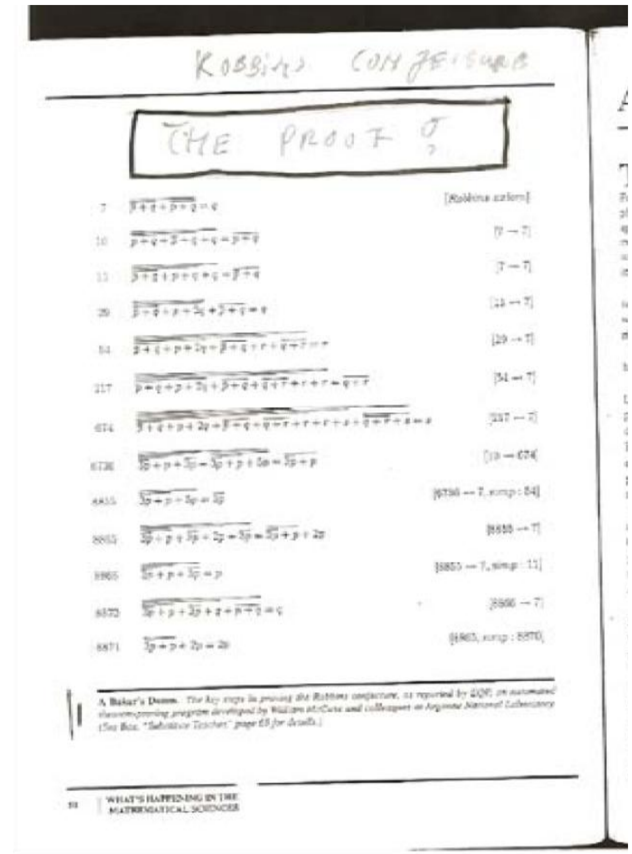


Image from Bart Selman

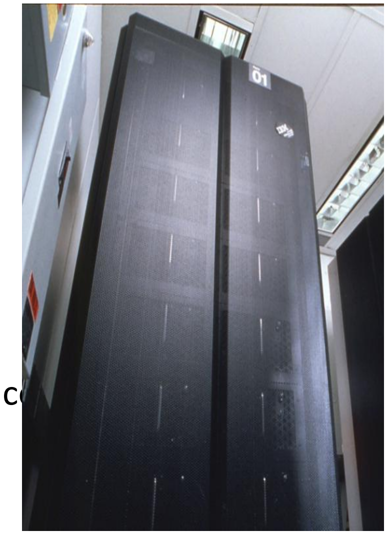
Game Playing

- Classic Moment: May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - “Intelligent creative” play
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - Can do about the same now with a PC cluster

- 1996: Kasparov Beats Deep Blue
  “I could feel --- I could smell --- a new kind of intelligenc

- 1997: Deep Blue Beats Kasparov
  “Deep Blue hasn't proven anything.”

- Huge game-playing advances recently, e.g. in Go!



Text from Bart Selman, image from IBM’s Deep Blue pages

Decision Making

– Applied AI involves many kinds of automation

- Scheduling, e.g. airline routing, military
- Route planning, e.g. Google maps
- Medical diagnosis
- Web search engines
- Spam classifiers
- Automated help desks
- Fraud detection
- Product recommendations
- … Lots more!

Real Life A.I. Examples

- Self Driving Cars
- Boston Dynamics
- Navigation Systems
- ASIMO
- Chatbots
- Human vs Computer Games
- Many More!

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 of AI

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

- Questions??

Introduction to AI (II)_Unit 1

Subject: AI

Subject Code:CO44001

Subject Faculty: Sonika Shrivastava

Foundations of AI

- Philosophy: logic, mind, knowledge
- Mathematics: proof, computability, probability
- Economics: maximizing payoffs
- Neuroscience: brain and neurons
- Psychology: thought, perception, action
- Control Theory: stable feedback systems
- Linguistics: knowledge representation, syntax

Brief History of AI

- 1943: McCulloch & Pitts: Boolean circuit model of brain
- 1950: Turing's “Computing Machinery and Intelligence”
- 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- 1956: Dartmouth meeting: “Artificial Intelligence” adopted

Brief History of AI

- 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"

Brief History of AI

- 1985—95: Neural networks return to popularity
- 1988— Resurgence of probability; general increase in technical depth, "Nouvelle AI": ALife, GAs, soft computing
- 1995— Agents…

Problem Solving through Artificial Intelligence Approach

- Artificial Intelligence is the study of systems that

think like humans	think rationally
act like humans	act rationally

Systems Thinking like Humans

- Formulate a theory of mind/brain
- Express the theory in a computer program
- Two Approaches
  - Cognitive Science and Psychology (testing/ predicting responses of human subjects)
  - Cognitive Neuroscience (observing neurological data)

Systems Acting like Humans

- Turing test: test for intelligent behavior
  - Interrogator writes questions and receives answers
  - System providing the answers passes the test if interrogator cannot tell whether the answers come from a person or not
- Necessary components of such a system form major AI sub-disciplines:
  - Natural language, knowledge representation, automated reasoning, machine learning

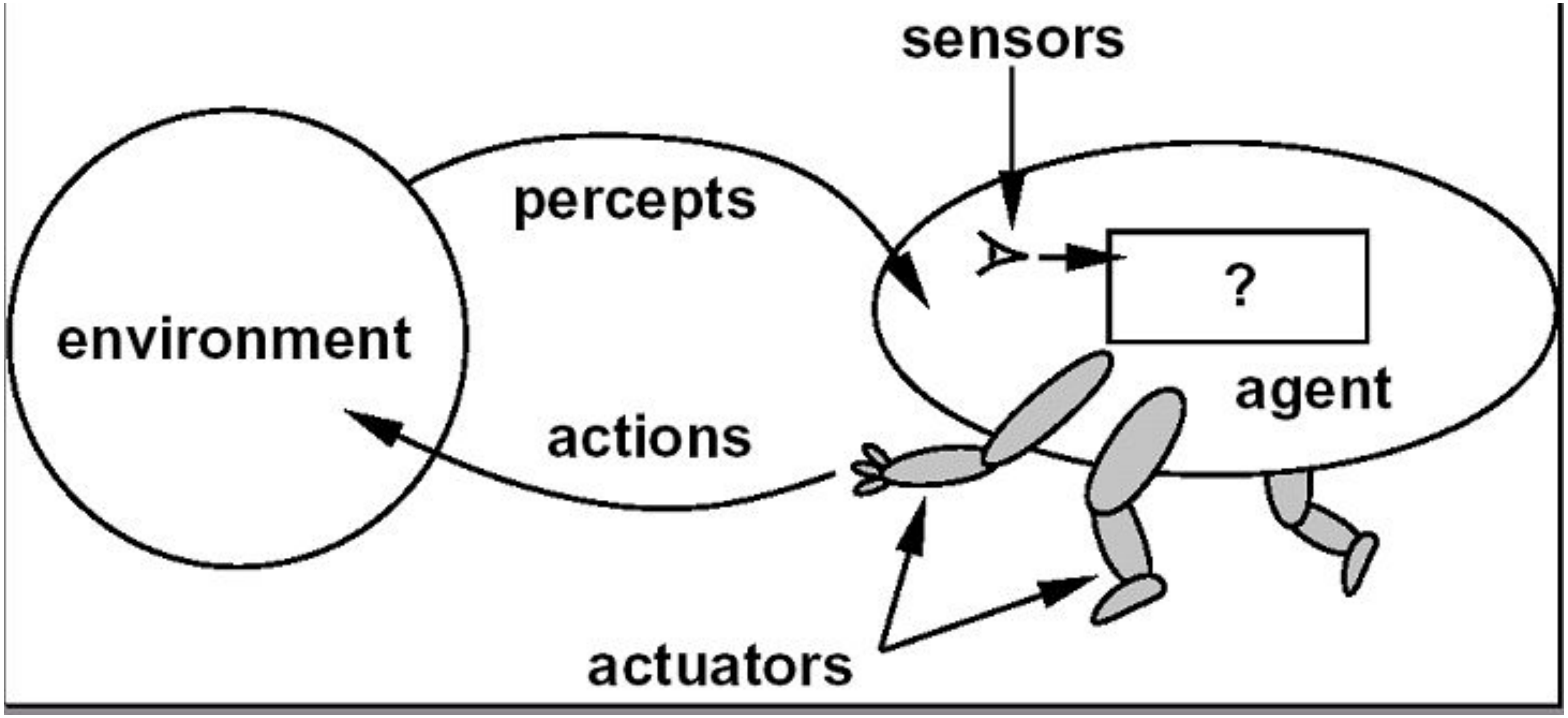
Systems Thinking Rationally

- “Rational” -> **ideal** intelligence
  (contrast with **human** intelligence)
- Rational thinking governed by precise “laws of thought”
  - syllogisms
  - notation and logic
- Systems (in theory) can solve problems using such laws

Systems Acting Rationally

- Agent: anything that perceives and acts on its environment
- AI: study of rational agents
- A rational agent carries out an action with the **best outcome** after considering past and current percepts

Agents



Agents

- A human agent has eyes, ears, and other organs for sensors and hands, legs, vocal tract, and so on for actuators.
- A robotic agent might have cameras and infrared range finders for sensors and various motors for actuators.
- A software agent receives keystrokes, file contents, and network packets as sensory inputs and acts on the environment by displaying on the screen, writing files, and sending network packets

Agent Function

- $a = F(p)$

  where p is the current percept, a is the action carried out, and F is the agent function

- F maps percepts to actions
  $F: P \rightarrow A$

  where P is the set of all percepts, and A is the set of all actions

- In general, an action may depend on all percepts observed so far, not just the current percept, so…

Agent Function Refined

- $a_k = F(p_0\, p_1\, p_2 \ldots p_k)$

  where $p_0\, p_1\, p_2 \ldots p_k$ is the sequence of percepts observed to date, a_k is the resulting action carried out
- F now maps *percept sequences* to actions

  $F: P^* \rightarrow A$

Structure of Agents

- Agent = architecture + program
- architecture
  - device with sensors and actuators
  - e.g., A robotic car, a camera, a PC, …
- program
  - implements the agent function on the architecture

Specifying the Task Environment

- PEAS
- Performance Measure: captures agent's aspiration
- Environment: context, restrictions
- Actuators: indicates what the agent can carry out
- Sensors: indicates what the agent can perceive

PEAS description for an Automated Taxi.

Performance Measure	Environment	Actuators	Sensors
Safe, fast, legal, comfortable trip, maximize profits	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, signal, horn, display	Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors,

PEAS description for an Medical diagnosis system.

Performance Measure	Environment	Actuators	Sensors
Healthy patient, reduced costs	Patient, hospital, staff	Display of questions, tests, diagnoses, treatments, referrals	Keyboard entry of symptoms, findings, patient's answers

Properties of Environments

- Fully versus partially observable
- Deterministic versus stochastic
- Episodic versus sequential
- Static versus dynamic
- Discrete versus continuous
- Single agent versus multiagent

Fully observable vs. partially observable:

- If an agent's sensors give it access to the complete state of the environment at each point in time,
- Fully observable environments are convenient because the agent need not maintain any internal state to keep track of the world.

Deterministic vs. stochastic.

- If the next state of the environment is completely determined by the current state and the action executed by the agent, then we say the environment is deterministic; otherwise, it is stochastic

Episodic vs. **sequential**:

- In an episodic task environment, the agent’s experience is divided into atomic episodes. In each episode the agent receives a percept and then performs a single action.
- Crucially, the next episode does not depend on the actions taken in previous

  episodes.
- Many classification tasks are episodic

Static vs. **dynamic:**

- If the environment can change while an agent is deliberating, then we say the environment is dynamic for that agent; otherwise, it is static.
- Static environments are easy to deal with because the agent need not keep looking at the world while it is deciding
- on an action, nor need it worry about the passage of time.
- Dynamic environments, on the other hand, are continuously asking the agent what it wants to do;

Discrete vs. **continuous**:

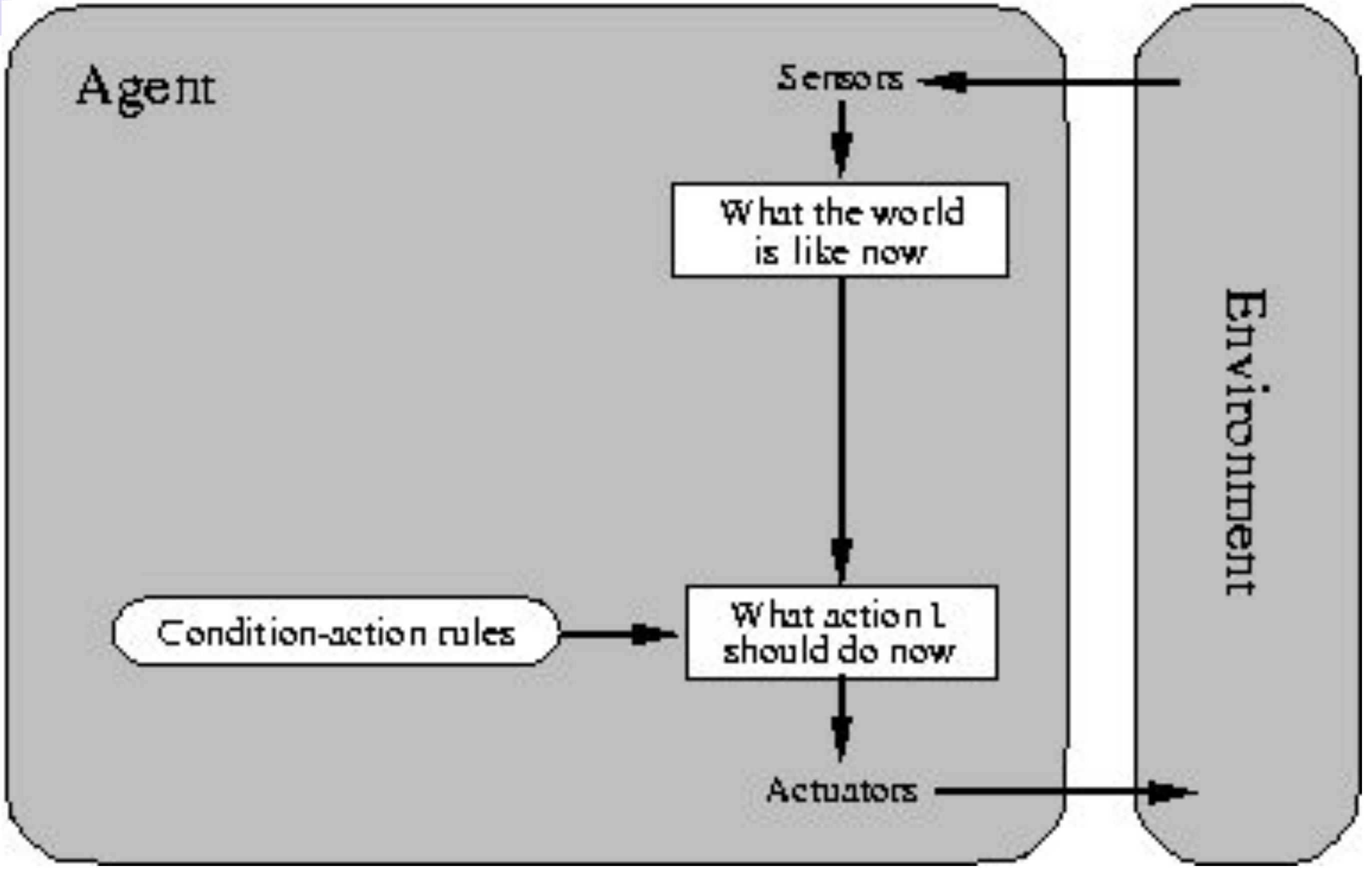
- The discrete/continuous distinction applies to the *state* of the environment, to the way *time* is handled, and to the *percepts* and *actions* of the agent.
- For example, the chess environment has a finite number of distinct states (excluding the clock).Chess also has a discrete set of percepts and actions.
- Taxi driving is a continuous-state and continuous-time problem:

Types of Agents

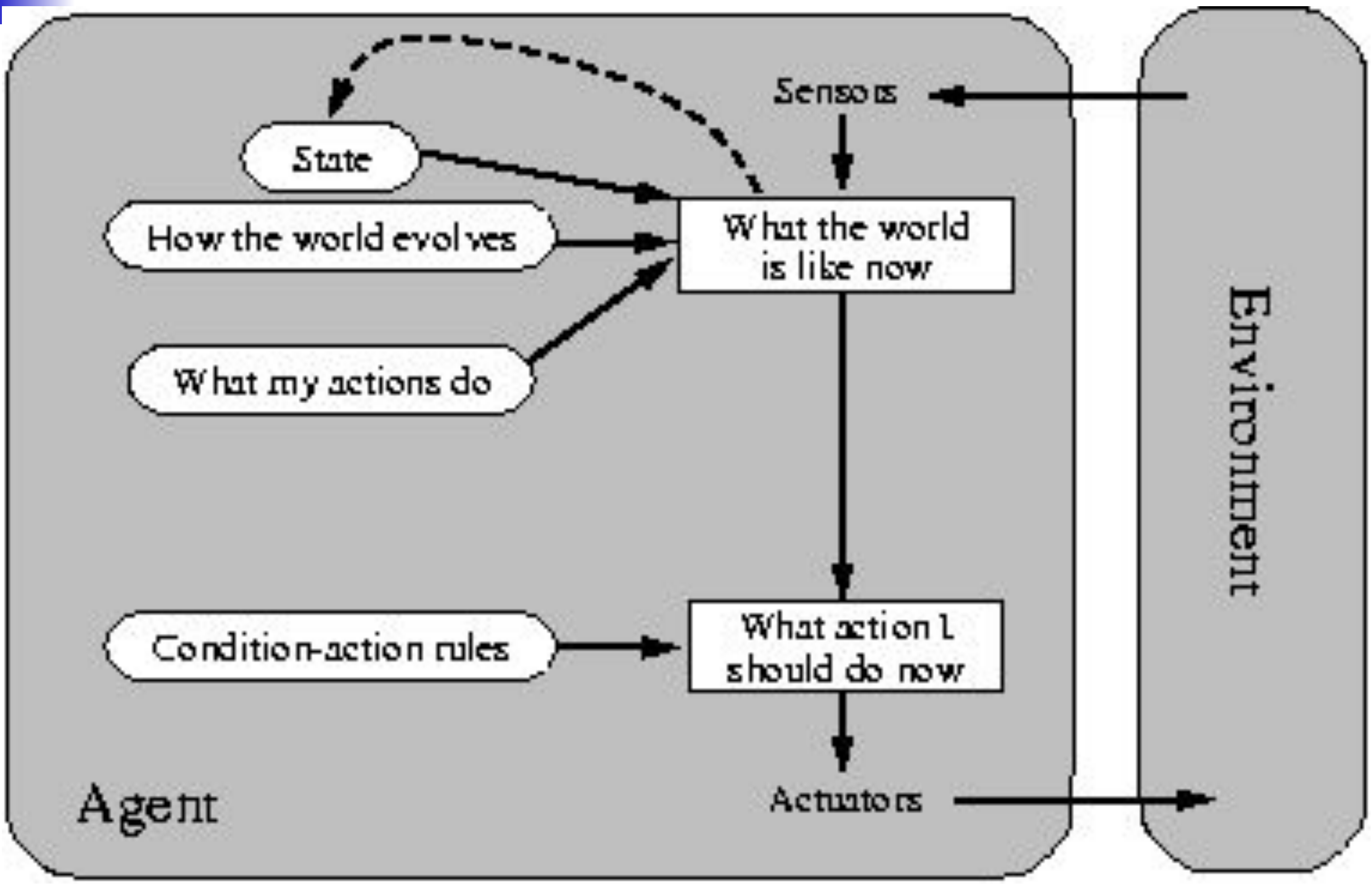
- Reflex Agent
- Reflex Agent with State
- Goal-based Agent
- Utility-Based Agent

- Learning Agent

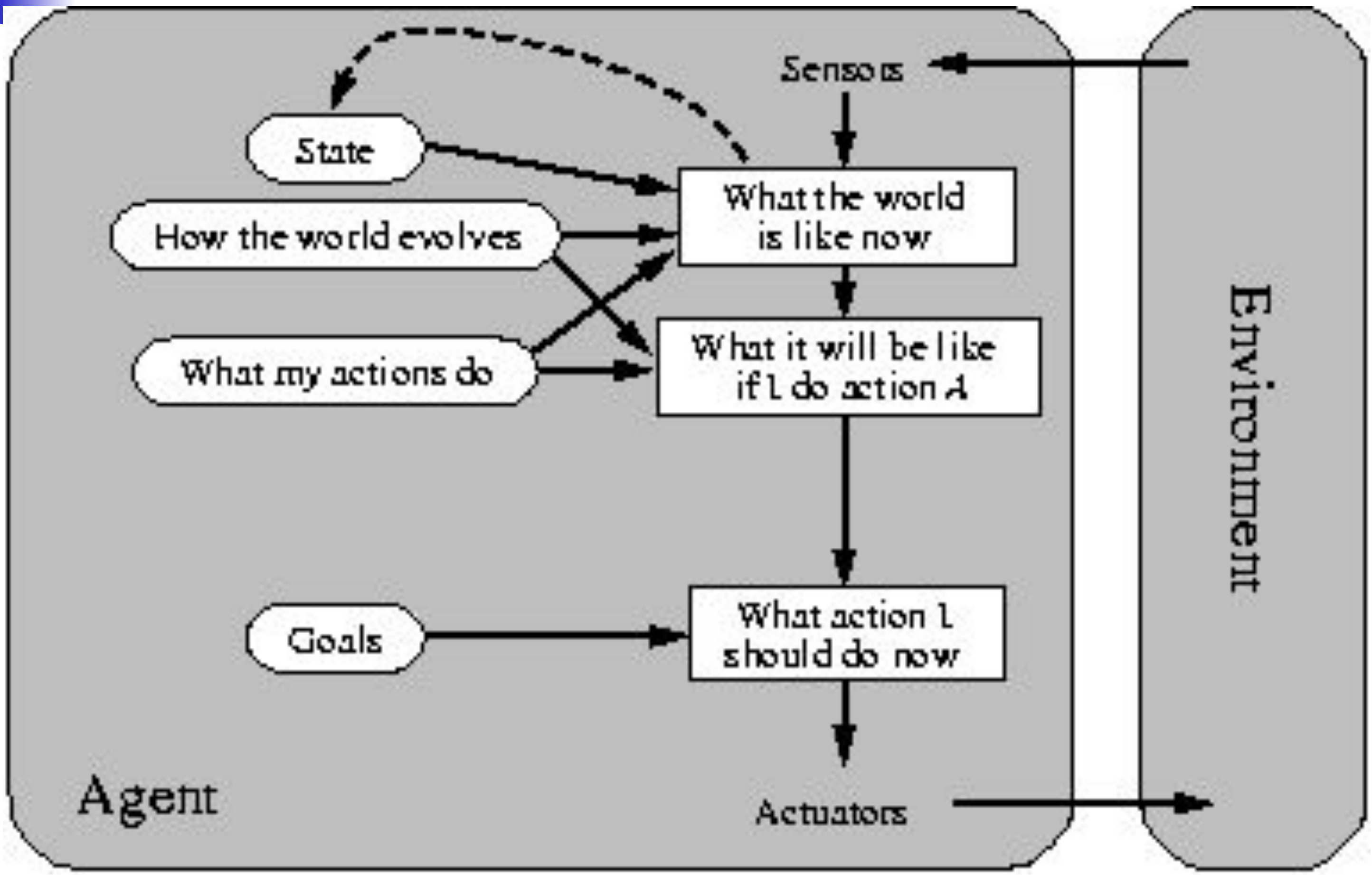
Reflex Agent



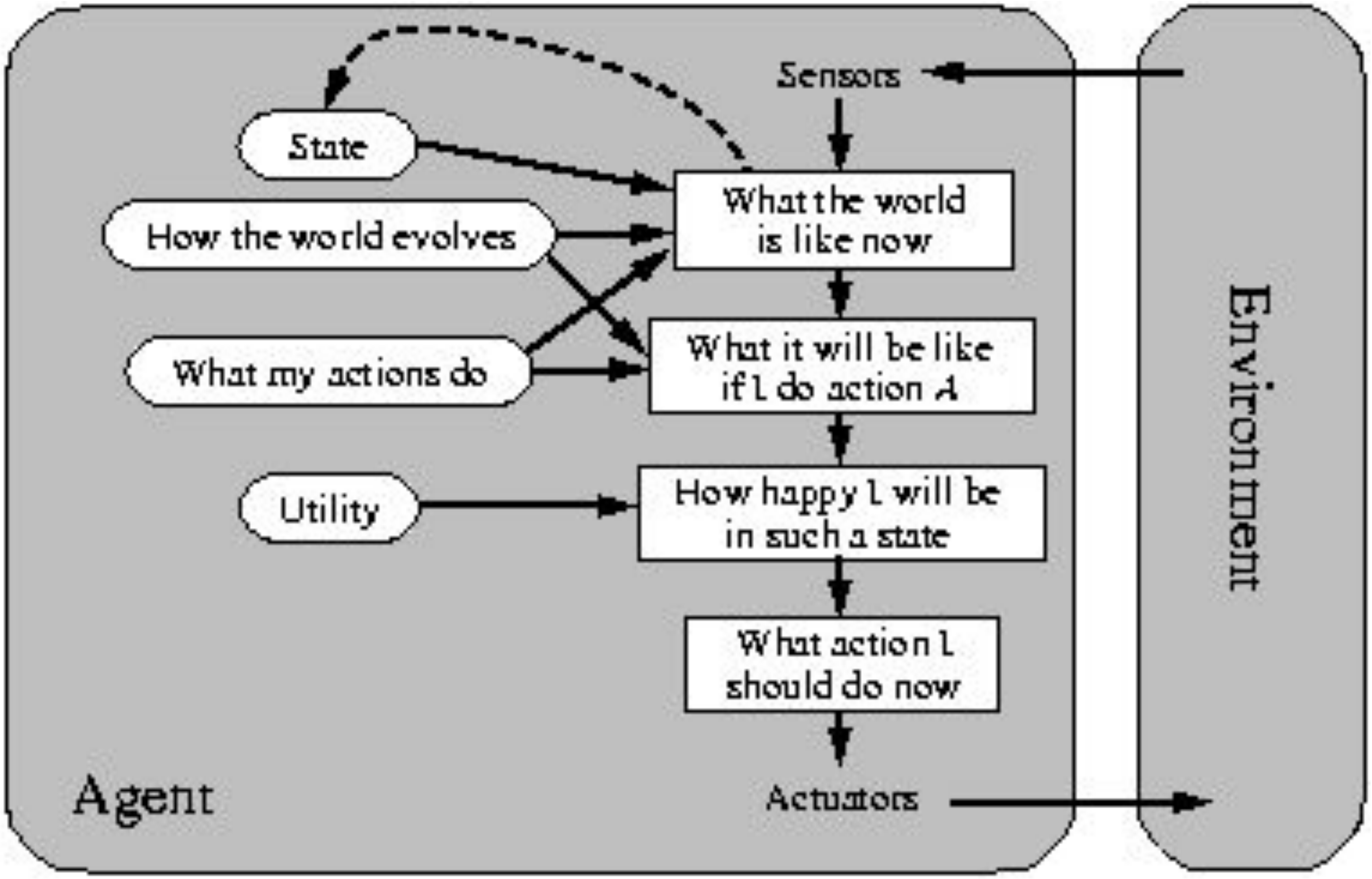
Reflex Agent with State



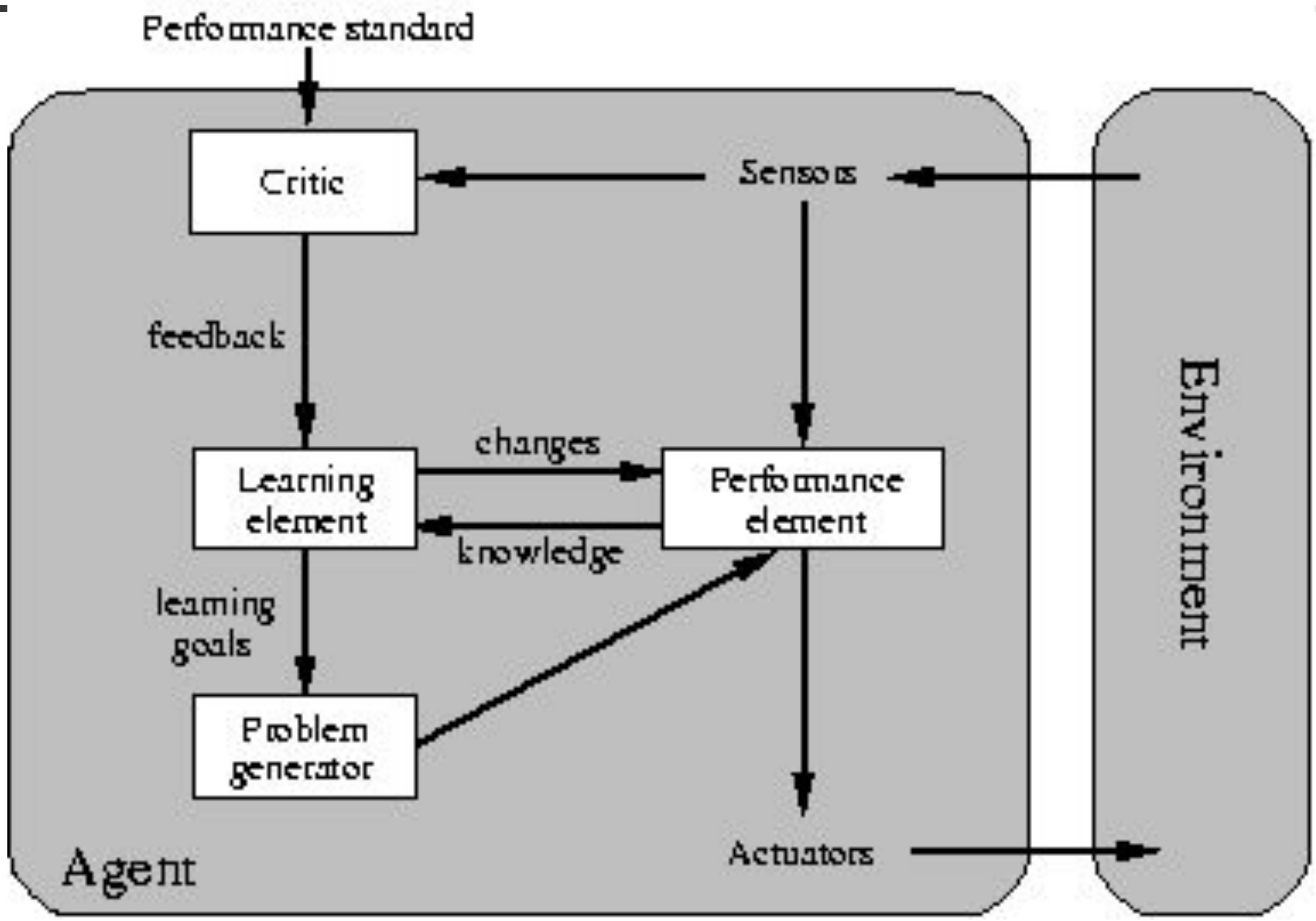
Goal-based Agent



Utility-based Agent



Learning Agent



Incorporating Goals

- Rules and "foresight"
  - Essentially, the agent's rule set is determined by its goals
  - Requires knowledge of future consequences given possible actions
- Can also be viewed as an agent with more complex state management
  - Goals provide for a more sophisticated next-state function

Incorporating Performance

- May have multiple action sequences that arrive at a goal
- Choose action that provides the best level of “happiness” for the agent
- Utility function maps states to a measure
  - May include tradeoffs
  - May incorporate likelihood measures

Incorporating Learning

- Can be applied to any of the previous agent types
  - Agent <-> Performance Element
- Learning Element
  - Causes improvements on agent/ **performance element**
  - Uses feedback from **critic**
  - Provides goals to **problem generator**

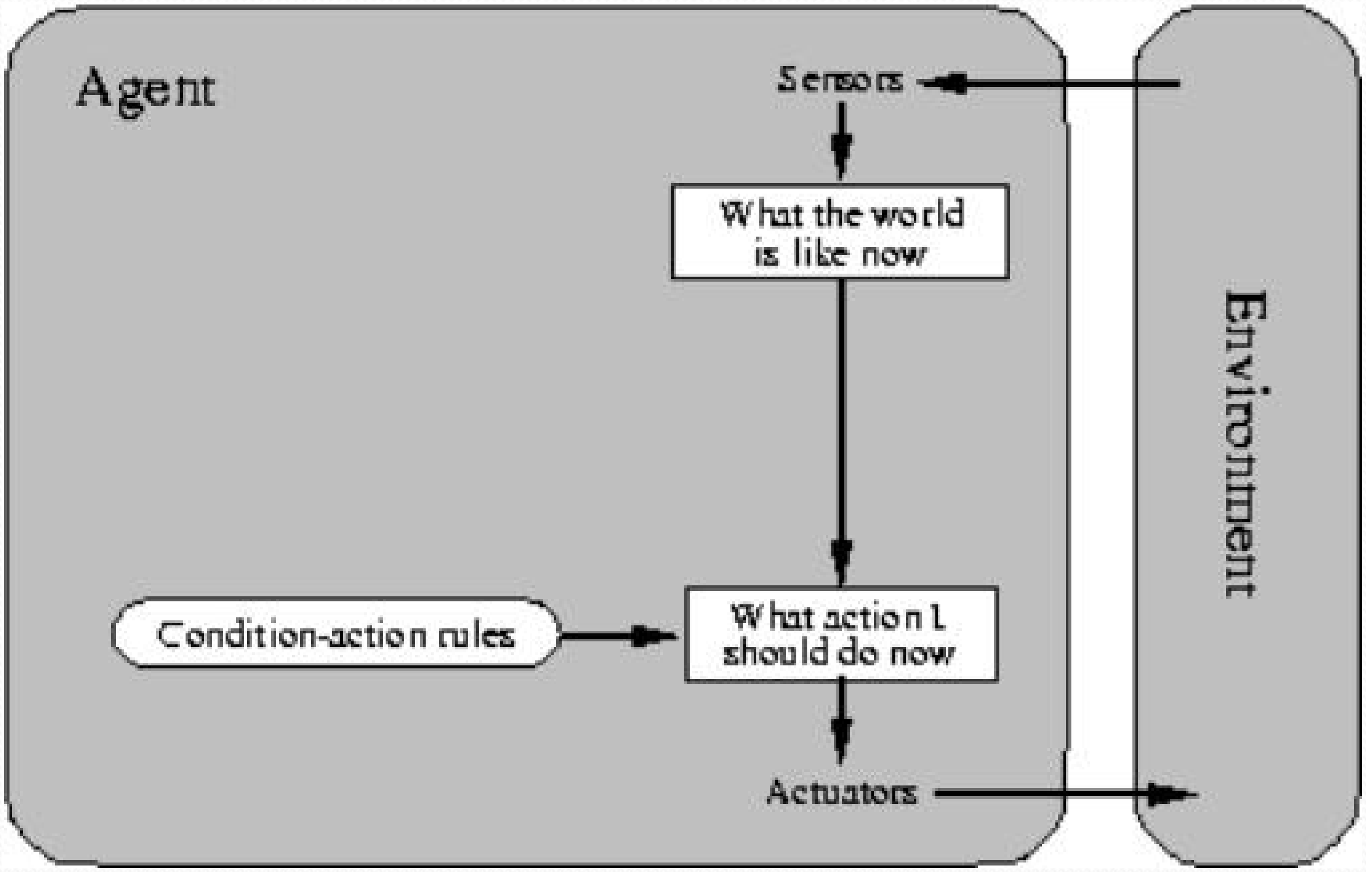
Problem Space
Unit 1

Subject: AI

Subject Code:CO44001

Subject Faculty: Sonika Shrivastava

Reflex Agent



Reflex Agent

function SIMPLE-REFLEX-AGENT(*percept*) **returns** an action
persistent: *rules*, a set of condition–action rules

state ← INTERPRET-INPUT(*percept*)
rule ← RULE-MATCH(*state*, *rules*)
action ← *rule*.ACTION
return *action*

Figure 2.10 A simple reflex agent. It acts according to a rule whose condition matches the current state, as defined by the percept.

Reflex Agent- Vacuum Cleaner

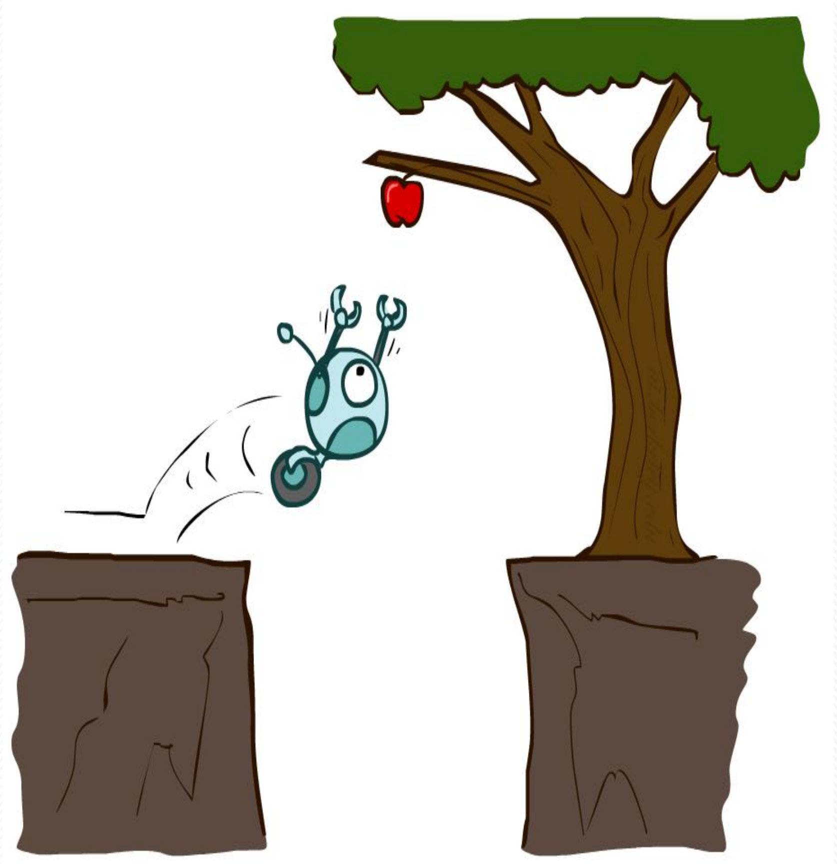
function REFLEX-VACUUM-AGENT([*location*,*status*]) **returns** an action

if *status* = *Dirty* **then return** *Suck*
else if *location* = *A* **then return** *Right*
else if *location* = *B* **then return** *Left*

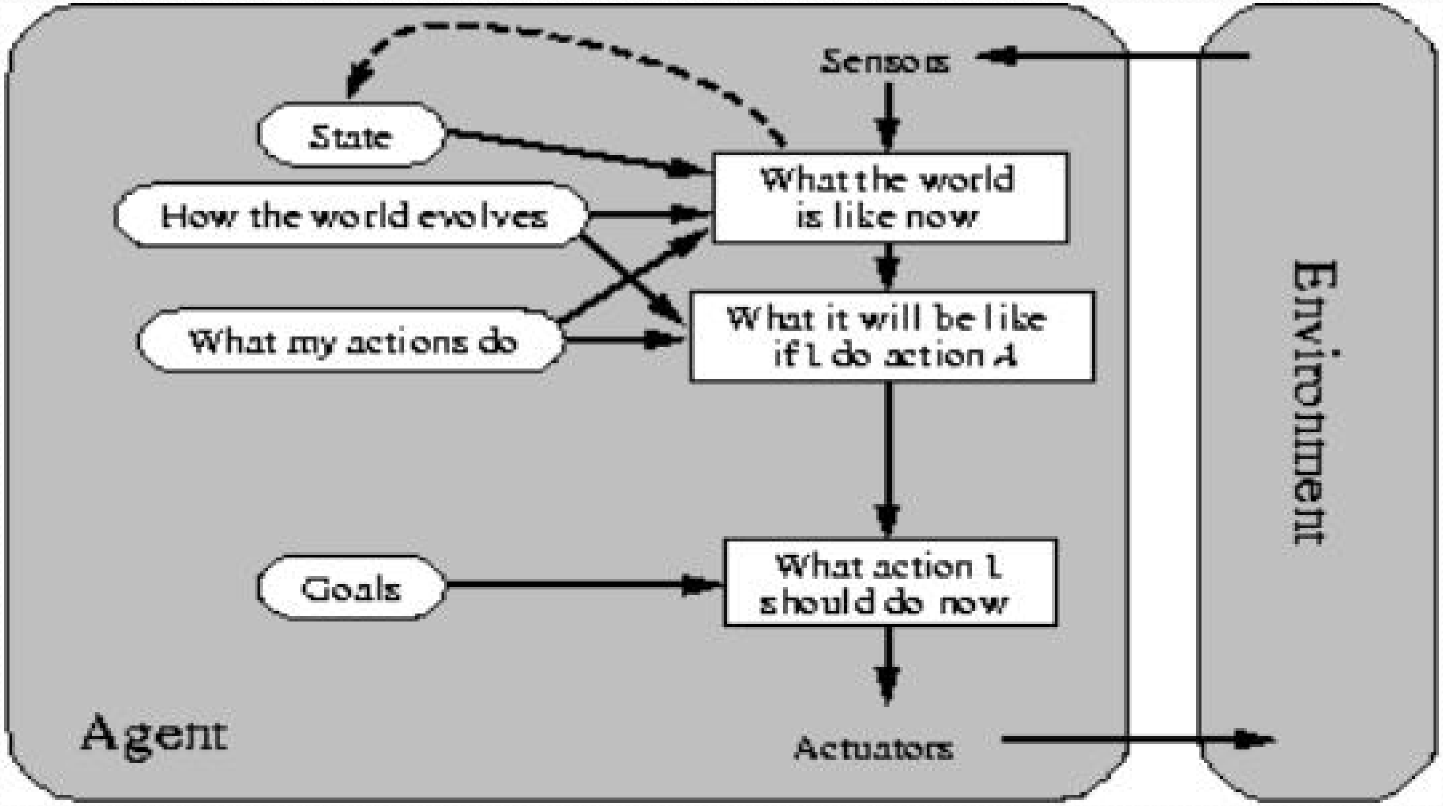
Figure 2.8 The agent program for a simple reflex agent in the two-state vacuum environment. This program implements the agent function tabulated in Figure 2.3.

Reflex Agents

- Choose action based on current percept (and maybe memory)
- May have memory or a model of the world's current state
- Do not consider the future consequences of their actions
- Consider how the world IS

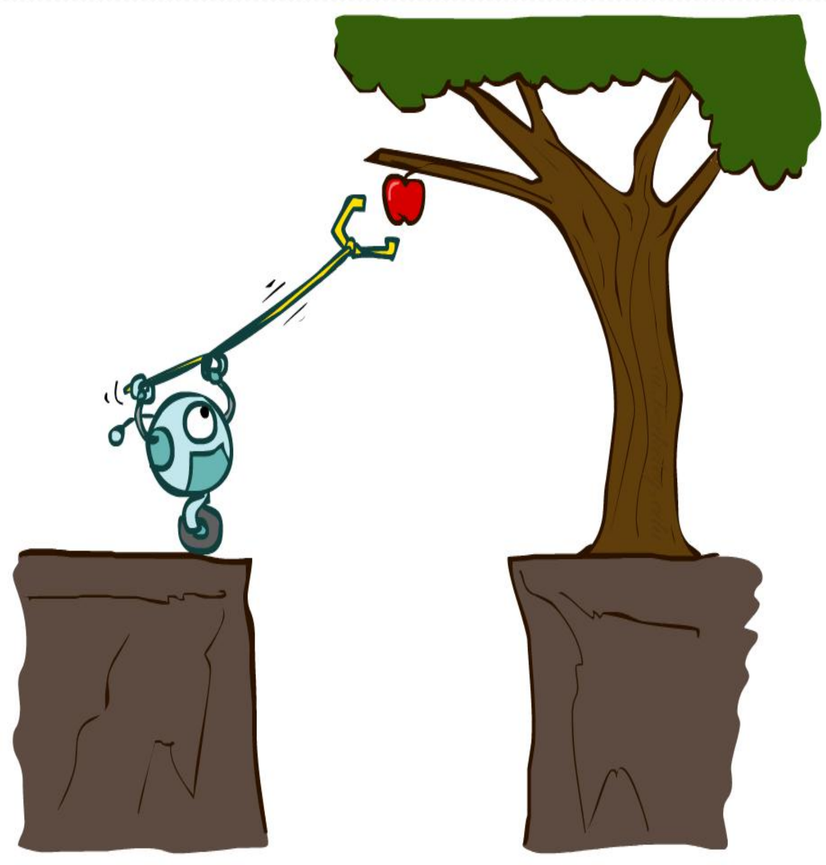


Goal-based Agent / **Problem-solving agent**



Problem-solving agent

- Must have a model of how the world evolves in response to actions
- Must formulate a goal (test)



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Problem formulation

It is the process of deciding what actions and states to consider, given a goal. Building a system to solve a problem requires the following steps

- Define the problem precisely including detailed specifications and what constitutes an acceptable solution;
- Analyze the problem thoroughly for some features may have a dominant affect on the chosen method of solution;
- Isolate and represent the background knowledge needed in the solution of the problem;
- Choose the best problem solving techniques in the solution

Components of Problem

- The **initial state** **that the agent starts in.**
- The **goal State** .
- A description of the possible **actions/ operations** **available to the agent.** Specify a set of *rules that describe the actions (operators) available.*
- A description of what each action does; the formal name for this is the TRANSITION MODEL .

Problem solving

- ***Problem solving is a process of generating solutions from observed data.***
- The problem solving procedure applies an operator to a state to get the next state.
- The process of applying an operator to a state and its subsequent transition to the next state, thus, is continued until the goal (desired) state is derived. Such a method of solving a problem is generally referred to as state space approach

DEFINING PROBLEM AS A STATE SPACE SEARCH

- Define a state space that contains all possible configurations of the relevant objects, without enumerating all the states in it. A state space represents a problem in terms of states and operators that change states
- Define some of these states as possible initial states;
- Specify one or more as acceptable solutions, these are goal states;
- Specify a set of rules as the possible actions allowed. This involves thinking about the generality of the rules,

DEFINING PROBLEM AS A STATE SPACE SEARCH

- A state space consists of:
- An *initial state.*
- A set of *final states;*
- A set of *operators that can change one state into another state.*

The Water Jug Problem

- In this problem, we use two jugs called four and three; four holds a maximum of four gallons of water and three a maximum of three gallons of water. How can we get two gallons of water in the four jug?

- Problem Formulation
- The start state is (0, 0)
- The goal state is (2, n)

The Water Jug Problem:Production Rules

Initial condition	**Goal comment**
1. (four, three) if four < 4	(4, three) fill four from tap
2. (four, three) if three< 3	(four, 3) fill three from tap
3. (four, three) If four > 0	(0, three) empty four into drain
4. (four, three) if three > 0	(four, 0) empty three into drain
5. (four, three) if four + three<4	(four + three, 0) empty three into four
6. (four, three) if four + three<3	(0, four + three) empty four into three
7. (0, three) If three > 0	(three, 0) empty three into four
8. (four, 0) if four > 0	(0, four) empty four into three
9. (0, 2)	(2, 0) empty three into four
10. (2, 0)	(0, 2) empty four into three
11. (four, three) if four < 4	(4, three-diff) pour diff, 4-four, into four from three
12. (three, four) if three < 3	(four-diff, 3) pour diff, 3-three, into three from four and a solution is given below four three rule

***(Fig. 2.2** Production Rules for the Water Jug Problem)*

The Water Jug Problem :Solution

Gallons in Four Jug	Gallons in Three Jug	Rules Applied
0	0	-
0	3	2
3	0	7
3	3	2
4	2	11
0	2	3
2	0	10

(Fig. 2.3 One Solution to the Water Jug Problem)

PROBLEM CHARACTERISTICS

- Is the problem decomposable into set of sub problems?
- Can the solution step be ignored or undone?
- Is the problem universally predictable?
- Is a good solution to the problem obvious without comparison to all the possible solutions?
- Is the desire solution a state of world or a path to a state?
- Is a large amount of knowledge absolutely required to solve the problem?
- Will the solution of the problem required interaction between the computer and the person?

The Water Jug Problem based on 7 Characteristic

Problem characteristic	Satisfied	Reason
Is the problem decomposable?	No	One Single solution
Can solution steps be ignored or undone?	Yes	
Is the problem universe predictable?	Yes	Problem Universe is predictable bcz to slove this problem it require only one person .we can predict what will happen in next step
Is a good solution absolute or relative?	absolute	**Absolute solution** , water jug problem may have number of solution , bt once we found one solution,no need to bother about other solution **Bcz it doesn't effect on its cost**
Is the solution a state or a path?	Path	Path to solution
What is the role of knowledge?		lot of knowledge helps to constrain the search for a solution.
Does the task require human-interaction?	Yes	additional assistance is required. Additional assistance, like to get jugs or pump

PRODUCTION SYSTEM

- The production system is a model of computation that can be applied to implement search algorithms and model human problem solving.
- Such problem solving knowledge can be packed up in the form of little quanta called productions

PRODUCTION SYSTEM

- A production system consists of following components.
- (a) A set of production rules, which are of the form A→B. Each rule consists of left hand side constituent that represent the current problem state and a right hand side that represent an output state.

  A rule is applicable if its left hand side matches with the current problem state.

PRODUCTION SYSTEM

- (b) A database, which contains all the appropriate information for the particular task. Some part of the database may be permanent while some part of this may pertain only to the solution of the current problem.
- (c) A control strategy that specifies order in which the rules will be compared to the database of rules and a way of resolving the conflicts that arise when several rules match simultaneously.
- (d) A rule applier, which checks the capability of rule by matching the content state with the left hand side of the rule and finds the appropriate rule from database of rules.