ARTIFICIAL INTELLIGENCE

L T P C

BCSE306L - 3 0 0 3

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

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Module – 1

AI & ITS ISSUES

1. Introduction - Definition
2. Evolution of AI
3. Classification of AI
4. Knowledge Inferring System
5. Uncertainty & Learning System

INTRODUCTION

Introduction :: Intelligence?

- The ability to acquire and apply knowledge and skills.
- The ability to learn or understand or to deal with new situations
- The mental capability that involves the ability to reason, to plan, to solve problems, to think abstractly, to comprehend complex ideas, to learn quickly and to learn from experience.

Need:

- Perception
- Learning
- Reasoning
- Use language and
- Problem solving

Introduction :: AI - Definition

AI is a branch of computer science, aims on building machines and software with intelligence similar to humans so that they can perform similar thinking, reasoning, decision-making, problem solving and natural language processing like human.

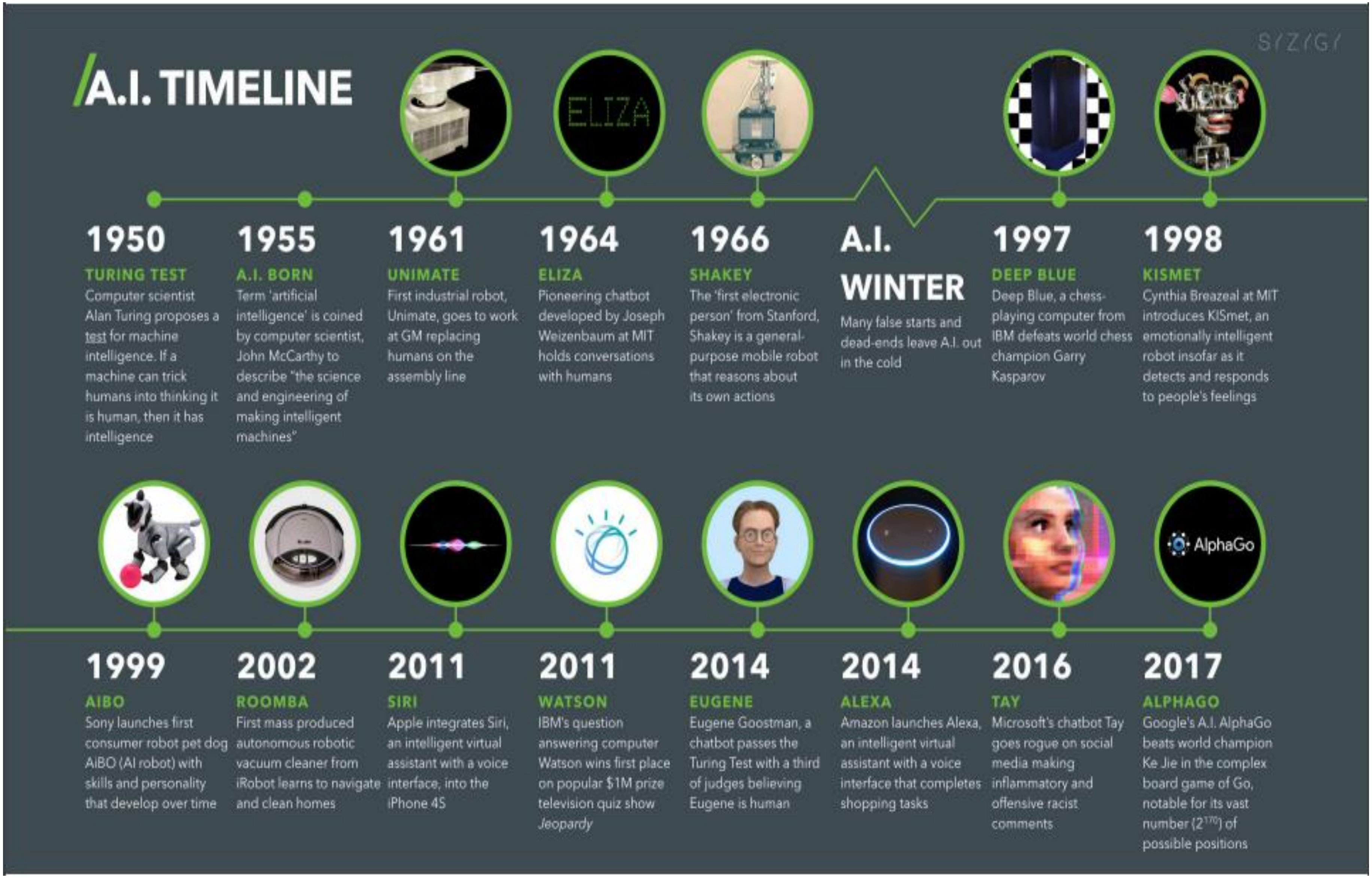
Past: how did the ideas in AI come about?

Present: what is the state of the art?

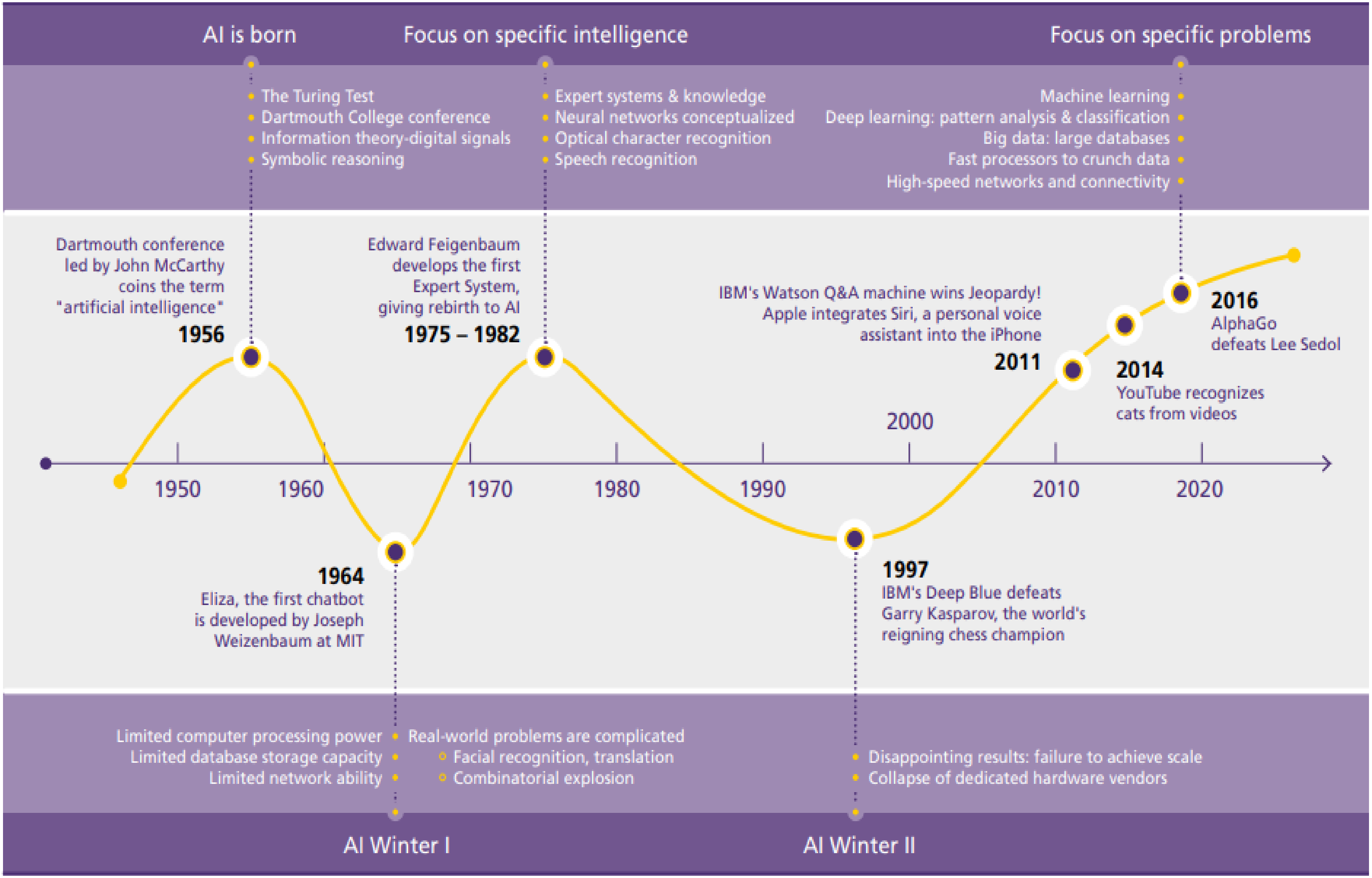
Future: will robots take over the world?

“The science and engineering of making intelligent machines”

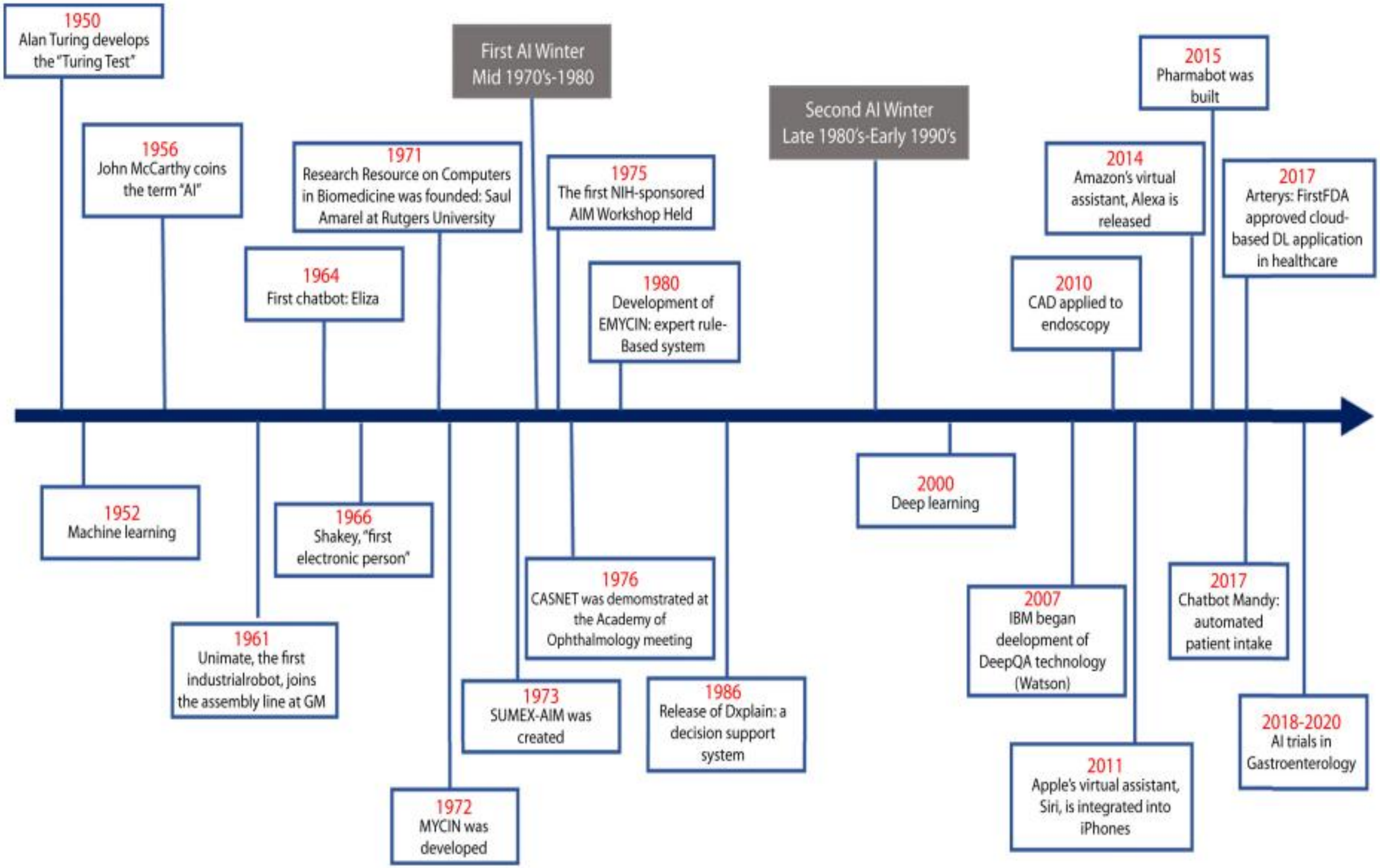
Introduction :: AI Timeline



Introduction :: The Rise of AI

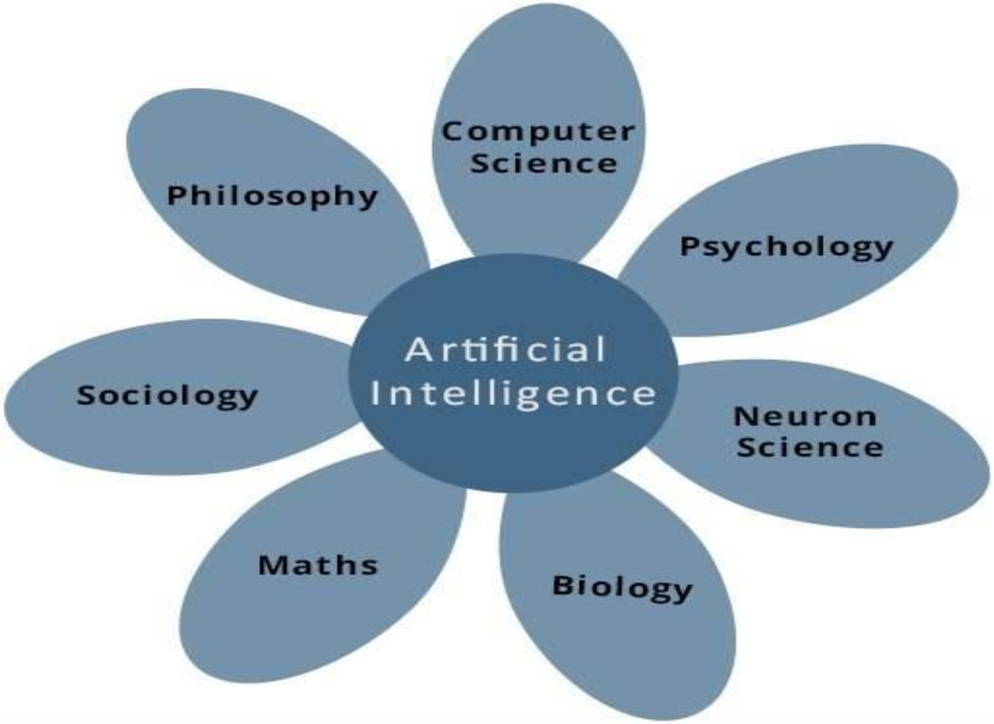


Introduction :: AI in Medicine



Introduction :: AI Prehistory

- ❖ Artificial Intelligence is not an easy science to describe.
- ❖ It has fuzzy borders with the following disciplines:
  - Mathematics
  - Computer science
  - Philosophy
  - Psychology
  - Statistics
  - Physics
  - Biology
  - and other disciplines



Introduction :: AI Foundations

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	physical substrate for mental activity
Psychology	phenomena of perception and motor control, experimental techniques
Computer Engineering	building fast computers
Control theory	design systems that maximize an objective function over time
Linguistics	knowledge representation, grammar

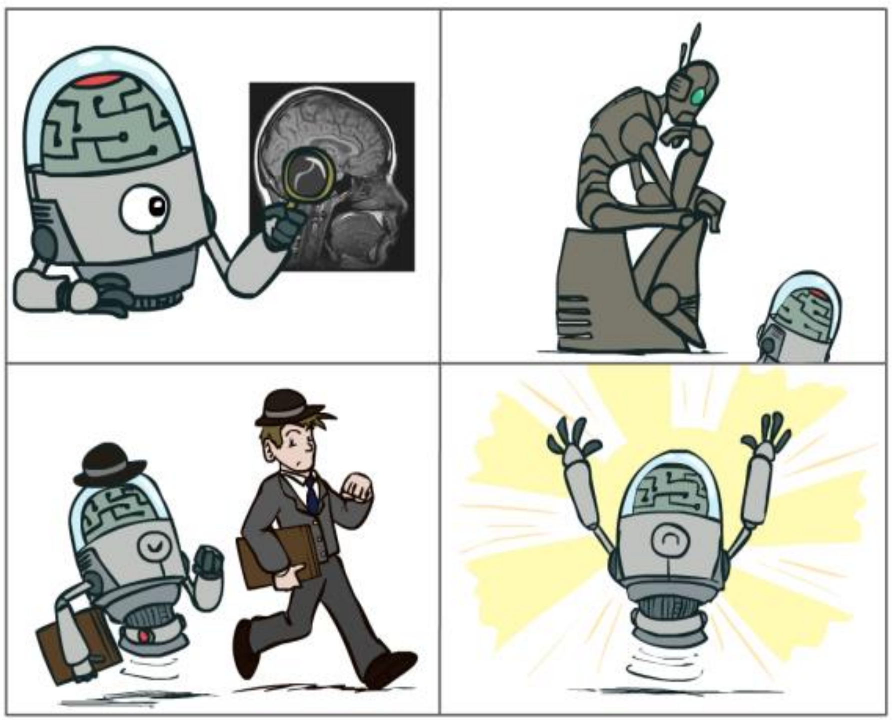
Introduction :: What is AI?

"The study and design of intelligent agents"

- An intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success.
- John McCarthy coined the term AI in 1956

Think like people

Think rationally



Act like people

Act rationally

Introduction :: What is AI?

"The study and design of intelligent agents"

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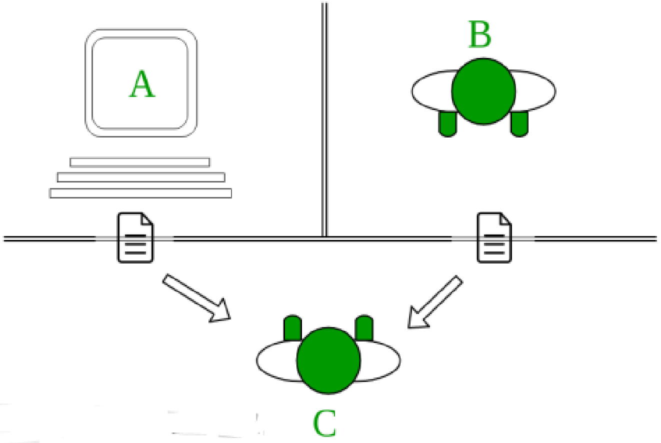
4 Approaches of AI

2. Thinking Humanly: The Cognitive Modeling Approach	3. Thinking Rationally: The "Laws of Thought" Approach
1. Acting Humanly: The Turing Test Approach (1950)	4. Acting Rationally: The Rational Agent Approach

Introduction :: What is AI?

Acting humanly: The Turing test approach

- In 1950, Turing defined a test of whether a machine could perform/act like a person



- A human judge engages in a natural language conversation with one human and one machine, each of which tries to appear human.
- If judge can't tell, machine passes the Turing test
- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes

Introduction :: What is AI?

Acting humanly: The Turing test approach

- The computer would need to possess the following capabilities
  - Natural language processing to enable it to communicate successfully in English/or other languages
  - Knowledge representation to store what it knows or hears
  - Automated reasoning to use the stored information to answer questions and to draw
  - Machine learning to adapt to new circumstances and to detect and extrapolate patterns
- Total Turing test includes a video signal, so the computer will need
  - Computer vision to perceive objects
  - Robotics to manipulate objects and move about

Introduction :: What is AI?

Thinking humanly: The cognitive modeling Approach

- ❖ The interdisciplinary field of cognitive science brings together computer models from AI and experimental techniques from psychology to construct precise and testable theories of the human mind
- ❖ Real cognitive science is necessarily based on experimental investigation of actual humans or animals. It 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.

Introduction :: What is AI?

What about the Brain?

- Brains (human minds) are very good at making rational decisions, but not perfect.
  - Rational: maximally achieving pre-defined goals
  - Rationality only concerns what decisions are made (not the thought process behind them)
  - Goals are expressed in terms of the utility of outcomes
  - Being rational means maximizing your expected utility
- Brains aren’t as modular as software, so hard to reverse engineer!
- “Brains are to intelligence as wings are to flight”
- Lessons learned from the brain: memory and simulation are key to decision making.

Introduction :: What is AI?

Thinking rationally: The “laws of thought” approach

- ❖ The Greek philosopher Aristotle, syllogisms [type of logical reasoning]
- ❖ Aristotle: what are correct arguments/thought processes?
- ❖ Several Greek schools developed various forms of logic: notation and rules of derivation for thoughts; may or may not have proceeded to the idea of mechanization.
- ❖ Direct line through mathematics and philosophy to modern AI

Problems:

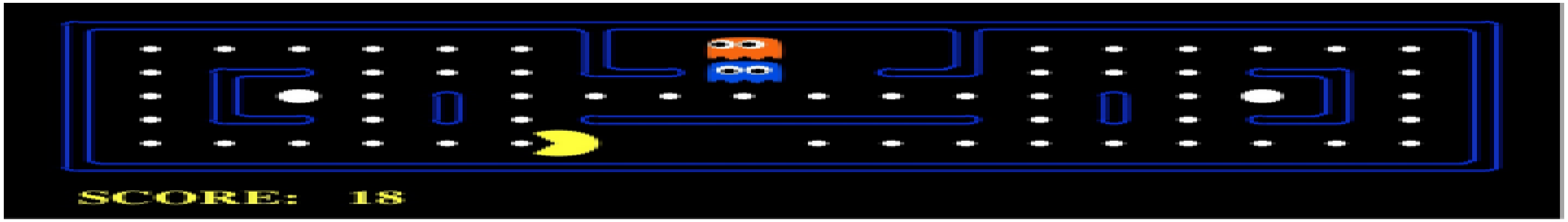
- ➢ Not all intelligent behavior is mediated by logical deliberation
- ➢ What is the purpose of thinking? What thoughts should I have?

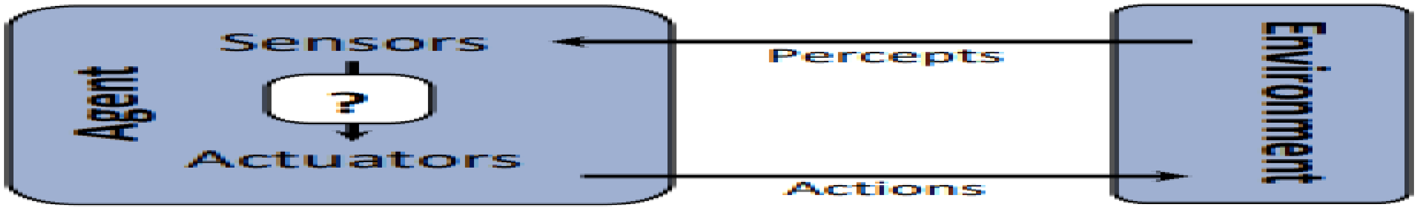
- ❖ The logicists hope to build on logic systems to create intelligent systems. The emphasis was on correct inferences.

Introduction :: What is AI?

Acting rationally: The rational agent approach

- Making correct inferences is sometimes part of being a rational agent, but not all
- An agent is just something that acts (agent comes from the Latin agere, to do). A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.





Introduction :: What is AI?

Acting rationally: The rational agent approach

- Characteristics of the sensors, actuators, and environment dictate techniques for selecting rational actions.
- This approach has two advantages:
  - It is more general than the “laws of thought” approach because correct inference is just one of several possible mechanisms for achieving rationality
  - It is more amenable to scientific development than are approaches based on human behavior or human thought

Introduction :: Operational Definition of AI

- Systems that *act* like humans

  Turing test

- Systems that *think* like humans

  Cognitive Science

- Systems that *think* rationally

  Logic-based AI

- Systems that *act* rationally

  Rational Agents

Introduction :: Why Study AI?

- AI is an interdisciplinary field of study. AI helps:
  - computer scientists and engineers build more useful and user-friendly computers
  - psychologists, linguists, and philosophers understand the principles that constitute what we call intelligence

Building AI systems is pretty hard

I went to the grocery store, I saw the milk on the shelf and I bought it

What did I buy?

- The milk?
- The shelf?
- The store?

An awful lot of knowledge of the world is needed to answer simple questions like this one

Introduction :: What can AI do?

- AI automates repetitive learning and discovery through data.
- AI adds intelligence
- AI adapts through progressive learning algorithms
- AI analyzes more and deeper data
- AI achieves incredible accuracy
- AI gets the most out of data

Quiz: Which of the following can be done at present?

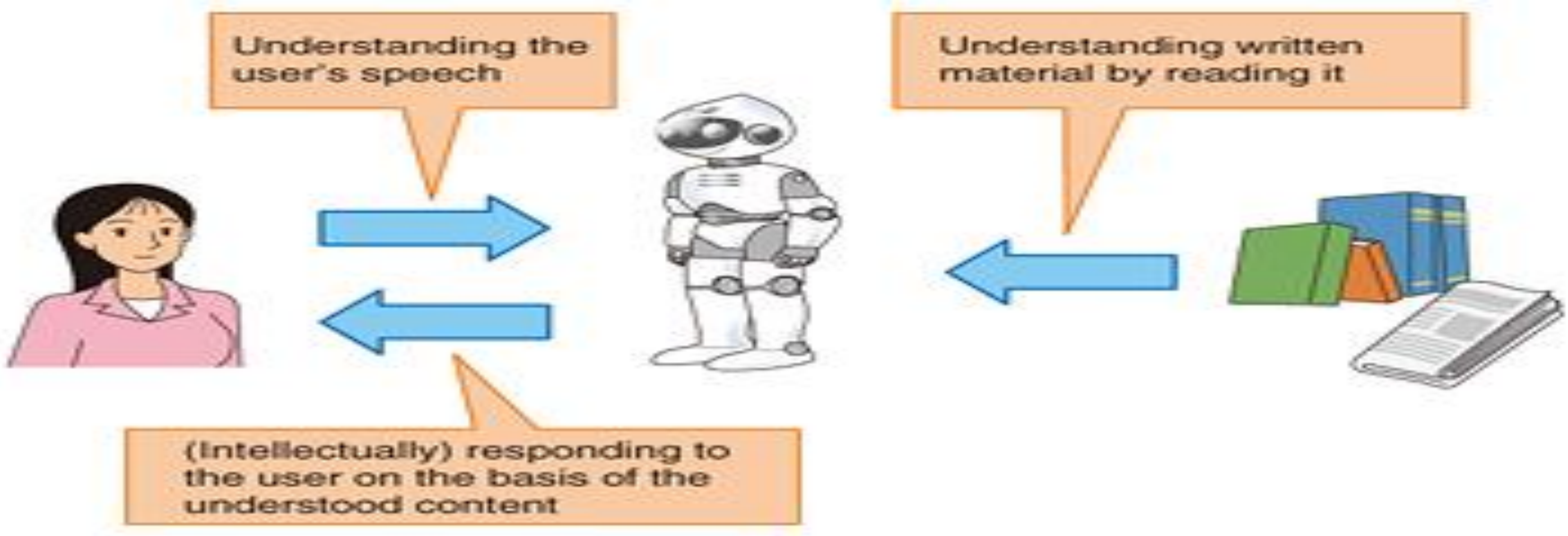
✓ Play a decent game of Jeopardy?
✓ Win against any human at chess?
✓ Win against the best humans at Go?
✓ Play a decent game of table tennis?
✓ Grab a particular cup and put it on a shelf?
✗ Unload any dishwasher in any home?
? Drive safely along the highway?
✗ Drive safely along Telegraph Avenue?
✓ Buy a week's worth of groceries on the web?
✗ Buy a week's worth of groceries at Berkeley Bowl?
? Discover and prove a new mathematical theorem?
✗ Perform a surgical operation?
✗ Unload a know dishwasher in collaboration with a person?
✓ Translate spoken Chinese into spoken English in real time?
? Write an intentionally funny story?

Introduction :: Major Branches of AI

- Perceptive system
  - A system that approximates the way a human sees, hears, and feels objects
- Vision system
  - Capture, store, and manipulate visual images and pictures
- Robotics
  - Mechanical and computer devices that perform tedious tasks with high precision
- Expert system
  - Stores knowledge and makes inferences
- Learning system
  - Computer changes how it functions or reacts to situations based on feedback

Introduction :: Major Branches of AI

- ❖ Natural language processing
  - ➢ Computers understand and react to statements and commands made in a “natural” language, such as English
- ❖ Neural network
  - ➢ Computer system that can act like or simulate the functioning of the human brain



Introduction :: Advantages of AI

- 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

Introduction :: Disadvantages of AI

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

Introduction :: Generic Techniques Developed using AI

- Forward/backward chaining (reasoning)
- Resolution theorem proving (reasoning)
- Proof planning (reasoning)
- Constraint satisfaction (reasoning)
- Davis-Putnam method (reasoning)
- Minimax search (games)
- Alpha-Beta pruning (games)
- Case-based reasoning (expert systems)
- Knowledge elicitation (expert systems)
- Neural networks (learning)
- Bayesian methods (learning)

Introduction :: Generic Techniques Developed using AI

- Explanation based (learning)
- Inductive logic programming (learning)
- Reinforcement (learning)
- Genetic algorithms (learning)
- Genetic programming (learning)
- Strips (planning)
- N-grams (NLP)
- Parsing (NLP)
- Behaviour based (robotics)
- Cell decomposition (robotics)

Introduction :: Representations/Languages used for AI

- First order logic
- Higher order logic
- Logic programs
- Frames
- Production Rules
- Semantic Networks
- Fuzzy logic
- Bayes nets
- Hidden Markov models
- Neural networks
- Strips

Introduction :: Representations/Languages used for AI

- Some standard AI programming languages have been developed in order to build intelligent programs efficiently and robustly. These include:
  - Prolog
  - Lisp (LISt Processing)
  - ML (Metalanguage)
- Other languages are also used extensively to build AI programs, including:
  - Perl
  - C++
  - Java
  - C

Introduction :: Application Areas of AI

- Agriculture
- Architecture
- Art
- Astronomy
- Bioinformatics
- Email classification
- Engineering
- Finance
- Fraud detection
- Information retrieval
- Law
- Mathematics
- Military
- Music
- Scientific discovery
- Story writing
- Telecommunications
- Telephone services
- Transportation
- Tutoring systems
- Video games
- Web search engines

Introduction :: AI Applications

- AI in Astronomy
  - Artificial Intelligence can be very useful to solve complex universe problems. AI technology can be helpful for understanding the universe such as how it works, origin, etc.
- AI in Healthcare
  - In the last, five to ten years, AI becoming more advantageous for the healthcare industry and going to have a significant impact on this industry.
  - Healthcare Industries are applying AI to make a better and faster diagnosis than humans. AI can help doctors with diagnoses and can inform when patients are worsening so that medical help can reach to the patient before hospitalization.

Introduction :: AI Applications

- **AI in Gaming**
  - AI can be used for gaming purpose. The AI machines can play strategic games like chess, where the machine needs to think of a large number of possible places.
- **AI in Finance**
  - AI and finance industries are the best matches for each other. The finance industry is implementing automation, Chatbot, adaptive intelligence, algorithm trading, and machine learning into financial processes.

Introduction :: AI Applications

- ## AI in Data Security
  - The security of data is crucial for every company and cyber-attacks are growing very rapidly in the digital world. AI can be used to make your data more safe and secure. Some examples such as AEG bot, AI2 Platform are used to determine software bug and cyber-attacks in a better way.
- ## AI in Social Media
  - Social Media sites such as Facebook, Twitter, and Snapchat contain billions of user profiles, which need to be stored and managed in a very efficient way. AI can organize and manage massive amounts of data. AI can analyze lots of data to identify the latest trends, hashtag, and requirement of different users.

Introduction :: AI Applications

- **AI in Travel & Transport**
  - AI is becoming highly demanding for travel industries. AI is capable of doing various travel related works such as from making travel arrangement to suggesting the hotels, flights, and best routes to the customers. Travel industries are using AI-powered chatbots which can make human-like interaction with customers for better and fast response.
- **AI in Automotive Industry**
  - Some Automotive industries are using AI to provide virtual assistant to their user for better performance. Such as Tesla has introduced TeslaBot, an intelligent virtual assistant.
  - Various Industries are currently working for developing self-driven cars which can make your journey more safe and secure.

Introduction :: AI Applications

- AI in Robotics
  - Artificial Intelligence has a remarkable role in Robotics. Usually, general robots are programmed such that they can perform some repetitive task, but with the help of AI, we can create intelligent robots which can perform tasks with their own experiences without pre-programmed.
  - Humanoid Robots are best examples for AI in robotics, recently the intelligent Humanoid robot named as Erica and Sophia has been developed which can talk and behave like humans.
- AI in Entertainment
  - We are currently using some AI based applications in our daily life with some entertainment services such as Netflix or Amazon. With the help of ML/AI algorithms, these services show the recommendations for programs or shows.

Introduction :: AI Applications

- **AI in Agriculture**
  - Agriculture is an area which requires various resources, labor, money, and time for best result. Now a day's agriculture is becoming digital, and AI is emerging in this field. Agriculture is applying AI as agriculture robotics, solid and crop monitoring, predictive analysis. AI in agriculture can be very helpful for farmers.
- **AI in E-commerce**
  - AI is providing a competitive edge to the e-commerce industry, and it is becoming more demanding in the e-commerce business. AI is helping shoppers to discover associated products with recommended size, color, or even brand.

Introduction :: AI Applications

- AI in education
  - AI can automate grading so that the tutor can have more time to teach. AI Chatbot can communicate with students as a teaching assistant.
  - AI in the future can be work as a personal virtual tutor for students, which will be accessible easily at any time and any place.

Introduction :: AI Applications

- AI in Natural Language
  - Speech Technologies (e.g. Siri, Alexa)
    - Automated speech recognition(ASR)
    - Text-to-Speech Synthesis (TTS)
  - Language Processing technologies
    - Question Answering
    - Machine Translation
    - Web Search
    - Text Classification, spam filtering, etc.
  - General Purpose Language Model?
    - GPT-3 by OpenAI: better funny stories here [https://www.gwern.net/GPT-3]
    - Jukebox by OpenAI: Interesting Music here [https://openai.com/blog/jukebox/]

Introduction :: AI Applications

❖ AI in Computer Vision

"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

"girl in pink dress is jumping in air."

"black and white dog jumps over bar."

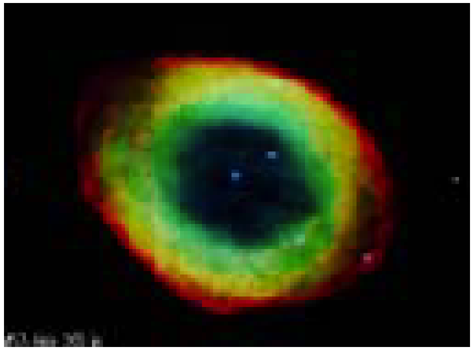
Image Captioning

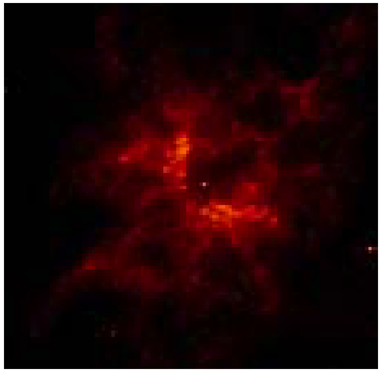
Image Segmentation

Deep-Fake

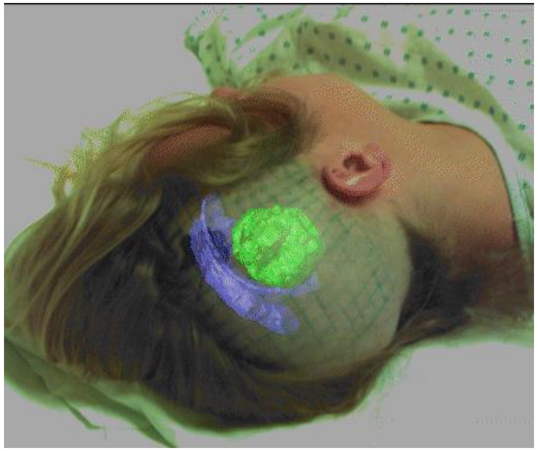
Introduction :: AI Applications

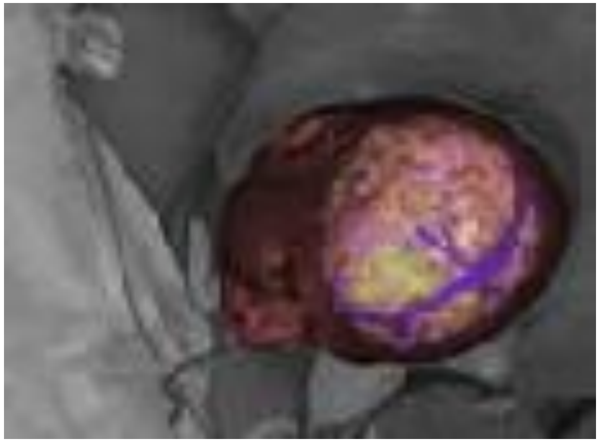
❖ Autonomous Planning & Scheduling: [Analysis of data]





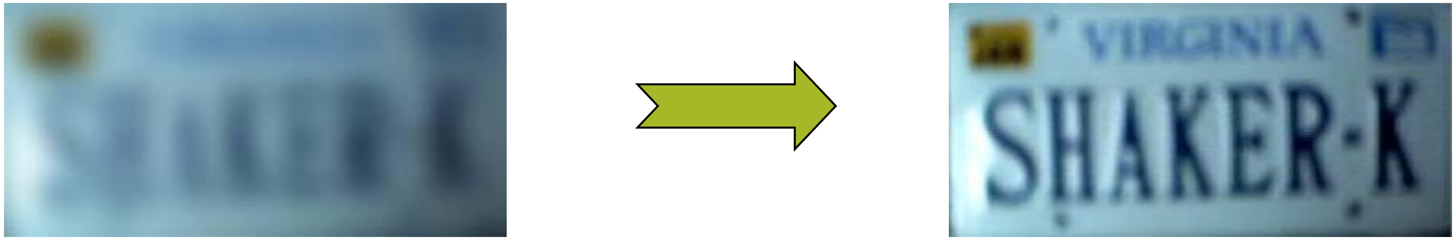
❖ Medicine: [Image guided surgery]

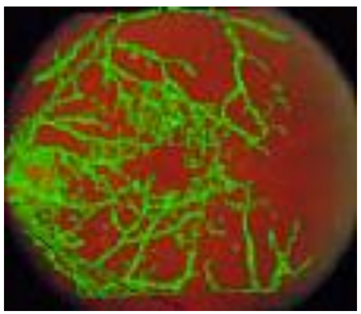


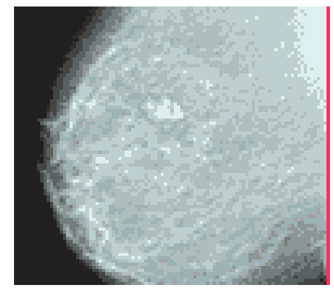


Introduction :: AI Applications

- Medicine: [Image analysis and enhancement]



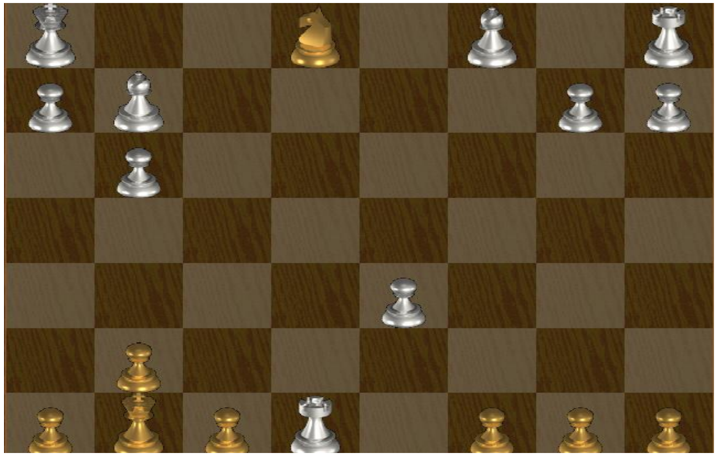




- Transportation: [Autonomous vehicle control & Pedestrian detection]

Introduction :: AI Applications

- Games



- Robotic toys:

Introduction :: AI Applications

- Other application areas:
  - Bioinformatics:
    - Gene expression data analysis
    - Prediction of protein structure
  - Text classification, document sorting:
    - Web pages, e-mails
    - Articles in the news
  - Video, image classification
  - Picture drawing
  - Perception.

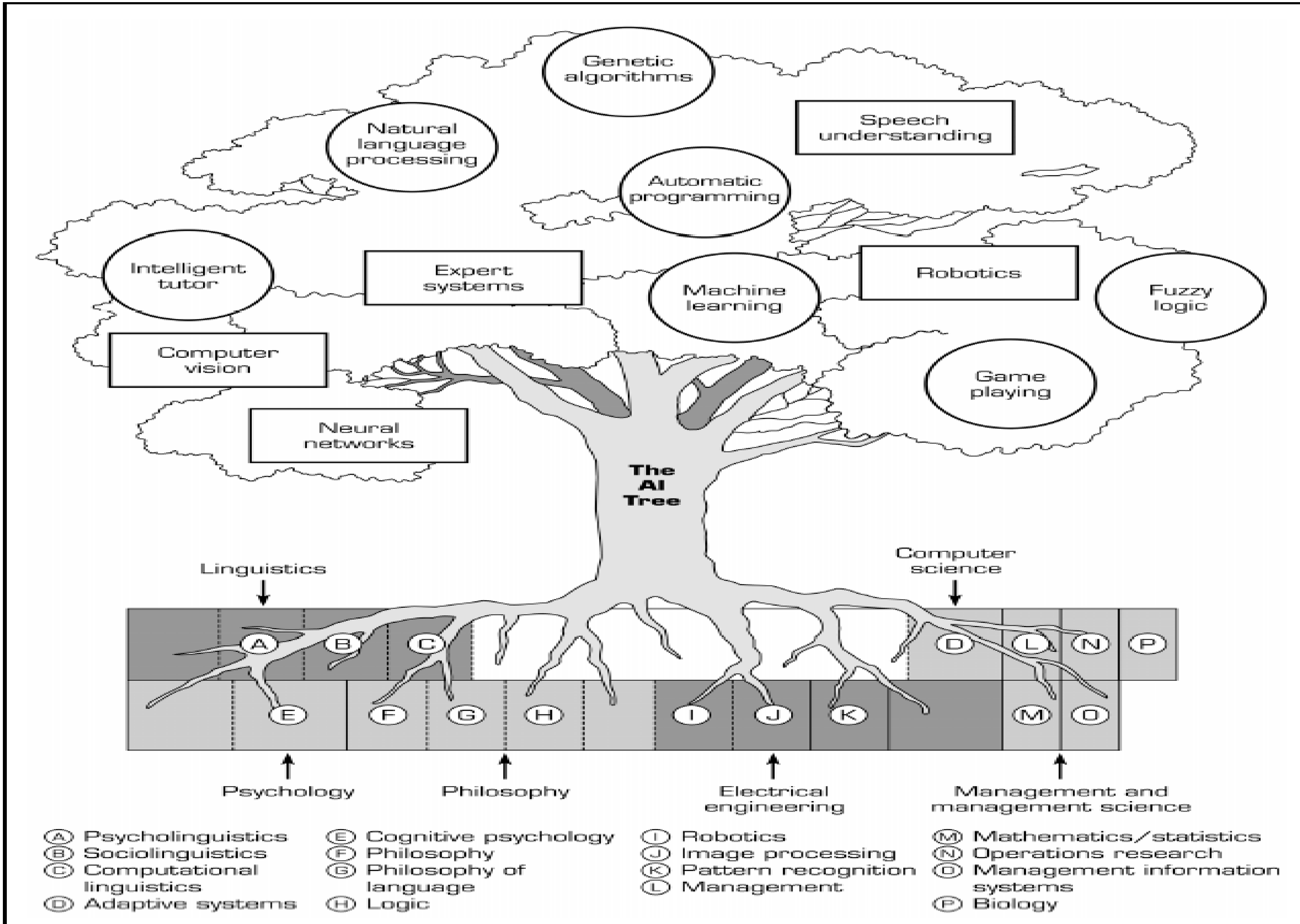


FIGURE 12.2 The Disciplines and Applications of AI

Introduction :: AI Sample Projects / Ideas

- http://web.stanford.edu/class/archive/cs/cs221/cs221.1192/2018/project-list.html
- https://www.cse.iitb.ac.in/~ganesh/internships
- http://www.cs.cornell.edu/courses/cs478/2001sp/mllinks/interesting_ai_demos_and_project.htm
- http://cs229.stanford.edu/projects2011.html
- https://docs.google.com/document/d/e/2PACX-1vRMprg-Uz9oEnjXOJpRPJ5oyEXRnJAz9qVeEB04sucx2o2RtQ-HRfom6IWS5ONhfoly0TOmJM7BxIzJ/pub

PLAGIARISM IS NOT PERMITTED.

kindly don’t copy someone’s project and pass it off as yours.

Introduction :: AI Categorizations

Based on strength, breadth, and application, AI can be described in different ways.

- ❖ Weak or Narrow Intelligence
- ❖ Strong or General Intelligence
- ❖ Super or Conscious Intelligence

Introduction :: AI Categorizations

- Weak or Narrow AI is AI that is applied to a specific domain. For example, language translators, virtual assistants, self-driving cars, AI-powered web searches, recommendation engines, and intelligent spam filters. Applied AI can perform specific tasks, but not learn new ones, making decisions based on programmed algorithms, and training data.
- Strong AI or Generalized AI is AI that can interact and operate a wide variety of independent and unrelated tasks. It can learn new tasks to solve new problems, and it does this by teaching itself new strategies. Generalized Intelligence is the combination of many AI strategies that learn from experience and can perform at a human level of intelligence.
- Super AI or Conscious AI is AI with human-level consciousness, which would require it to be self-aware. Because we are not yet able to adequately define what consciousness is, it is unlikely that we will be able to create a conscious AI in the near future.

Introduction :: AI Categorizations

- Artificial general intelligence is also referred to as "strong AI" or "full AI". It as the ability of a machine to perform "general intelligent action".
- Weak artificial intelligence (weak AI), also known as narrow AI. It is an artificial intelligence that is focused on one narrow task.
- A superintelligence is a hypothetical agent that possesses intelligence far surpassing that of the brightest and most gifted human minds.
- "Superintelligence" may also refer to a property of problem-solving systems (e.g., superintelligent language translators or engineering assistants) whether or not these high-level intellectual competencies are embodied in agents that act in the world.
- A superintelligence may or may not be created by an intelligence explosion and associated with a technological singularity.

AGENTS
&
ENVIRONMENTS

Agents

- ❖ An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.

Agent = Architecture+ Program

Architecture = the machinery that an agent executes on

Agent Program = an implementation of an agent function

- ❖ All the surrounding things and conditions of an agent in which it operates, is the environment for an agent.

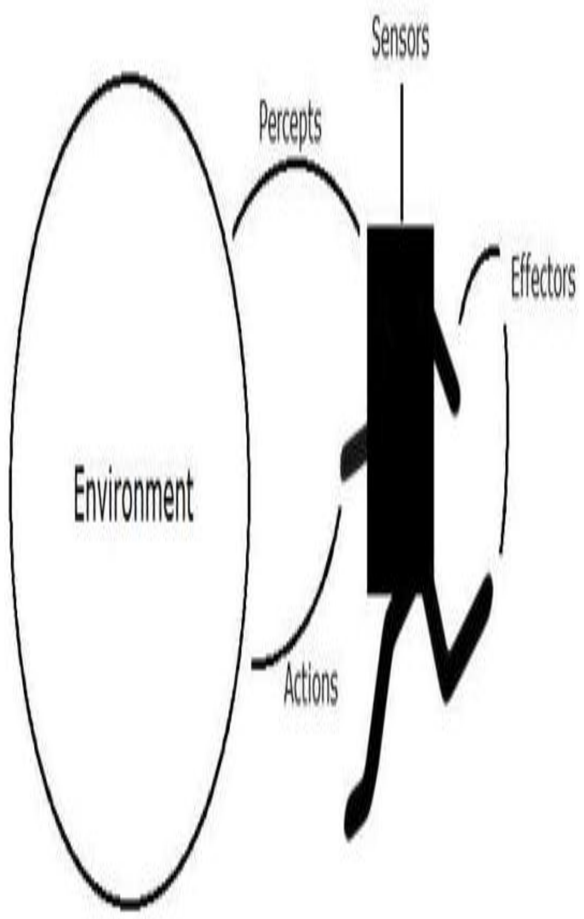
- ❖ Example: Autonomous Vehicle

Agents

- Human agent:
  - eyes, ears, and other organs for sensors;
  - hands, legs, mouth, and other body parts for actuators
- Robotic agent:
  - cameras and infrared range finders for sensors
  - various motors for actuators
- Software agent:
  - keystrokes, file contents as sensory input and act on those inputs and display output on the screen.

Agents :: Terms

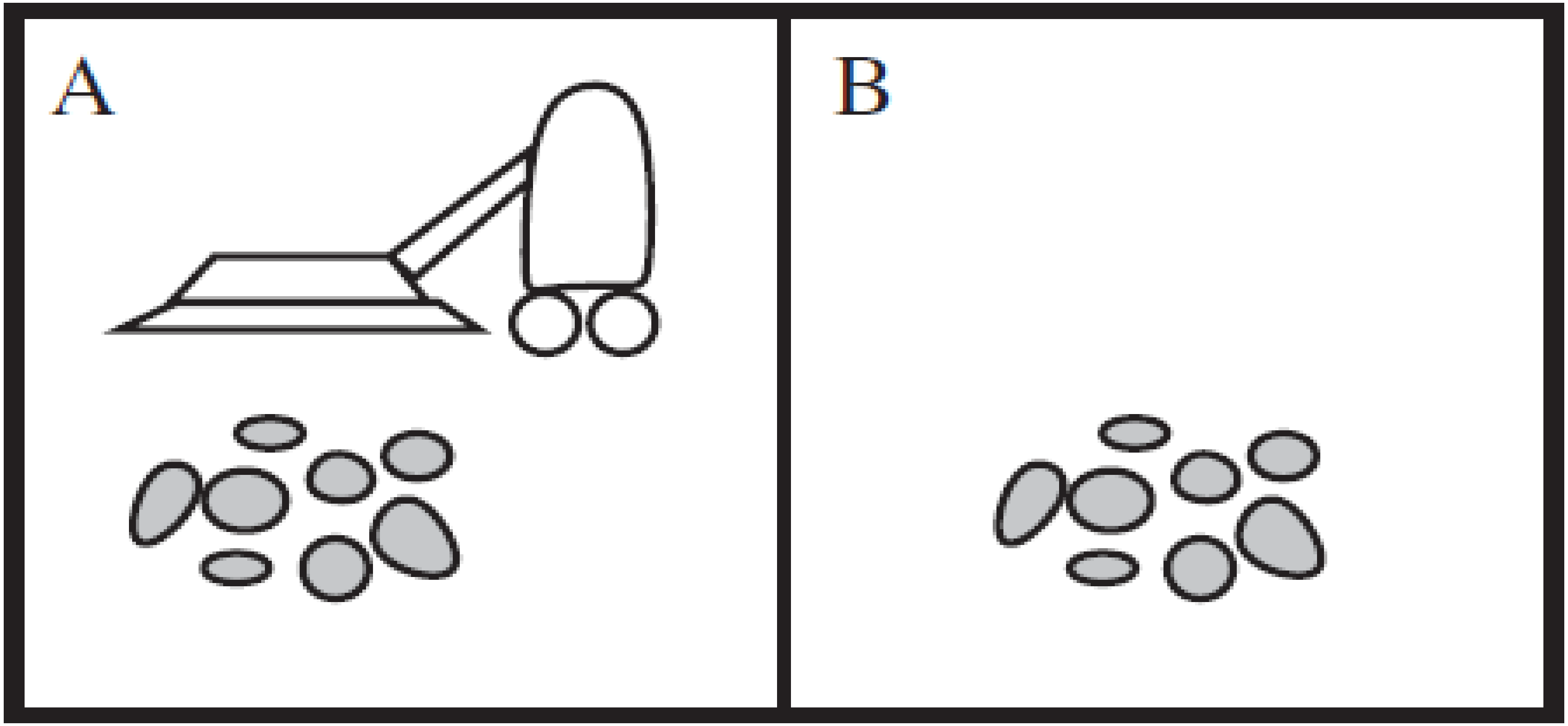
- Sensor: Sensor is a device which detects the change in the environment and sends the information to other electronic devices. An agent observes its environment through sensors.
- Actuators: Actuators are the component of machines that converts energy into motion. The actuators are only responsible for moving and controlling a system. An actuator can be an electric motor, gears, rails, etc.
- Effectors: Effectors are the devices which affect the environment. Effectors can be legs, wheels, arms, fingers, wings, fins, and display screen.



Agent & Environment :: Example

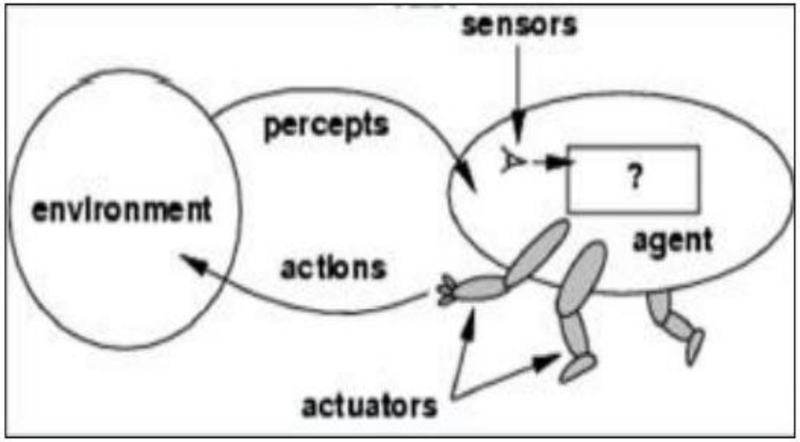
AI based Vacuum Cleaner:

- Percepts: location and contents, e.g., [Dirty]
- Actions: Left, Right, Suck, No Opration



Agent & Environment :: Example

- The agent function maps from percept histories to actions: [f: P* → A]
- The agent program runs on the physical architecture to produce f
- An agent should strive to "do the right thing", based on what it can perceive and the actions it can perform.
- The right action is the one that will cause the agent to be most successful.
- Performance measure: An objective criterion for success of an agent's behaviour. Example: performance measure of a vacuum-cleaner agent could be
  - ✓ amount of dirt cleaned up,
  - ✓ amount of time taken,
  - ✓ amount of electricity consumed,
  - ✓ amount of noise generated, etc.



Rational Agents

- Four factors affecting rational at any given time is:
  - The performance measure that defines the criterion of success
  - The agent’s prior knowledge of the environment
  - Best possible actions that an agent can perform.
  - The agent’s percept sequence to date

- A rational agent is an agent which has clear preference, models uncertainty, and acts in a way to maximize its performance measure with all possible actions.
- For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.

Rational Agents

- A rational agent is said to perform the right things. AI is about creating rational agents to use for game theory and decision theory for various real-world scenarios.
- Agents can perform actions in order to modify future precepts' so as to obtain useful information (information gathering, exploration)
- An agent is autonomous if its behaviour is determined by its own experience (with ability to learn and adapt)

Nature of Environment

- INTRODUCTION
  - Must decide and think about “Task environment”
  - Task environments are essentially the “problems” to which rational agents are the “solution”
- SPECIFYING THE TASK ENVIRONMENT
  - It involves grouping the following measuring factors together under the heading of the “Task environment”
  - PEAS (Performance, Environment, Actuator, Sensors)

Agents :: PEAS

- PEAS is a type of model on which an AI agent works upon. When we define an AI agent or rational agent, then we can group its properties under PEAS representation model. It is made up of four words:

  P: Performance measure

  E: Environment

  A: Actuators

  S: Sensors

- Based on these properties of an agent, they can be grouped together or can be differentiated from each other.

- Must first specify the setting for intelligent agent design

Agents :: PEAS

- Performance: All the necessary results that an agent gives after processing, comes under its performance.

- Environment: It basically consists of all the things under which the agents work.

- Actuators: The devices, hardware or software through which the agent performs any actions or processes any information to produce a result are the actuators of the agent.

- Sensors: The devices through which the agent observes and perceives its environment are the sensors of the agent.

Agents :: PEAS - Example

Agent: Part Picking Robot

- Performance measure: Percentage of parts in correct bins
- Environment: Conveyor belt with parts, bins
- Actuators: Jointed arm and hand
- Sensors: Camera, joint angle sensors

Agent: Medical Diagnosis System

- Performance measure: Healthy patient, minimize costs
- Environment: Patient, hospital, staff
- Actuators: Screen display (questions, tests, diagnoses, treatments, referrals)
- Sensors: Keyboard (entry of symptoms, findings, patient's answers)

Agents :: PEAS - Example

Agent: Automated Taxi Driver

- Performance measure: Safe, fast, legal, comfortable trip, maximize profits
- Environment: Roads, other traffic, pedestrians, customers
- Actuators: Steering wheel, accelerator, brake, signal, horn
- Sensors: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

Agent: Interactive English tutor

- Performance measure: Maximize student's score on test
- Environment: Set of students
- Actuators: Screen display (exercises, suggestions, corrections)
- Sensors: Keyboard

Agents :: PEAS – Example [Home Work]

- Agent: Chess Game
- Agent: Autonomous Rover
- Agent: Satellite Image Analysis System
- Agent: Refinery Controller

Agents :: Environment Types

Environments

- Fully observable Vs Partially observable
- Single agent vs. Multiagent
- Deterministic vs. Stochastic
- Episodic Vs Sequential
- Static vs. Dynamic
- Discrete vs. Continuous
- Known vs. Unknown

Agents :: Environment Types

Fully observable vs. Partially observable

- Fully observable: An agent's sensors give it access to the complete state of the environment at each point in time.
- A fully observable environment is easy as there is no need to maintain the internal state to keep track history of the world.
- An environment might be partially observable because of noisy and inaccurate sensors or because parts of the state are simply missing from the sensor data
- If the agent has no sensors at all then the environment is unobservable.
- Example:
  - Taxi Driving
- Vacuum agent with local dirt sensor cannot tell whether dirt is there is dirt in other square. An automated taxi cannot see what other drivers are thinking.

Agents :: Environment Types

Single agent vs. Multiagent

- The distinction between single-agent and multi-agent environments may seem simple enough.
- If only one agent is involved in an environment, and operating by itself then such an environment is called single agent environment.
- However, if multiple agents are operating in an environment, then such an environment is called a multiagent environment.
- Example:
  - An agent solving a crossword puzzle by itself is clearly in a single-agent environment
  - An agent playing chess is in a two agent environment. In chess, the opponent entity B is trying to maximize its performance measure, thus minimizing agent A's performance measure. Thus chess is a competitive multiagent environment.

Agents :: Environment Types

Single agent vs. Multiagent

- Maze game
- Football that includes 10 players
- In the taxi driving environment, avoiding collisions maximizes the performance measures of all agents, so it is a partially co-operative multiagent environment.

Agents :: Environment Types

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 (Next state is completely predictable); otherwise, it is stochastic (Next step has some uncertainty).
- Most real situations are so complex that it is impossible to keep track of all the unobserved aspects; for practical purposes, they must be treated as stochastic (nondeterministic).
- In a deterministic, fully observable environment, agent does not need to worry about uncertainty.
- Example:
  - Tic Tac Toe game

Agents :: Environment Types

Deterministic vs. Stochastic

- ❖ Taxi driving is clearly nondeterministic, because one can never predict the behaviour of traffic exactly; moreover, one’s tires may blow out unexpectedly and one’s engine may seize up without warning.

- ❖ The vacuum world is deterministic, but variations can include nondeterministic elements such as randomly appearing dirt and an unreliable suction mechanism.

Agents :: Environment Types

Episodic vs. Sequential

- Episodic : The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself. In an episodic environment, there is a series of one-shot actions, and only the current percept is required for the action.
- In sequential environments, on the other hand, the current decision could affect all future decisions. An agent requires memory of past actions to determine the next best actions.
- Example:
  - An agent that has to spot defective parts on an assembly line bases each decision on the current part, regardless of previous decisions.
  - Chess and taxi driving are sequential: in both cases, short-term actions can have long-term consequences.

Agents :: Environment Types

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.
- If the environment itself does not change with the passage of time but the agent's performance score does, then we say the environment is semidynamic.
- Example:
  - Taxi driving is an example of a dynamic environment whereas Crossword puzzles are an example of a static environment.
  - Chess played with a clock is semidynamic.
  - Playing football

Agents :: Environment Types

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.
- ❖ If in an environment there are a finite number of percepts and actions that can be performed within it, then such an environment is called a discrete environment else it is called continuous environment.(Time moves in fixed step).
- ❖ Example:
  - ➢ A chess game comes under discrete environment as there is a finite number of moves that can be performed.
  - ➢ A self-driving car is an example of a continuous environment.

Agents :: Environment Types

Known vs. Unknown

- Strictly speaking, this distinction refers not to the environment itself but to the agent's (or designer's) state of knowledge about the "laws of physics" of the environment.
- In a known environment, the outcomes for all actions are given. If the environment is unknown, the agent will have to learn how it works in order to make good decisions.
- It is quite possible for a known environment to be partially observable. For example, in solitaire card games, I know the rules but am still unable to see the cards that have not yet turned over.
- Conversely, an unknown environment can be fully observable. For example, in a new video game, the screen may show the entire game state but still I don't know what the buttons do until I try them.

Agents :: Environment Types - Example

	Chess with a clock	Chess without a clock	Taxi driving
Fully observable	Yes	Yes	No
Deterministic	Strategic	Strategic	No
Episodic	No	No	No
Static	Semi	Yes	No
Discrete	Yes	Yes	No
Single agent	No	No	No

- ❖ The environment type largely determines the agent design
- ❖ The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

Agents :: Environment Types - Example

Task Environment	Observable	Agents	Deterministic	Episodic	Static	Discrete
Crossword puzzle						
Chess with a clock						
Poker						
Backgammon						
Taxi driving						
Medical diagnosis						
Image analysis						
Part-picking robot						
Refinery controller						
Interactive English tutor						

Home Work !

Agents :: Table Driven Agent

- Trivial agent program that keeps track of the percept sequence and then uses it to index into a table of action to decide what to do
- The table represents explicitly the agent function that the agent program embodies
- In order to build a rational agent, the designers must construct a table that contains the appropriate action for every possible percept sequence

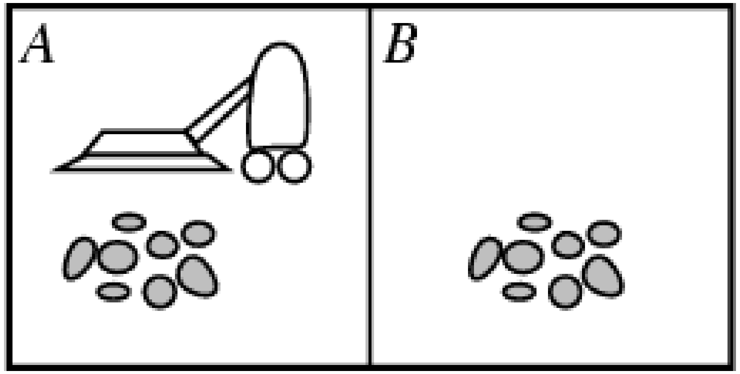
Agent program for a vacuum-cleaner agent

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

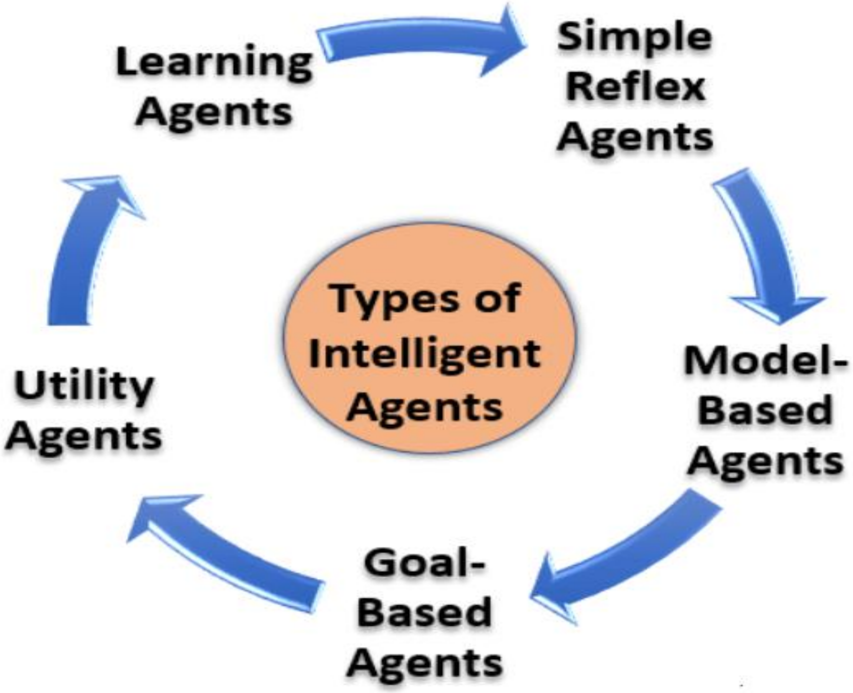


Agents :: Table Driven Agent

- Huge table (Example: chess requires $10^{(150)}$ entries in the lookup table)
- Take a long time to build the table
- No autonomy
- Even with learning, need a long time to learn the table entries

Agents :: Types

- Five basic types in order of increasing generality:
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based agents
  - Learning agent



Agents :: Simple Reflex Agents

- The Simple reflex agents are the simplest agents. These agents take decisions on the basis of the current percepts and ignore the rest of the percept history.
- These agents only succeed in the fully observable environment.
- The Simple reflex agent does not consider any part of percepts history during their decision and action process.
- The Simple reflex agent works on Condition-action rule, which means it maps the current state to action. Such as a Room Cleaner agent, it works only if there is dirt in the room.

Agents :: Simple Reflex Agents

Percept sequence	Action
[A, Clean]	*Right*
[A, Dirty]	*Suck*
[B, Clean]	*Left*
[I3, Dirty]	*Suck*
[A, Clean], [A, Clean]	*Right*
[A, Clean], [A, Dirty]	*Suck*
.	:
[A, Clean], [A, Clean], [A, Clean]	*Right*
[A, Clean], [A, Clean], [A, Dirty]	*Suck*
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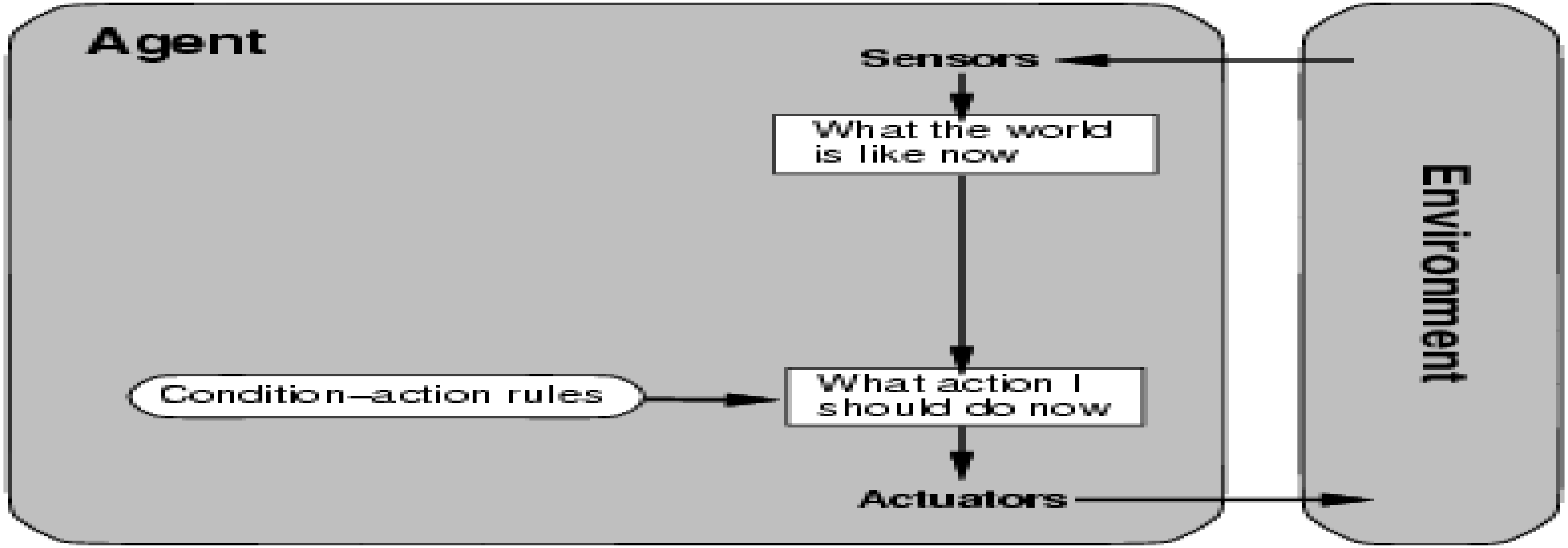


Agents :: Simple Reflex Agents

```
function SIMPLE-REFLEX-AGENT(percept) returns action
    static: rules, a set of condition-action rules

    state ← INTERPRET-INPUT(percept)
    rule ← RULE-MATCH(state, rules)
    action ← RULE-ACTION[rule]
    return action
```

- The INTERPRET-INPUT function generates an abstract description of the current state from the percept
- RULE-MATCH function returns the first rule in the set of rules that matches the given state description

Agents :: Simple Reflex Agents

- Simple reflex agents have the admirable property of being simple, but they turn out to be of very limited intelligence (The correct decision can be made on the basis of only the current percept i.e., environment is fully observable)
- Even a little bit of unobservability can cause serious trouble (They do not have knowledge of non-perceptual parts of the current state)
- Mostly too big to generate and to store.
- Not adaptive to changes in the environment.

Agents :: Simple Reflex Agents

- Advantage
  - Easy to implement
  - Uses much less memory than table-driven agent
- Disadvantage
  - Will only work correctly if the environment is fully observable.
  - Infinite loops

Agents :: Model-based Reflex Agents

- The Model-based agent can work in a partially observable environment, and track the situation.

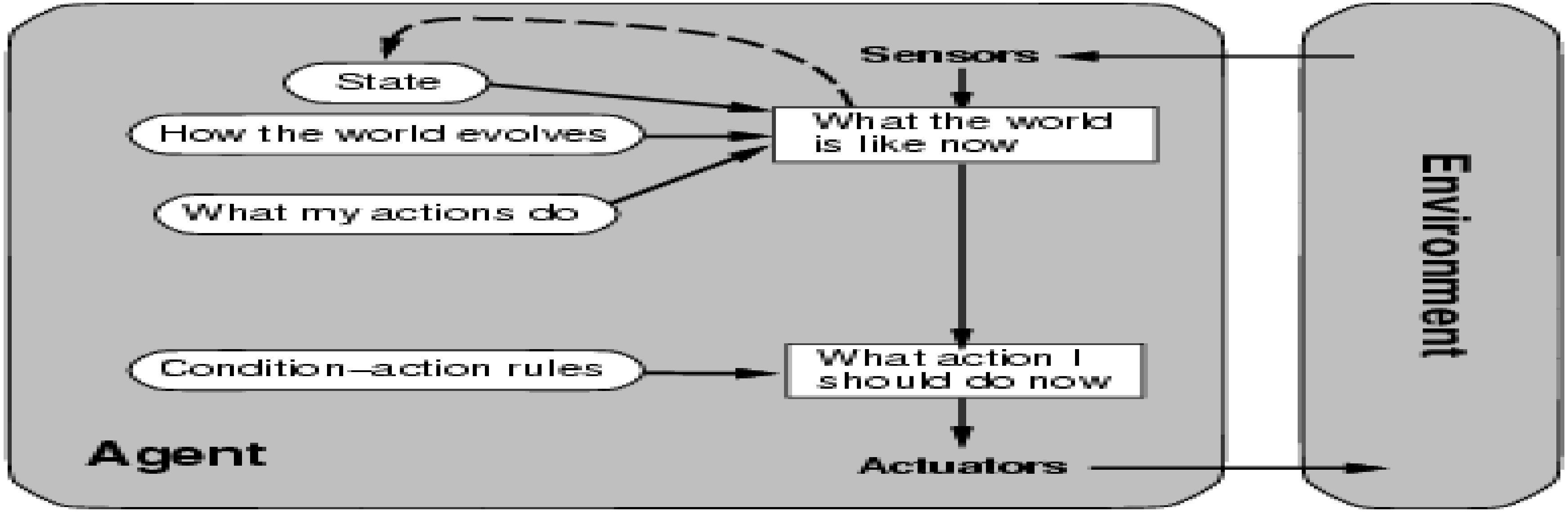
- A model-based agent has two important factors:
  - Model: It is knowledge about "how things happen in the world," so it is called a Model-based agent.
  - Internal State: It is a representation of the current state based on percept history.

- The agent should maintain some sort of internal state that depends on the percept history and thereby reflects at least some of the unobserved aspect of the current state

Agents :: Model-based Reflex Agents

- Updating this internal state information as requires two kinds of knowledge to be encoded in the agent program
  - Information about how the world evolves independently of the agent (Transition model)
  - Information about how the agent's own actions affect the world (Sensor model)
- It works by finding a rule whose condition matches the current situation.
- A model-based agent can handle partially observable environments by use of model about the world.
- The agent has to keep track of internal state which is adjusted by each percept and that depends on the percept history.
- The current state is stored inside the agent which maintains some kind of structure describing the part of the world which cannot be seen.

Agents :: Model-based Reflex Agents



function REFLEX-AGENT-WITH-STATE(*percept*) **returns** an action

static: *state*, a desription of the current world state

rules, a set of condition-action rules

action, the most recent action, initially none

state ← UPDATE-STATE(*state*, *action*, *percept*)

rule ← RULE-MATCH(*state*, *rules*)

action ← RULE-ACTION[*rule*]

return *action*

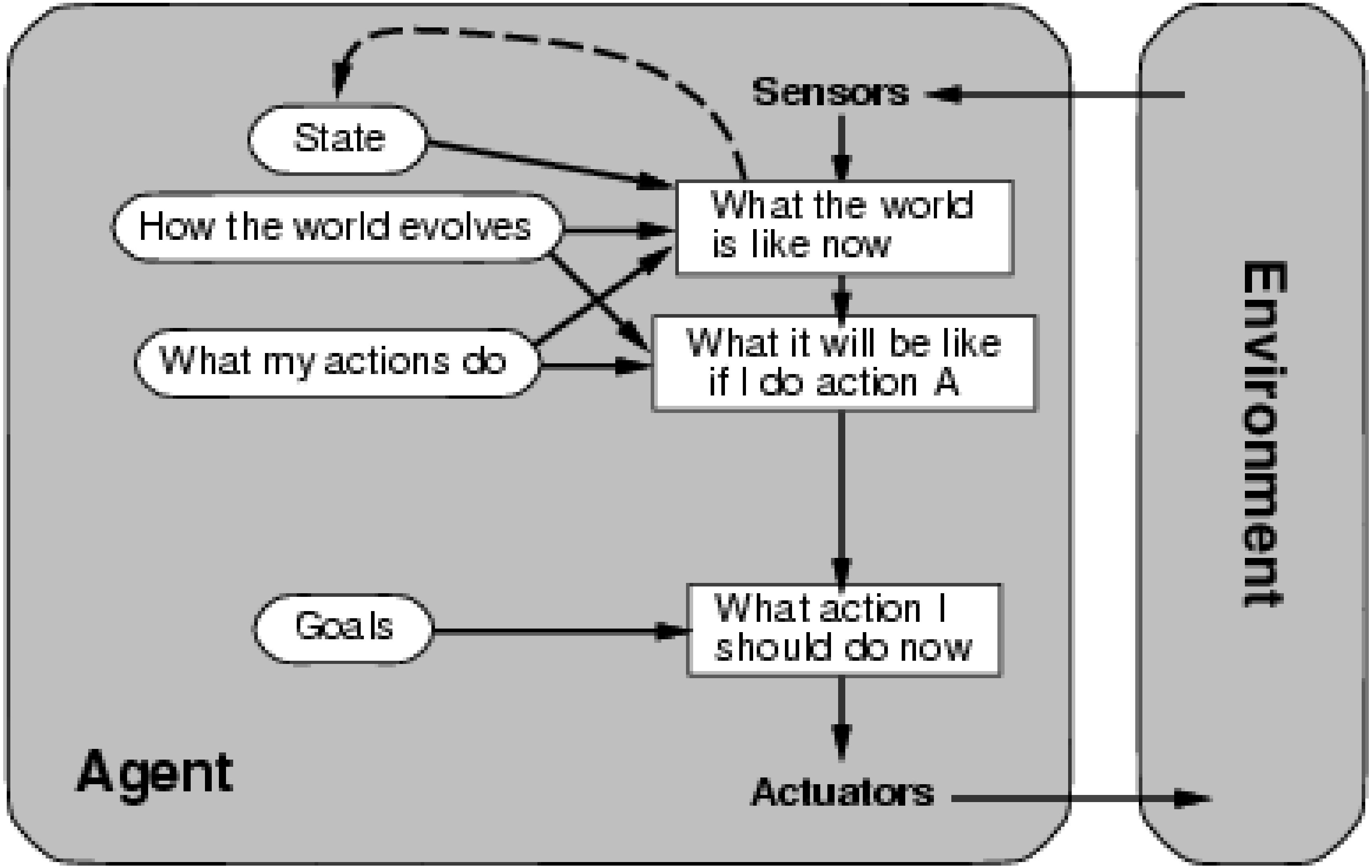
Agents :: Model-based Reflex Agents

- ❖ These agents have the model, "which is knowledge of the world" and based on the model they perform actions.
- ❖ Updating the agent state requires information about:
  - ➢ How the world evolves
  - ➢ How the agent's action affects the world.
- ❖ The above said state information is implemented in simple Boolean circuits or in complete scientific theories called transition model of the world
- ❖ An agent that uses such a model is called a model-based agent

Agents :: Goal-based Agents

- Goal information guides agent’s actions (looks to the future)
- Sometimes achieving goal is simple eg. from a single action
- Other times, goal requires reasoning about long sequences of actions
- Flexible: simply reprogram the agent by changing goals
- The knowledge of the current state environment is not always sufficient to decide for an agent to what to do.
- The agent needs to know its goal which describes desirable situations.
- Goal-based agents expand the capabilities of the model-based agent by having the "goal" information.
- They choose an action, so that they can achieve the goal.
- These agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not. Such considerations of different scenario are called searching and planning, which makes an agent proactive.

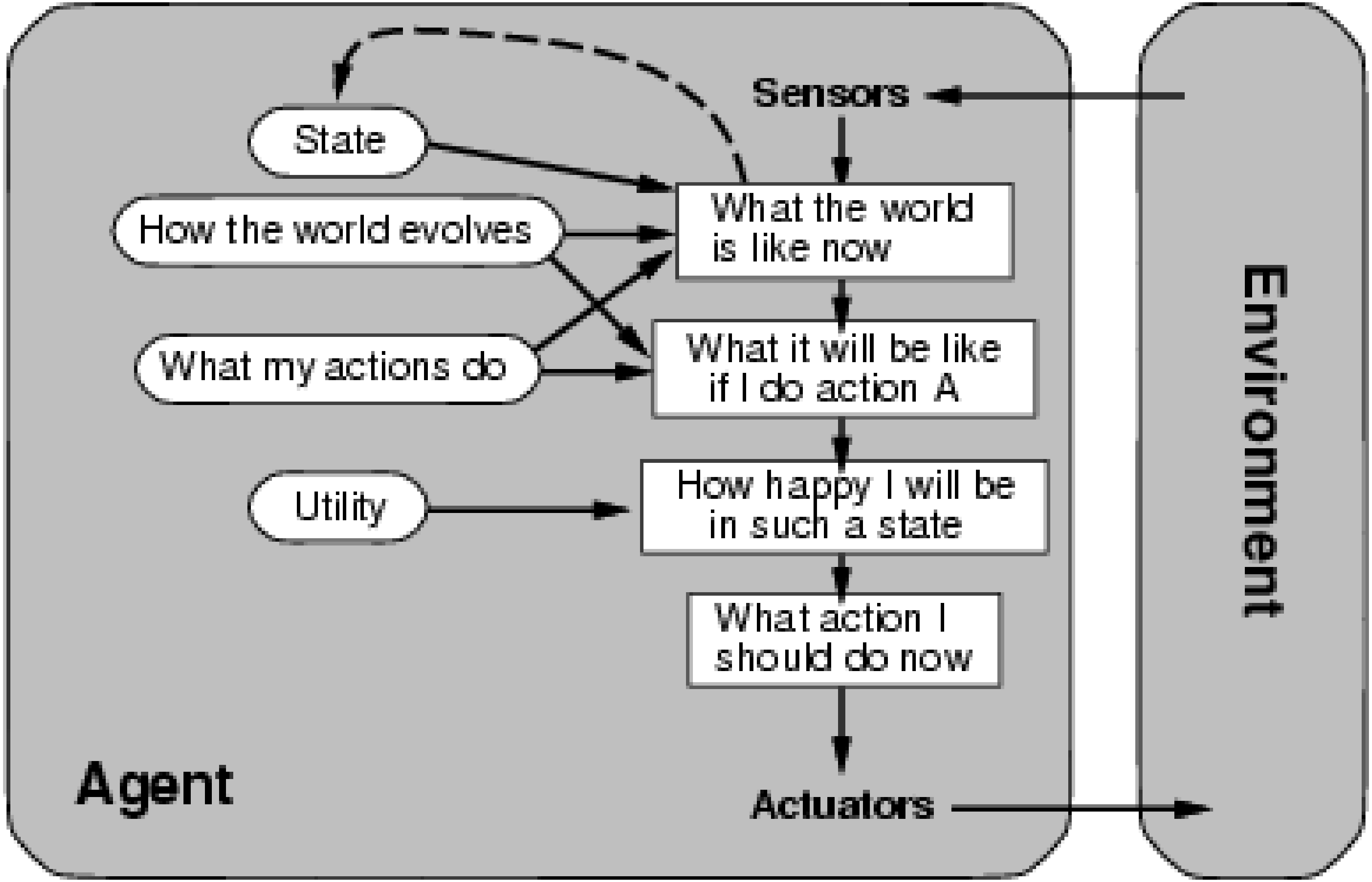
Agents :: Goal-based Agents



Agents :: Utility-based Agents

- What if there are many paths to the goal?
- Utility measures which states are preferable to other state
- Maps state to real number (utility or “happiness”)
- These agents are similar to the goal-based agent but provide an extra component of utility measurement which makes them different by providing a measure of success at a given state.
- Utility-based agent act based not only goals but also the best way to achieve the goal.
- The Utility-based agent is useful when there are multiple possible alternatives, and an agent has to choose in order to perform the best action.
- The utility function is essentially an internationalization of the performance measures. It maps each state to a real number to check how efficiently each action achieves the goals.

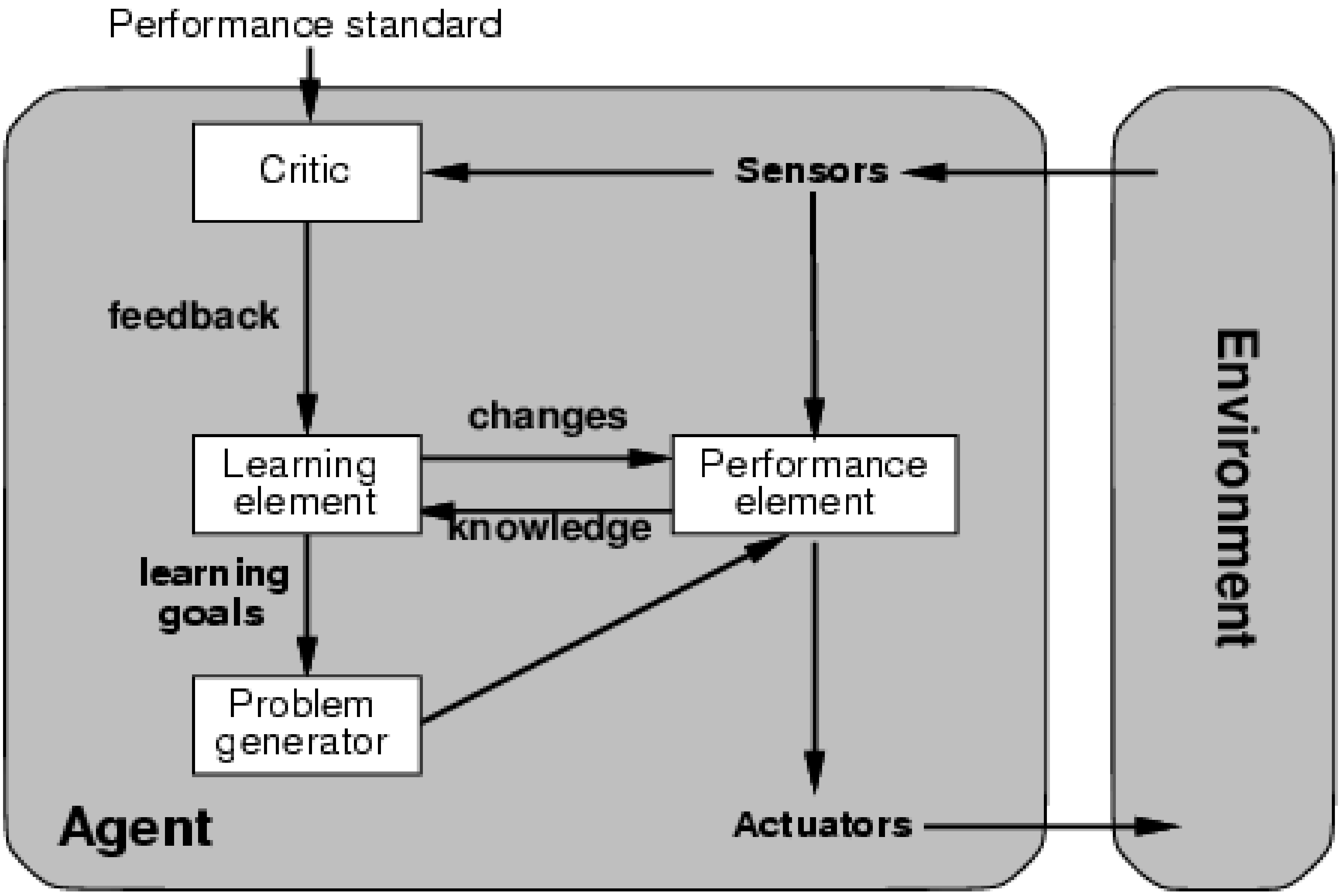
Agents :: Utility-based Agents



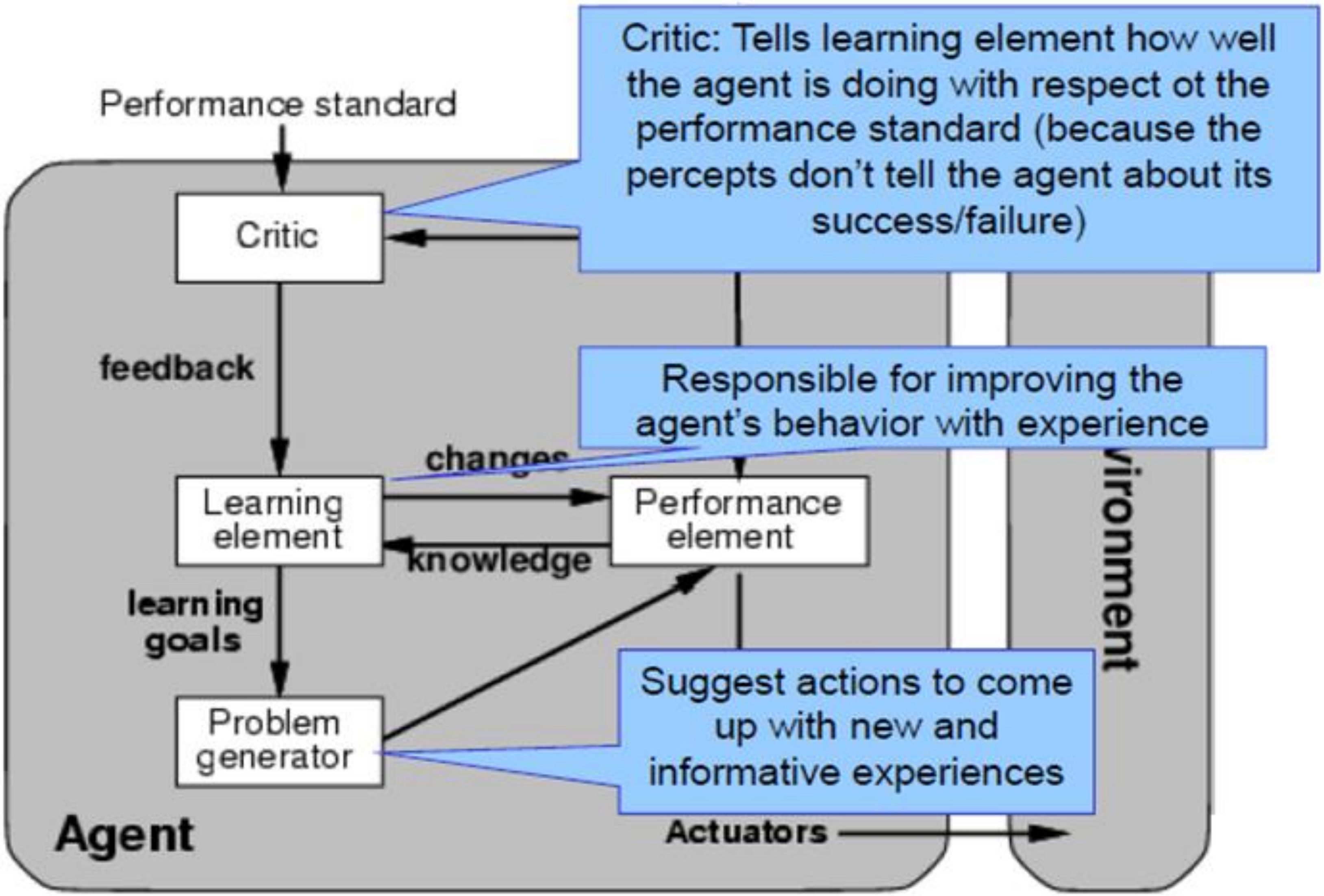
Agents :: Learning-based Agents

- A learning agent in AI is the type of agent which can learn from its past experiences, or it has learning capabilities.
- It starts to act with basic knowledge and then able to act and adapt automatically through learning.
- A learning agent has mainly four conceptual components, which are:
  - Learning element: It is responsible for making improvements by learning from environment
  - Critic: Learning element takes feedback from critic which describes that how well the agent is doing with respect to a fixed performance standard.
  - Performance element: It is responsible for selecting external action
  - Problem generator: This component is responsible for suggesting actions that will lead to new and informative experiences.

Agents :: Learning-based Agents



Agents :: Learning-based Agents



Agents :: Learning-based Agents

- Hence, learning agents are able to learn, analyze performance, and look for new ways to improve the performance.
- For example, suppose the taxi driving agent receives no tips from passengers who have been thoroughly shaken up during the trip.
- Hence, the external performance standard must inform the agent that loss of tips is a negative contribution to its overall performance; then the agent might be able to learn that violent maneuvers do not contribute to its own utility.

Disclaimer

The material for the presentation has been compiled from various sources such as prescribed text books by Russell and Norvig and other tutorials and lecture notes. The information contained in this lecture/ presentation is for educational purpose only.

Thank You *for* Your Attention !