Artificial Intelligence & Soft Computing

CSC 703

Subject In-charge

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Chapter 1

Introduction to Artificial Intelligence & Soft Computing techniques

Based on CO1: Identify the various characteristics of Artificial Intelligence and Soft Computing techniques.

Outline of AI

- Introduction & Definition of AI
- Intelligent Systems
  - Agents & Environments,
  - Rationality,
  - Nature of Environment,
  - Structure of Agent,
  - Types of Agent.

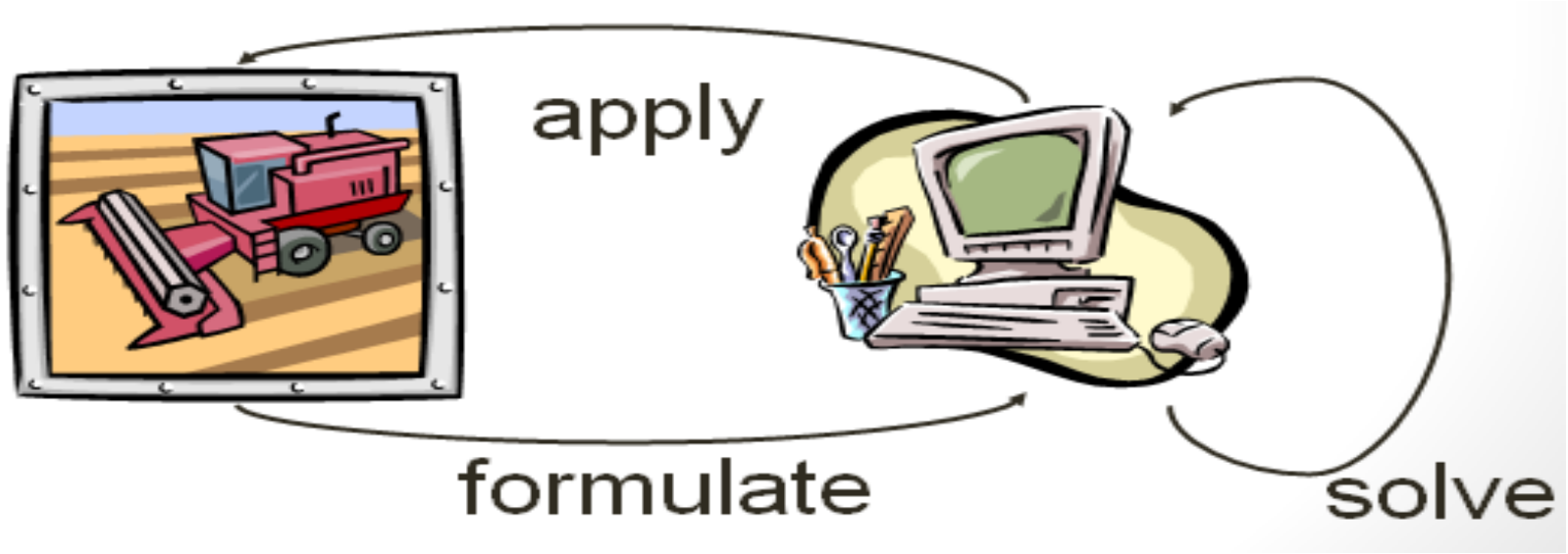
Outline of SC

- Soft Computing:
  - Introduction of soft computing,
  - Soft computing vs. Hard computing,
  - Types of soft computing techniques

Introduction to AI

Introduction to AI

- Computers making decisions in real-world problems
- A.I. is the study of how to make computers do things at which, at the moment, people are better.



Activity Time

- What is AI, How could you define it:
- **Use the below link to share your opinion by polling for the below question:**
  - https://docs.google.com/forms/d/e/1FAIpQLSf2JcQa1vTf3_acJ2WARtC6YbCthz1qPKAC7w7QuRwQbey89A/viewform

Definition of Artificial Intelligence

- 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 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* ?

Defining AI W.r.t to 4 Sub Domain?

	HUMAN	RATIONAL
THOUGHT	Systems that think like humans	Systems that think rationally
BEHAVIOUR	Systems that act like humans	Systems that act rationally

1. Systems that act like humans: Turing test

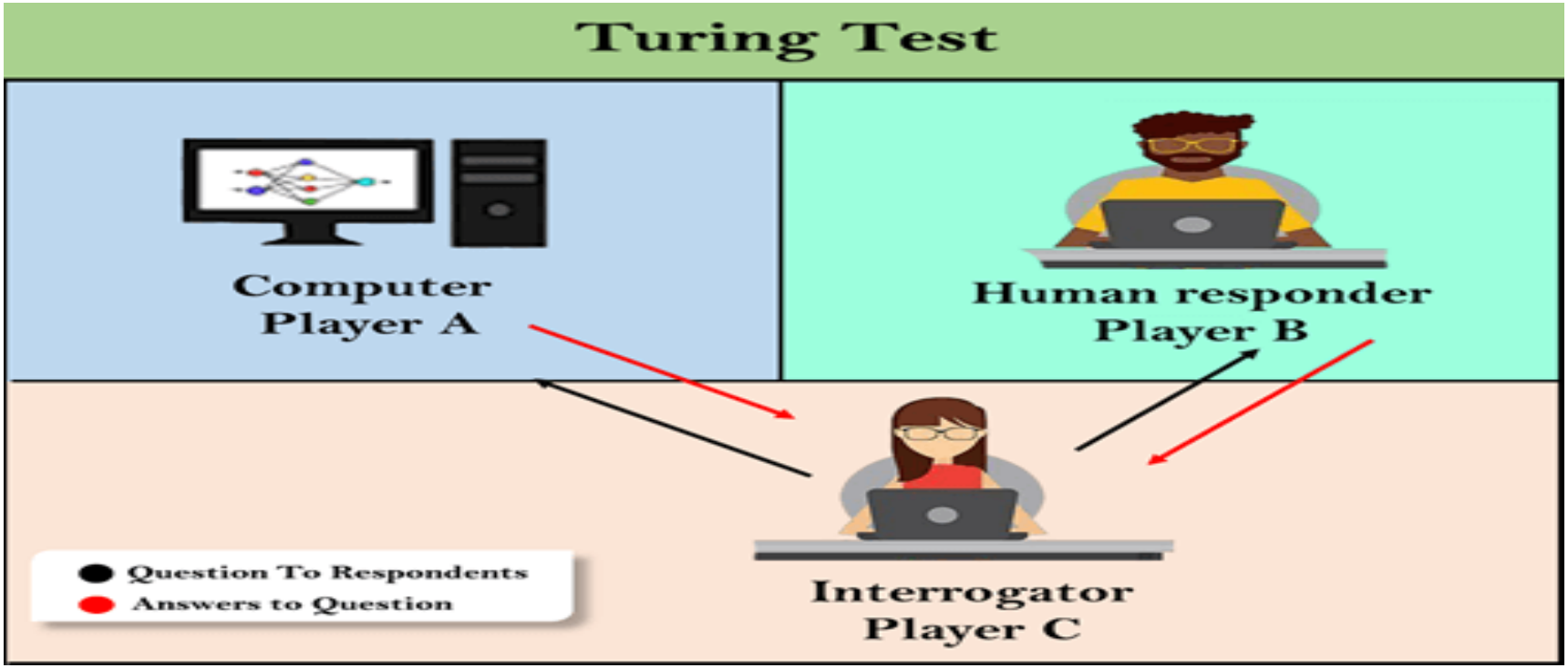
- *Definition of AI W.r.t Human and its behaviour:*
  - *"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight)*
  - *One such study that focuses on Human and its behaviour is Turing test*

Mumbai University Asked Question: Explain Turing Test Designed for satisfactory operational definition of Intelligence (5 marks)

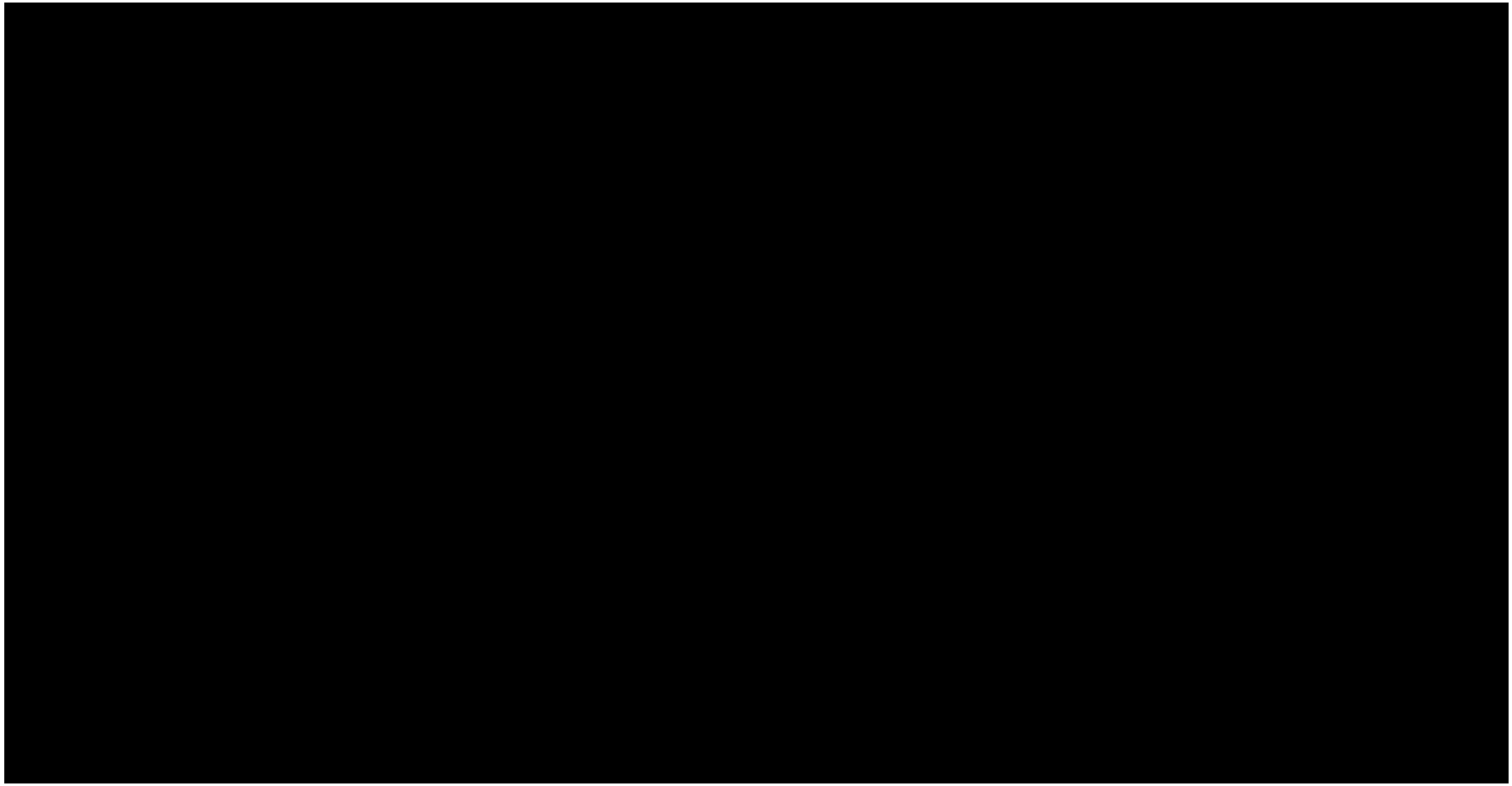
Turing Test Approach (MUQ)

The Turing Test approach (designed by Alan Turing)

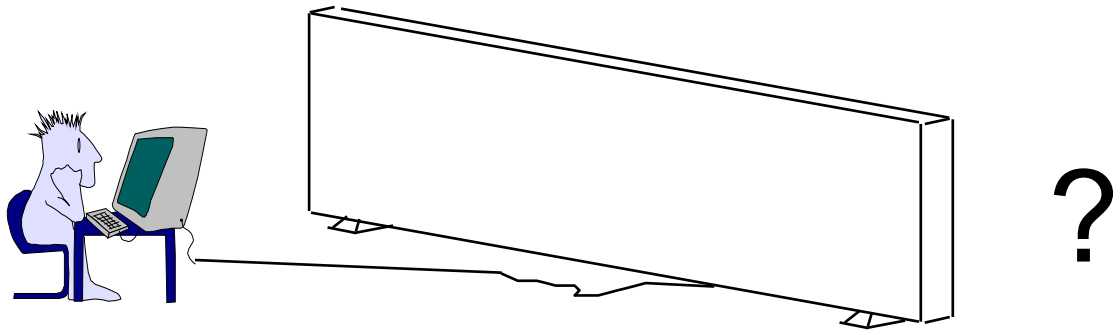
- a human questioner cannot tell if there is a computer or a human answering his question, via teletype (remote communication). The computer must behave intelligently



Turing test: (Video Explanation)



1. Systems that act like humans: Turing Test



- ***What is the Turing test intended to establish?***
  - Whether a particular entity can exhibit intelligent behavior
    - True or False (use Chat section to reply)

1. Systems that act like humans: Common Examples

- 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

What is the Turing test intended to establish?

Lets take a poll, to see what you know:

- www.mentimeter.com , use code: 127201

What is Artificial Intelligence ?

	HUMAN	RATIONAL
THOUGHT	Systems that think like humans	Systems that think rationally
BEHAVIOUR	Systems that act like humans	Systems that act rationally

2. Systems that think like humans: cognitive modeling

- Humans as observed from 'inside'
- How do we know how humans think?
  - Introspection vs. psychological experiments
- Cognitive Science: *it is the interdisciplinary study of minds*
  - *Example:* Our ability to solve problems has to do with cognitive brain functions. If our car is broken, we can go through a checklist of things we are familiar with that might allow us to figure out what exactly is causing the problem.
- *"The exciting new effort to make computers think … machines with minds in the full and literal sense" (Haugeland)*

What is Artificial Intelligence ?

	HUMAN	RATIONAL
THOUGHT	Systems that think like humans	Systems that think rationally
BEHAVIOUR	Systems that act like humans	Systems that act rationally

3.Systems that think ‘rationally’: "laws of thought"

- **Rational behavior** refers to a decision-making process that is based on making choices that result in the optimal level of benefit or utility for an individual.
- The rational person has self-control and is unmoved by emotions and external factors and, hence, knows what is best for himself. Alas behavioral economics explains that humans are not rational and are incapable of making good decisions
- Humans are not always ‘rational’, they can be at times irrational (unpredictable)
- Logical approach is often not feasible in terms of computation time (needs ‘guidance’)
  - Sometimes logic cannot reason a correct conclusion
  - At that time, some specific (in domain) human knowledge or information is used
- *“The study of the computations that make it possible to perceive, reason, and act” (Winston)*

What is Artificial Intelligence ?

	HUMAN	RATIONAL
THOUGHT	Systems that think like humans	Systems that think rationally
BEHAVIOUR	Systems that act like humans	Systems that act rationally

4. Systems that act rationally:"Rational agent"

- *"The branch of CS that is concerned with the automation of intelligent behavior"*
- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information.

Rational agents

- An agent is an entity that perceives and acts
- This course is about designing rational agents
  - As ***LOGIC + Domain knowledge is required for doing the right thing in order to*** maximize goal achievement, given the available information.
- Abstractly, an agent is a function from percept histories to actions:

$$[f: P^* \rightarrow A]$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

4.Systems that act rationally:"Rational agent"

- **Study AI as Rational Agent –**
- **<u>2 Advantages:</u>**
  - It is more general than using logic only
    - ***Because: LOGIC + Domain knowledge is required***
  - It allows extension of the approach with more scientific methodologies

Activity Time: Match the following

- **Use the below link to take up the activity:**
- https://docs.google.com/forms/d/e/1FAIpQLSdmKpYpSvpQTFrkDmKyR6-EMZbS5pmj131GB4cq4ZL3Bf7XvQ/viewform

Activity Result: Match the following

	System that act like human	System that think like human	System that think rationally	System that act Rationally
The branch of CS that is concerned with the automation of intelligent behavior	○	○	○	◉
The exciting new effort to make computers think ... machines with minds in the full and literal sense	○	◉	○	○
The study of how to make computers do things at which, at the moment, people are better	◉	○	○	○
The study of the computations that make it possible to perceive, reason, and act	○	○	◉	○

Activity Result: Match the following

Match the domains *

	Human & Behavior	Rational & Thought	Human & Thought	Rational & Behavior
System that think like human	○	○	◉	○
System that act like human	◉	○	○	○
System that think rationally	○	◉	○	○
System that act rationally	○	○	○	◉

What is Artificial Intelligence?-(Summary)

- **Systems that think like humans**
  - **Cognitive Modeling Approach**
  - *"The exciting new effort to make computers think … machines with minds in the full and literal sense" (Haugeland)*
- **Systems that act like humans**
  - **Turing Test Approach**
  - *"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight)*

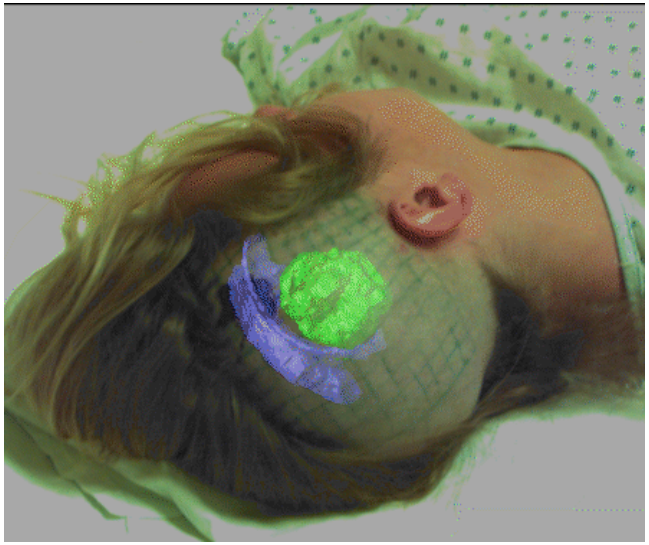
- **Systems that think rationally**
  - **"Laws of Thought" approach**
  - *"The study of the computations that make it possible to perceive, reason, and act" (Winston)*
- **Systems that act rationally**
  - **Rational Agent Approach**
  - *"The branch of CS that is concerned with the automation of intelligent behavior"*

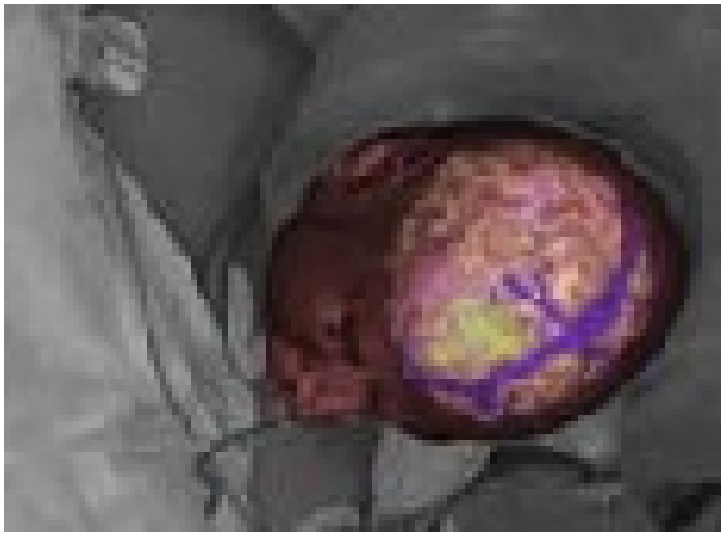
AI Applications

- AI techniques are used in many common applications, to list a few are following applications:
  - Intelligent user interfaces
  - Search Engines
  - Spell/grammar checkers
  - Context sensitive help systems
  - Medical diagnosis systems
  - Regulating/Controlling hardware devices and processes (e.g, in automobiles)
  - Voice/image recognition (more generally, pattern recognition)
  - Scheduling systems (airlines, hotels, manufacturing)
  - Error detection/correction in electronic communication
  - Program verification / compiler and programming language design
  - Web search engines / Web spiders
  - Web personalization and Recommender systems (collaborative/content filtering)
  - Personal agents
  - Customer relationship management
  - Credit card verification in e-commerce / fraud detection
  - Data mining and knowledge discovery in databases
  - Computer games

Current Trends

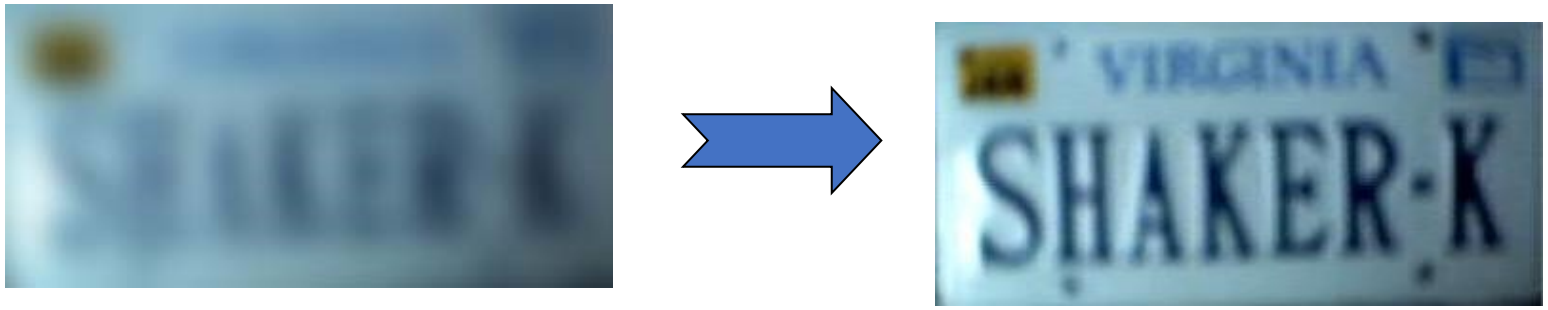
- **Medicine**:
  - Image guided surgery

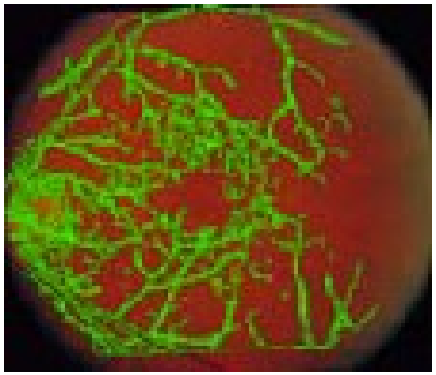


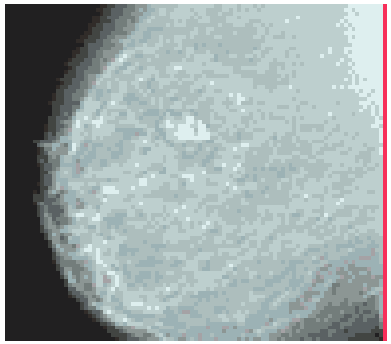


Current Trends

- **Medicine**:
  - Image analysis and enhancement





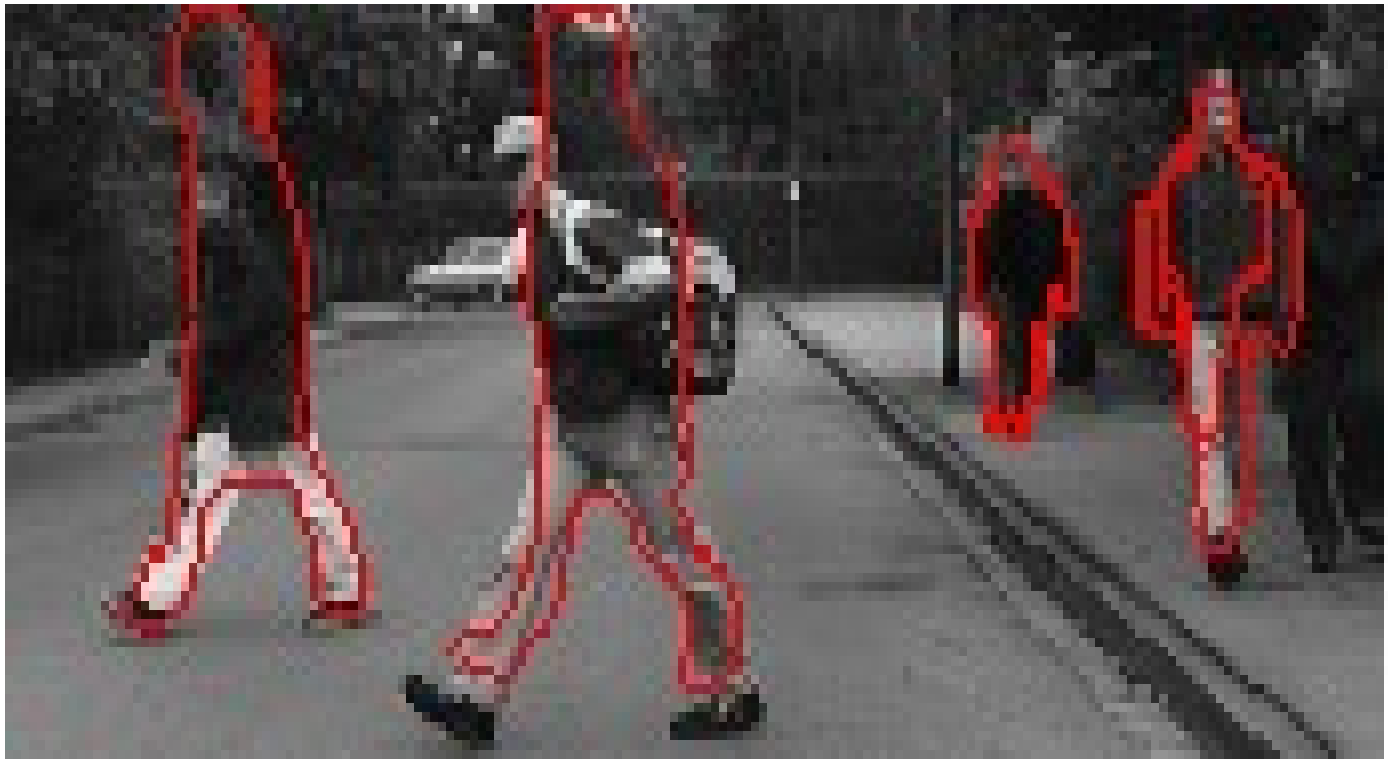


Current Trends

- **Transportation**:
  - **Autonomous vehicle control:**

Current Trends

- **Transportation**:
  - **Pedestrian detection:**

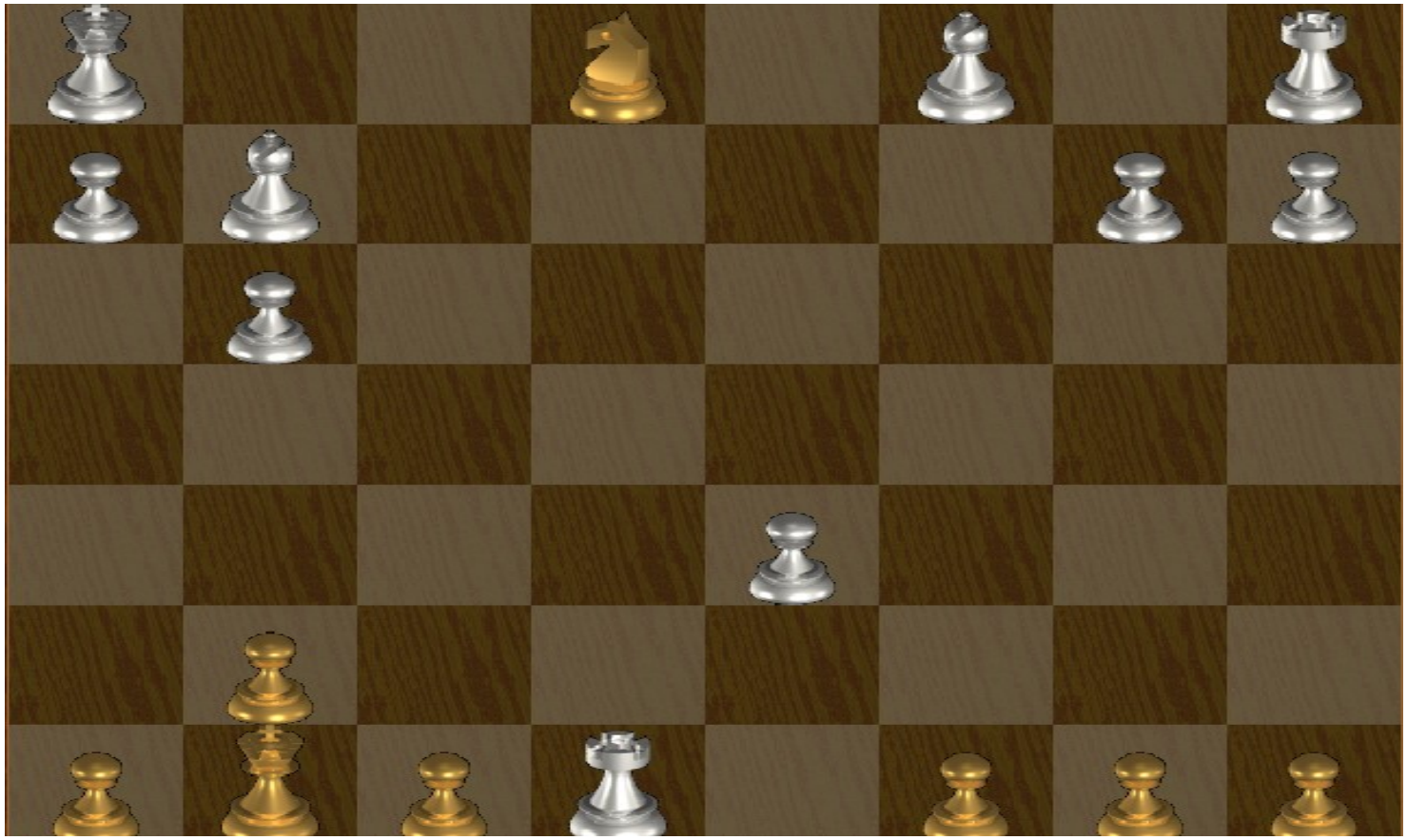


Current Trends

Games:

Current Trends

- **Games**:



Current Trends

- **Robotic toys**:

Outline of AI

- Introduction & Definition of AI
- Intelligent Systems
  - Agents & Environments,
  - Rationality,
  - Nature of Environment- PEAS (Performance measure, Environment, Actuators, Sensors)
  - Structure of Agent,
  - Types of Agent.

What is an intelligent system?

- **What is intelligence?**
  - A truly intelligent system adapts itself to deal with changes in problems (automatic learning)
  - Few machines can do that at present

- **There are two types of Intelligence:**

1. **Machine intelligence:** has a computer, follow problem solving processes something like that in humans
2. **Intelligent systems:** display machine-level intelligence, reasoning, often learning, not necessarily self-adapting

Categorization of Intelligent Systems: based on IS in Your Everyday Life

- **Post Office**
  - automatic address recognition and sorting of mail
- **Banks**
  - automatic check readers, signature verification systems
  - automated loan application classification
- **Telephone Companies**
  - automatic voice recognition for directory inquiries
  - automatic fraud detection,
  - classification of phone numbers into groups
- **Credit Card Companies**
  - automated fraud detection, automated screening of applications
- **Computer Companies**
  - automated diagnosis for help-desk applications

What build an intelligent system?

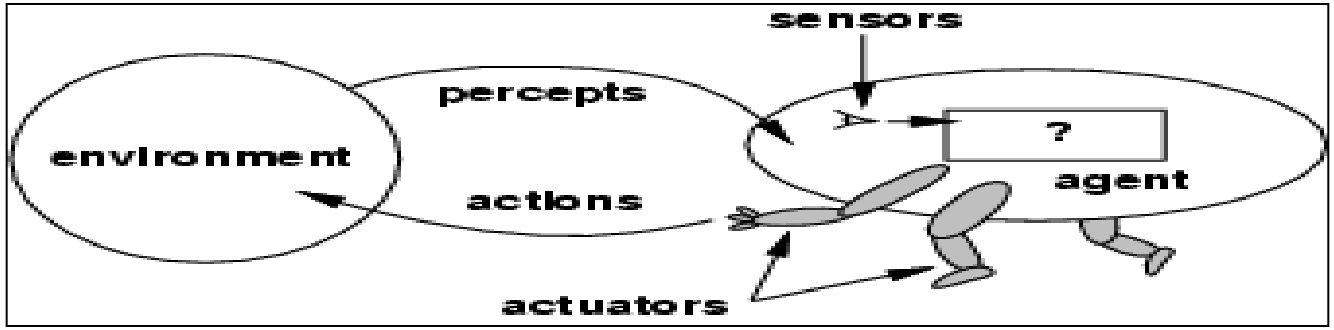
Lets take a poll, to see what you know:

- www.mentimeter.com , use code: 144346

Agents & Environments

Agents

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



- **Example:** **1.Human agent**
  - Sensors: eyes, ears, and other organs;
  - actuators : hands, legs, mouth, and other body parts.
- **Example:** **2.Robotic agent**
  - Sensors: cameras and infrared range finders
  - actuators : various motors.

Agents

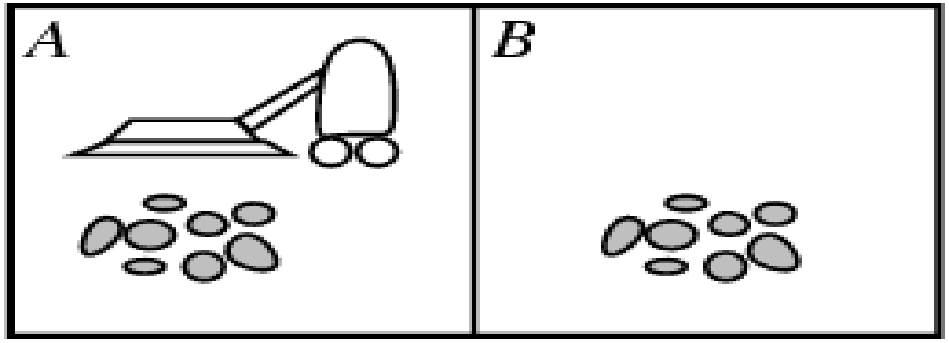
- Mathematically, agent's behavior is described by the **Agent function,** that maps any given sequence to an action.

$$[f: P^* \rightarrow A]$$

- Internally, the Agent function for an artificial agent will be implemented by an **Agent Program.**
- The agent program runs on the physical architecture to produce *f*

Agent = architecture + program

Example: Vacuum-cleaner world with just two locations



- Percepts: location and contents, e.g., [A, Dirty]
- Actions: *Left*, *Right*, *Suck*, *No Operation*
- **One very simple agent function is the following:**
  - If the current square is dirty, then Suck, otherwise move to the other Square.

Simple Agent function for the vacuum-cleaner world

Percept Sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, 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

If agent randomly choose its action, then we would have to try each sequence many times to identify the probability of each action. One ,might imagine that acting randomly is rather silly, but we will see this that it can be very intelligent later in this chapter..

Concept of Rationality

1. Define Rationality and Rational Agent. Give an example of Rational Action performed by an Intelligent Agent. 5marks
2. Define Rational Agent. Explain task set properties of Environment. 8 Marks

Rational agents: Concept of Rationality

- Rationality is distinct from omniscience (all-knowing with infinite knowledge)
- **Agents can perform actions** in order to modify future percepts so as to obtain useful information (information gathering, exploration)
- **An agent is autonomous/independent** if its behavior is determined by its own experience (with ability to learn and adapt)
- 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.

Rational agents: Concept of Rationality

- **Rational Agent:** 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.

- **Performance measure:** An objective criterion for success of an agent's behavior.
  - E.g., 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.

What is rational at any given time depends on 4 things:

- The Performance measure that defines the criterion of Success.
- Prior knowledge of the environment
- The actions The agent's that the agent can perform
- The agent's percept sequence to date.

Agent functions and programs

- The job of AI is to design the Agent Program that implements the agent function mapping percepts to actions.
- One agent function (or a small equivalence class) is **Rational.**
- **Aim:** Find a way to implement the Rational Agent Function concisely.
- Table driven agent program is invoked for each new percept & returns an action each time. It keeps track of the percept sequence using its own private data structure.

function TABLE-DRIVEN-AGENT (*percept*) **returns** an action
Static: *percepts*, a sequence, initially empty
table, a table of actions, indexed by percept sequences, initially fully specified

append *percept* to the end of *percepts*
action <- LOOKUP *(percepts, table)*
return *action*

Agent Program for a Simple Reflex Agent in 2 State Vacuum Environment

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

Know about Agents:

Please write your answer in the google form link:

https://docs.google.com/forms/d/e/1FAIpQLScijDNjKvLWCfIZA0Pl-z7nNw0N-RZvOQsCcP_0g-TX2Q_eHg/viewform

Nature of Environment

1. Give PEAS for Internet Shopping Agent. Characterize its Environment. (Dec 2015) (5 Marks)
2. Give PEAS for Robot Soccer Player. Characterize its Environment. (May 2016) (5 Marks)
3. What are PEAS Descriptor? Give PEAS descriptor for Robot meant for Cleaning the house. (Dec 2016) (5 Marks)

PEAS

What are PEAS description? Give PEAS description for part Picking Robot? **(5) June 2011**

- PEAS: Performance measure, Environment, Actuators, Sensors
- Must first specify the setting for intelligent agent design.
- Consider, E.g., the Task of designing an automated taxi driver:
  - **Performance measure:** Safe, fast, legal, comfortable trip, maximize profits (used to evaluate how well an agent solves the task at hand)
  - **Environment:** Roads, other traffic, pedestrians, customers, signal (surroundings beyond the control of the agent)
  - **Actuators:** Steering wheel, accelerator, brake, horn (determine the actions the agent can perform)
  - **Sensors:** Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard (provide information about the current state of the environment)

PEAS: Examples

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

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

In-class Exercise

Develop a PEAS description of the task environment for a face-recognition agent

Performance Measure	
Environment	
Actuators	
Sensors	

Lets share answer here:

www.mentimeter.com , use code: 144346

PEAS: Examples

- **Agent:** Robot Soccer Player
- **Performance measure:** Maximize goals, No Foul, Stick to Rules ,Should win
- **Environment:** Players, Referee, Ground, Ball, Cards.
- **Actuators**: Jointed arm and hand
- **Sensors**: Camera, joint angle sensors, motion controllers

Asked in May 2016(5 Marks)

- **Agent:** Home Cleaning Agent
- **Performance measure:** Fast Cleaning, Less time consuming, Less electricity consumption, Less noise generated, % of parts in correct Place, More dirt cleaned up
- **Environment:** User, Home, People, Household Objects
- **Actuators:** Jointed arm and hand
- **Sensors:** Keyboard (Text input)/Microphone (Voice Input)

Asked in Dec 2016 (5 Marks)

Give PEAS description for part Picking Robot?

1. Part Picking Robot
2. Internet Shopping

Please write your answer in the google form link:

https://docs.google.com/forms/d/e/1FAIpQLSeOtKI2gU1OhFnK1a3Nsmf30eFKdhFu6HvFWuft80KxS94TQA/viewform

PEAS: Activity-Answer

- **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

Asked in May 2013, June 2011, Dec 2016

- **Agent:** Internet Shopping Agent
- **Performance measure:** Maximize Profit, Best Offers, User-friendly interface, Fast Response, Less time consuming
- **Environment:** Customers
- **Actuators:** Screen display (Suggestions, Search's)
- **Sensors:** Keyboard

Asked in Dec 2015 (5 Marks)

Set Environment Types

1. Explain task set properties of Environment. (08) Dec 2011
2. Write short note on Agent Environments. (10) June 2011

Environment Types

Write short note on Agent Environments.
(10) June 2011

1. Fully observable (vs. Partially Observable): An agent's sensors give it access to the complete state of the environment at each point in time.
2. Deterministic (vs. Stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic)
3. Episodic (vs. Sequential): 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 Sequential Current decision affect all future decisions.
4. Static (vs. Dynamic): The environment is unchanged while an agent is deliberating. (The environment is semidynamic if the environment itself does not change with the passage of time but the agent's performance score does)
5. Discrete (vs. Continuous): A limited number of distinct, clearly defined percepts and actions.
6. Single agent (vs. Multi Agent): An agent operating by itself in an environment.

Properties of Environments

Fully observable: can access complete state of environment at each point in time	vs	Partially observable: could be due to noisy, inaccurate or incomplete sensor data
Deterministic: if next state of the environment completely determined by current state and agent's action	vs	Stochastic: a partially observable environment can appear to be stochastic. (**Strategic**: environment is deterministic except for actions of other agents)
Episodic: agent's experience divided into independent, atomic episodes in which agent perceives and performs a single action in each episode.	Vs	Sequential: current decision affects all future decisions
Static: agent doesn't need to keep sensing while decides what action to take, doesn't need to worry about time	vs	Dynamic: environment changes while agent is thinking (**Semidynamic**: environment doesn't change with time but agent's performance does)
Discrete: (note: discrete/continuous distinction applies to states, time, percepts, or actions)	vs	Continuous
Single agent	vs	Multiagent: agents affect each others performance measure – cooperative or competitive

What you know about PEAS & Environment

Please take a quiz in the google form link:
https://docs.google.com/forms/d/e/1FAIpQLSeQNm1Np9NmdOB3v2jZHvIxKDIIBXzHaoGOYhSvAs-gHjWjHA/viewform

Environment Types Examples

Type of Environment	Chess with a clock	Chess without a clock	Part Picking Robot	Interactive English Teacher
Fully observable	Full	Full	Partial	Partial
Deterministic	Strategic	Strategic	Stochastic	Stochastic
Episodic	Sequential	Sequential	Episodic	Sequential
Static	Semi-Dynamic	Semi-Dynamic	Dynamic	Dynamic
Discrete	Discrete	Discrete	Continuously	Discrete
Single agent	Multi	Multi	Single	Multi

Activity Time:

- Give Environment types for
  - Medical Diagnosis
  - Crossword
  - Taxi driving

- Please write your answer in the google form link:
- https://docs.google.com/forms/d/e/1FAIpQLSehxrA4eY6lpUZlCI16wq7YhhQ-TBFuhbOkeTxs9Gx-eY0OPw/viewform

Activity Time:

Type of Environment	Medical Diagnosis	Taxi driving	Crossword
Fully observable	Partial	Partial	Full
Deterministic	Stochastic	Stochastic	Deterministic
Episodic	Sequential	Sequential	Sequential
Static	Dynamic	Dynamic	Static
Discrete	Continuous	Continuously	Discrete
Single agent	Multi	Multi	Single

Examples of task environments

Task Environment	Observable	Deterministic	Episodic	Static	Discrete	Agents
Crossword puzzle	Fully	Deterministic	Sequential	Static	Discrete	Single
Chess with a clock	Fully	Strategic	Sequential	Semi	Discrete	Multi
Poker	Partially	Stochastic	Sequential	Static	Discrete	Multi
Backgammon	Fully	Stochastic	Sequential	Static	Discrete	Multi
Taxi driving	Partially	Stochastic	Sequential	Dynamic	Continuous	Multi
Medical diagnosis	Partially	Stochastic	Sequential	Dynamic	Continuous	Multi
Image analysis	Fully	Deterministic	Episodic	Semi	Continuous	Single
Part-picking robot	Partially	Stochastic	Episodic	Semi	Continuous	Single
Refinery controller	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Interactive English tutor	Partially	Stochastic	Sequential	Dynamic	Discrete	Multi

Structure and Types of Agents

1. Explain Goal based agent & Utility based Agent with Diagram. State difference between them. (Dec 2011) (8 marks)
2. Draw and describe architecture of Goal based Agent (Dec 2016) (06 marks)

Agents is made up of:

What are the composition for agents in artificial intelligence?

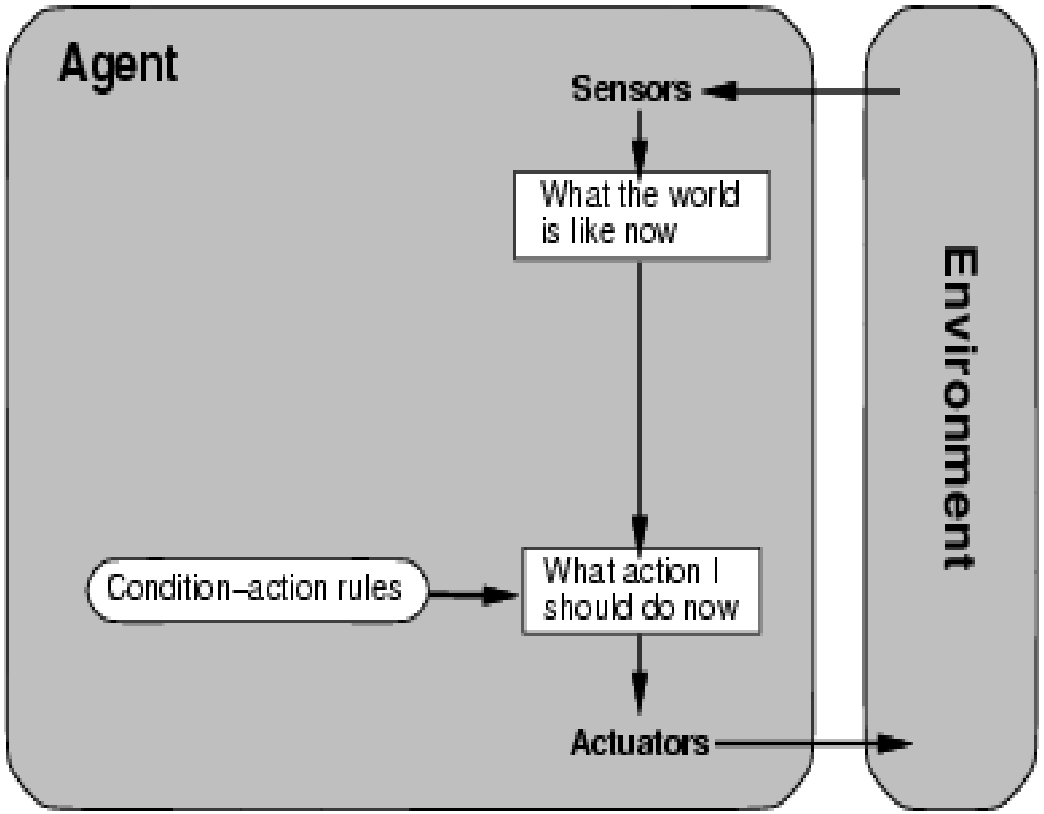
a. Program
b. Architecture
c. Both Program & Architecture

Agent types

- Five basic types in order of increasing generality:
  1. Simple reflex agents
  2. Model-based reflex agents
  3. Goal-based agents
  4. Utility-based agents
  5. Learning Agents

Simple reflex agents

- The Simplest kind of agent is the **Simplex reflex agent**.
- These agents select actions on the basis of the *current percept*, ignoring the rest of the percept history.
- **Example: Vacuum agent** is a simple reflex agent, because its decision is based only on the current location and on whether that contains dirt.



They have the admirable property of being very simple, but they turn out to be of very limited intelligence. The agent will work *only if the correct decision can be made on the basis of only the current percept- that is only if the environment is fully observable.*

Simple Reflex Agent

- Simple reflex agents act only on the basis of the current percept, ignoring the rest of the percept history. The agent function is based on the *condition-action rule*: if condition then action.
- This agent function only succeeds when the environment is fully observable. Some reflex agents can also contain information on their current state which allows them to disregard conditions whose actuators are already triggered.
- Infinite loops are often unavoidable for simple reflex agents operating in partially observable environments. Note: If the agent can randomize its actions, it may be possible to escape from infinite loops.

Simple reflex agents

function SIMPLE-REFLEX-AGENT (*percept*) **returns** an action

Static: *rules, a set of condition-action rules*

state ← *INTERPRET-INPUT (percept)*

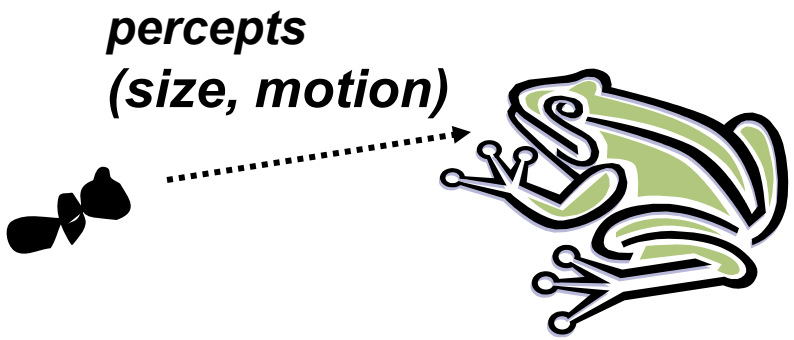
rule ← *RULE-MATCH(state, rules)*

action ← *RULE-ACTION [rule]*

return *action*

It acts according to a rule whose condition matches the current state , as defined by the percept.

A Simple Reflex Agent in Nature



RULES:

(1) If small moving object,
then activate SNAP

(2) If large moving object,
then activate AVOID and inhibit SNAP

ELSE (not moving) then NOOP

needed for completeness

Action: SNAP or AVOID or NOOP

Know about Simple reflex Agent:

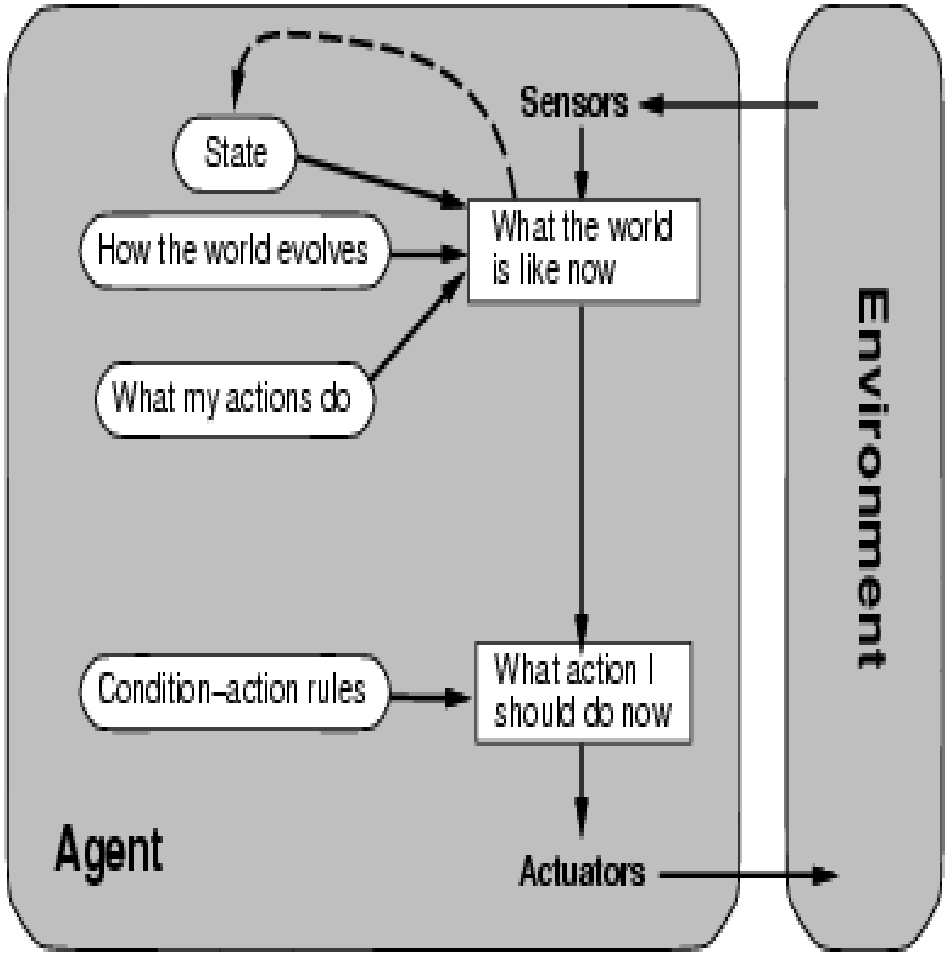
1. **What is a simple reflex agent?**
   - A program that can adapt to its environment.
   - A program that predicts future behaviors and acts.
   - A program that aligns itself to changing goals.
   - A program that acts based on its current environment.

2. **How does the "condition-action rule" work with a simple reflex agent?**
   - When rules are established, they are based on actions.
   - When a condition is met, the agent overrides certain rules.
   - When a condition is met, the agent acts based on the rule.
   - Conditions mean nothing and rules are made to be broken.

Model-based reflex agents

- For the world that is *partially observable*
  - the agent has to keep track of an internal state
    - ✓ That depends on the percept history
    - ✓ Reflecting some of the unobserved aspects

    E.g., driving a car and changing lane
- Requiring two types of knowledge
  - ***How the world evolves independently of the agent***
  - ***How the agent's actions affect the world***
  - This knowledge about **"how the world works"** is called a model of the world, hence the name **"model-based agent"**.



Explain structure of agent that keeps track of the world. **(5) Dec 2010**

Model-based reflex agents

- A model-based agent can handle partially observable environments.
- Its current state is stored inside the agent maintaining some kind of structure which describes the part of the world which cannot be seen.
- This knowledge about "how the world works" is called a model of the world, hence the name "model-based agent".
- A model-based reflex agent should maintain some sort of internal model that depends on the percept history and thereby reflects at least some of the unobserved aspects of the current state.
- ***Percept history and impact of action on the environment can be determined by using internal model. It then chooses an action in the same way as reflex agent.***

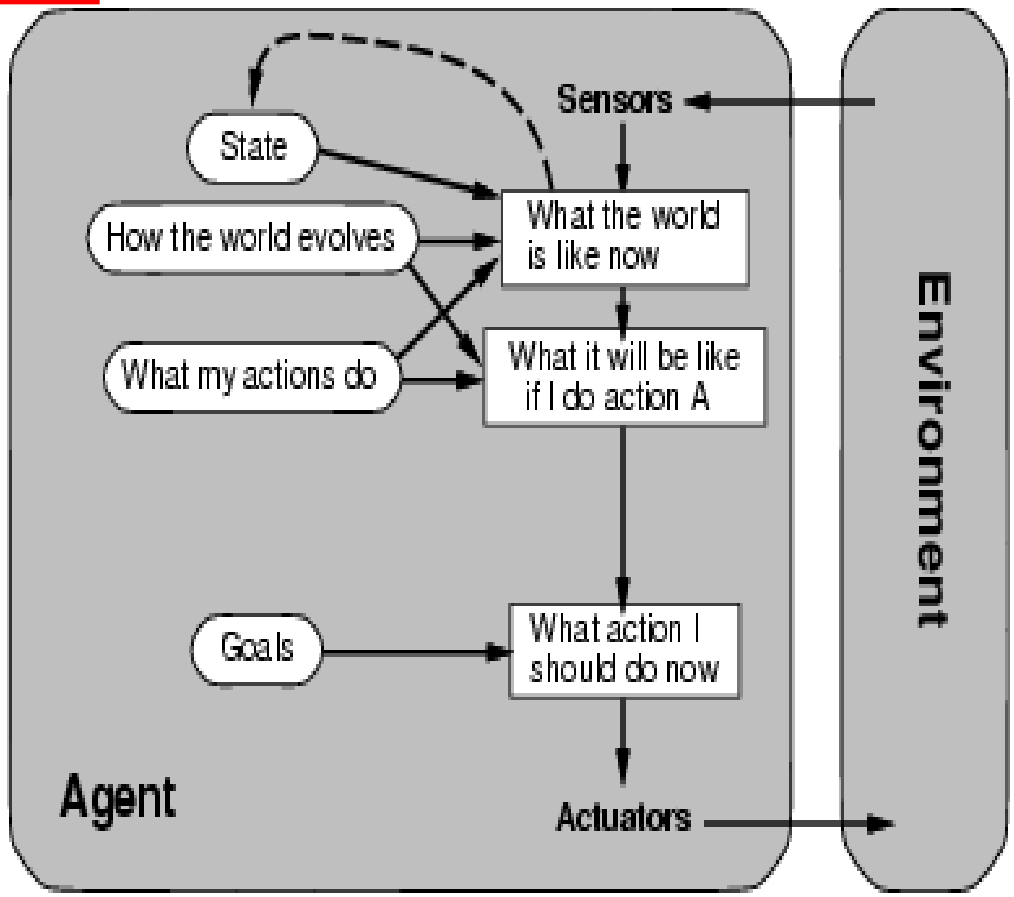
Model-based reflex agents

```
function REFLEX-AGENT-WITH-STATE(percept) returns action
    static: state, a description of the current world state
            rules, a set of condition-action rules

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

Goal-based agents

- Knowing state and environment is sometimes not Enough.
  - ✓ Taxi can go left, right, straight
- Have a goal
  - ✓ A destination to get to
- Goal-based agents further expand on the capabilities of the model-based agents, by using "goal" information.



Model based agent will drive the car based on internal model. But Goal based agent will drive the car in order to reach the goal.

Goal-based agents

- Goal-based agents further expand on the capabilities of the model-based agents, by using "goal" information.
- Goal information describes situations that are desirable. This allows the agent a way to choose among multiple possibilities, selecting the one which reaches a goal state.
- Search and planning are the subfields of artificial intelligence devoted to finding action sequences that achieve the agent's goals.

Know about Agent:

1. **Which of the following does not represent a Goal based agent?**

a) Reaching the goal in minimal amount of time

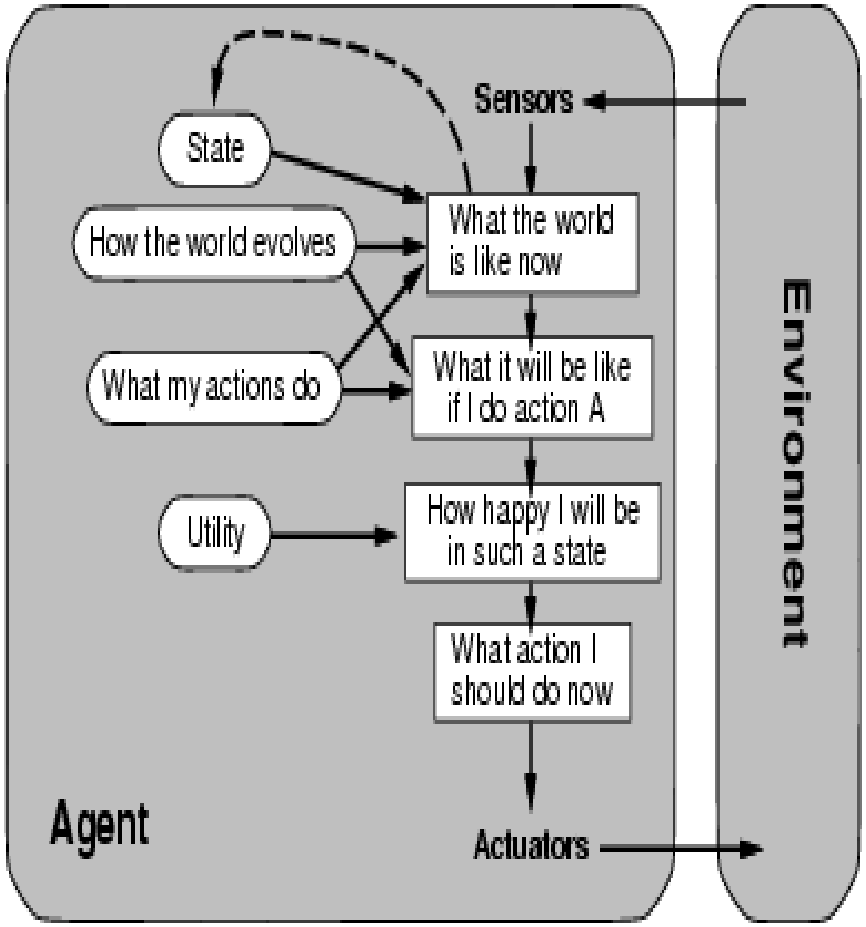
b) Reaching the goal in minimal cost

c) Reaching the initial state again after reaching the goal state

d) None of the above

Utility-based agents

- **Goals alone are not enough**
  - to generate **high-quality** behavior
  - E.g. meals in Canteen, good or not ?
- **Many action sequences → the goals**
  - some are better and some worse
  - If ***goal means success***,
  - then **utility** means the ***degree of success*** (how successful it is)
- **It is said state A has higher utility**
  - If state A is more preferred than others
- **Utility is therefore a function**
  - that maps a state onto a real number
  - the degree of success



Explain Utility based Agent with neat Diagram. **(8) Dec 2011**

Utility-based agents

- Goal-based agents only distinguish between goal states and non-goal states.
- It is possible to define a measure of how desirable a particular state is. This measure can be obtained through the use of a utility function which maps a state to a measure of the utility of the state.
- A more general performance measure should allow a comparison of different world states according to exactly how happy they would make the agent. The term utility can be used to describe how "happy" the agent is.

Know about Agent:

1. **State whether the following condition is true or false?** "A simple reflex based agent does not care about meeting the utility of the user."

2. **Which of the mentioned properties of the Utility-based AI agent differentiates it from the rest of the AI agents?**
   a) Responding and providing solution to the problem
   b) Meeting the preference of the user
   c) Meeting the goal
   d) All of the above

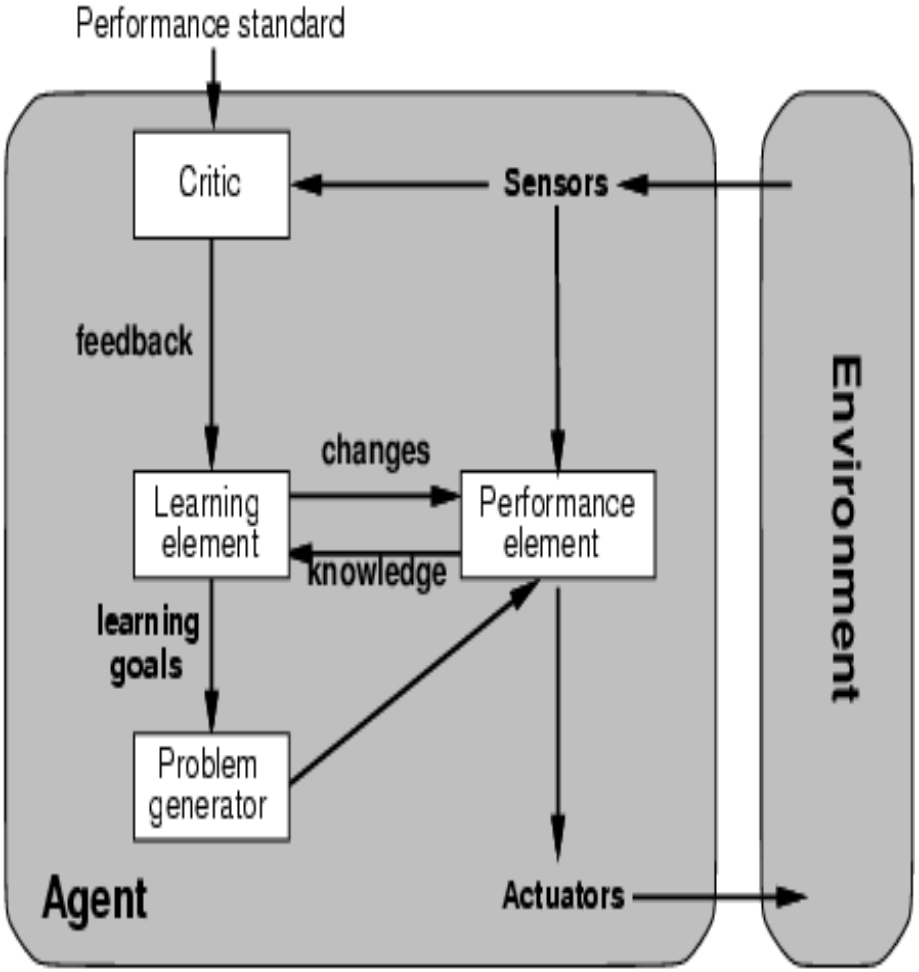
3. **Which of the following is considered as the most powerful AI agent?**
   a) Simple based reflex agent
   b) Model based reflex agent
   c) Goal based agent
   d) Utility based agent

Learning Agent

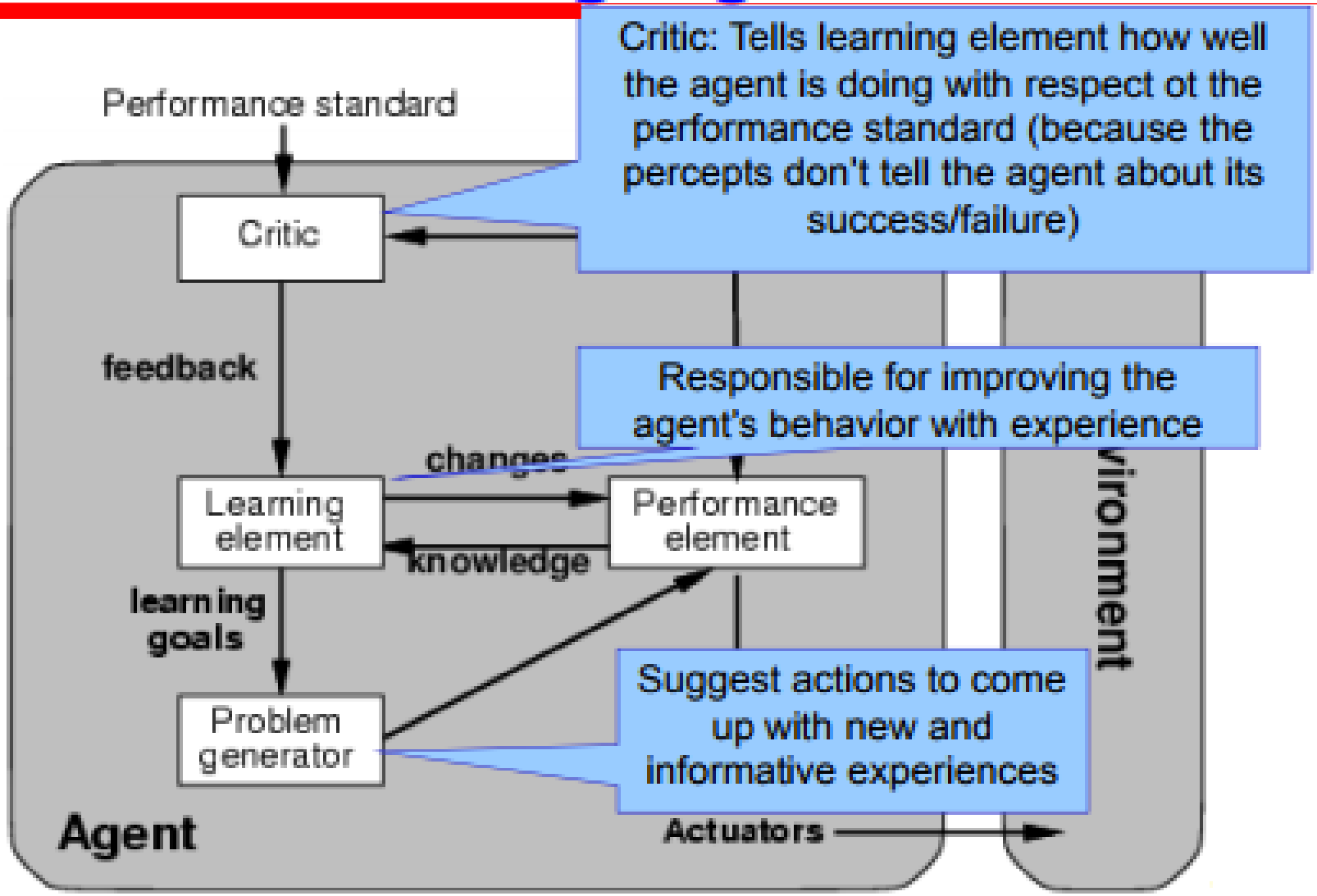
1. Explain Learning agent with diagram. Also explain Inductive learning. (8 marks) Dec 2011, (10 marks) June 2013
2. Explain Learning agent with diagram. Hence Explain various methods of learning. (10 marks) Dec 2010
3. What are the building blocks of Learning Agent. Explain each of them with Block Diagram. (8 marks) Dec-2015, May 2016, Dec 2016

Learning agents

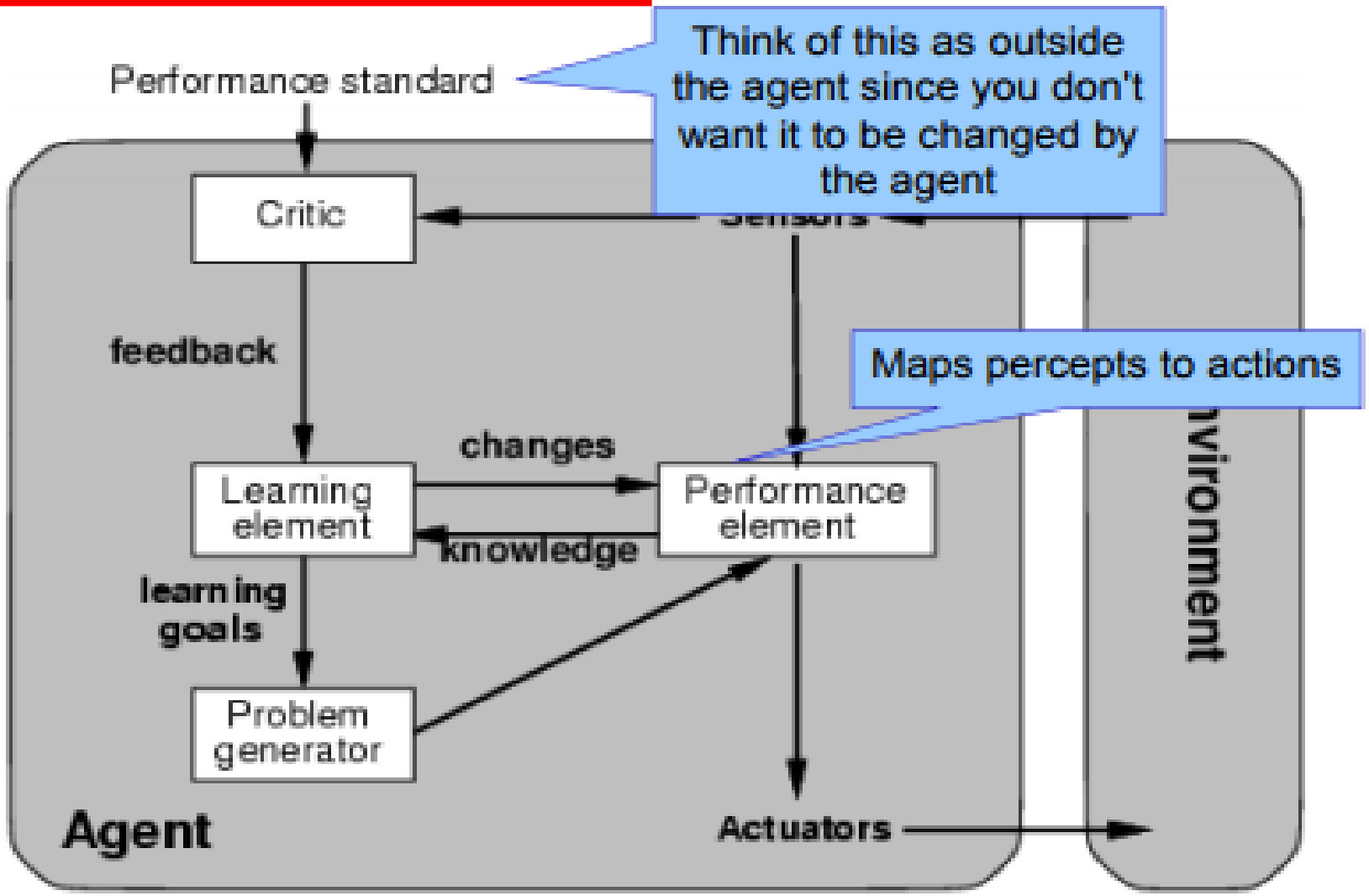
- After an agent is programmed, can it work immediately?
  - No, it still need teaching
- In AI,
  - Once an agent is done
  - We teach it by giving it a set of examples
  - Test it by using another set of examples
- We then say the agent learns
  - A learning agent



Learning Agents



Learning Agents



Learning Agent

- Learning has the advantage that it allows the agents to initially operate in unknown environments and to become more competent than its initial knowledge alone might allow. The most important distinction is between the "**learning element",** which is responsible for ***making improvements,*** and the **"performance element",** which is responsible ***for selecting external actions***.
- The learning element uses feedback from the "critic" on how the agent is doing and determines how the performance element should be modified to do better in the future. The performance element is what we have previously considered to be the entire agent: it takes in percepts and decides on actions.
- The last component of the learning agent is the "problem generator". It is responsible for suggesting actions that will lead to new and informative experiences.

Know about Learning Agent:

1. **Which is used to improve the agents performance?**
   a) Perceiving
   b) Learning
   c) Observing
   d) Critic
2. **Which element in the agent are used for selecting external actions?**
   a) Perceive
   b) Performance
   c) Learning
   d) Actuator

Know about type of Agents:

3. **How does a simple reflex agent differ from other types of intelligent agents?**
   - It cannot think or modify its behavior.
   - It cannot accomplish a goal.
   - It cannot process its current environment.
   - It cannot follow pre-selected rules

4. **Which agent deals with happy and unhappy states?**
   - Simple reflex agent
   - Model based agent
   - Learning agent
   - Utility based agent

Summary: Intelligent Agents

- An **agent** perceives and acts in an environment, has an architecture, and is implemented by an agent program.
- Task environment – **PEAS (P**erformance**, E**nvironment, **A**ctuators, **S**ensors**)**
- The most challenging environments are inaccessible, nondeterministic, dynamic, and continuous.
- An **ideal agent** always chooses the action which maximizes its expected performance, given its percept sequence so far.
- An **agent program** maps from percept to action and updates internal state.
  - **Reflex agents** respond immediately to percepts.
    - simple reflex agents
    - model-based reflex agents
  - **Goal-based agents** act in order to achieve their goal(s).
  - **Utility-based agents** maximize their own utility function.
- Agents can improve their performance through **learning.**

Outline of SC

- Soft Computing:
  - Introduction of soft computing,
  - Soft computing vs. Hard computing,
  - Types of soft computing techniques

Introduction to SC

What is Computing?

- The discipline of computing is the systematic study of algorithmic processes that describe and transform information

Types of Computing

1. Hard Computing
2. Soft Computing

What is Hard Computing ?

- Hard Computing deals with precise models where accurate solutions are achieved quickly.
- **Example** (normal day to day computing)
  - calculator based on binary logic and numerical analysis
  - graphics,
  - computer databases,
  - computer security i.e. cryptography etc.

What is Soft Computing?

- Soft computing unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation.
  - The role model for soft computing is the human mind.
  - Soft computing techniques resemble biological processes.
- It includes designing a cognitive machine that can
  - learn and recognize complicated pattern like human faces,
  - understand distorted speech
  - decipher sloppy handwriting
  - comprehend tone of natural languages.
- **Example :** Washing machine using Fuzzy Logic

Difference between Hard & Soft Computing

Hard Computing	Soft Computing
based on binary logic, crisp systems, numerical analysis and crisp software	based on fuzzy logic, neural nets and probabilistic reasoning
requires programs to be written	can evolve its own programs
Deterministic	Incorporates stochasticity
Sequential computation	allows parallel computations

Constituents of Soft Computing

The major constituents of soft computing includes

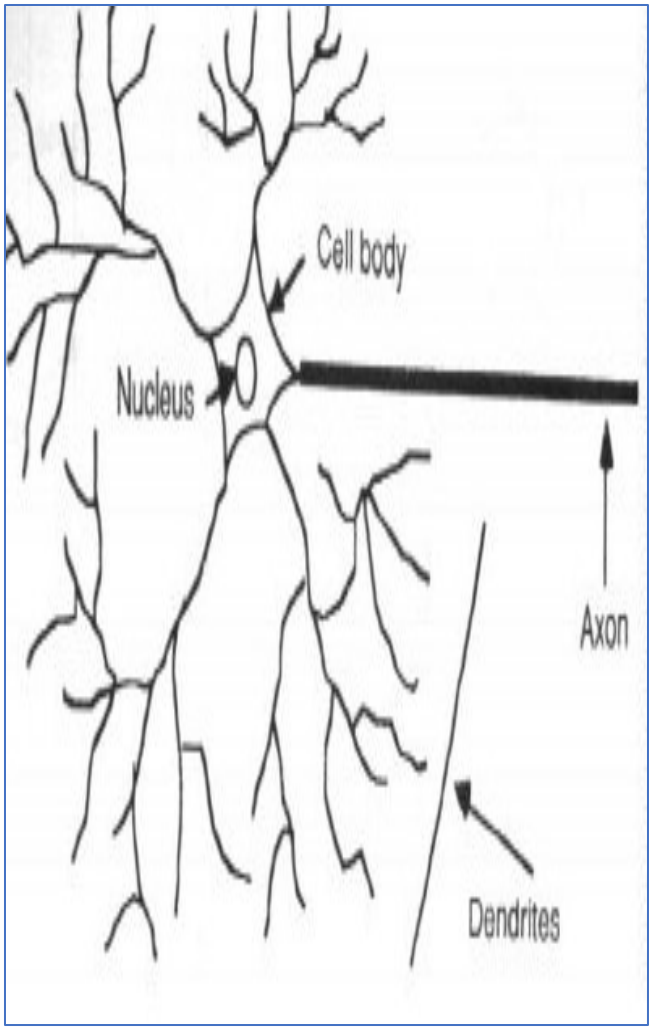
1. **Neural networks**
2. **Fuzzy systems**
3. **Evolutionary algorithms**

1. Neural networks

- An Artificial Neural Network (ANN) is a computational model that is inspired by the way biological neural networks in the human brain process information.

Components of a neuron

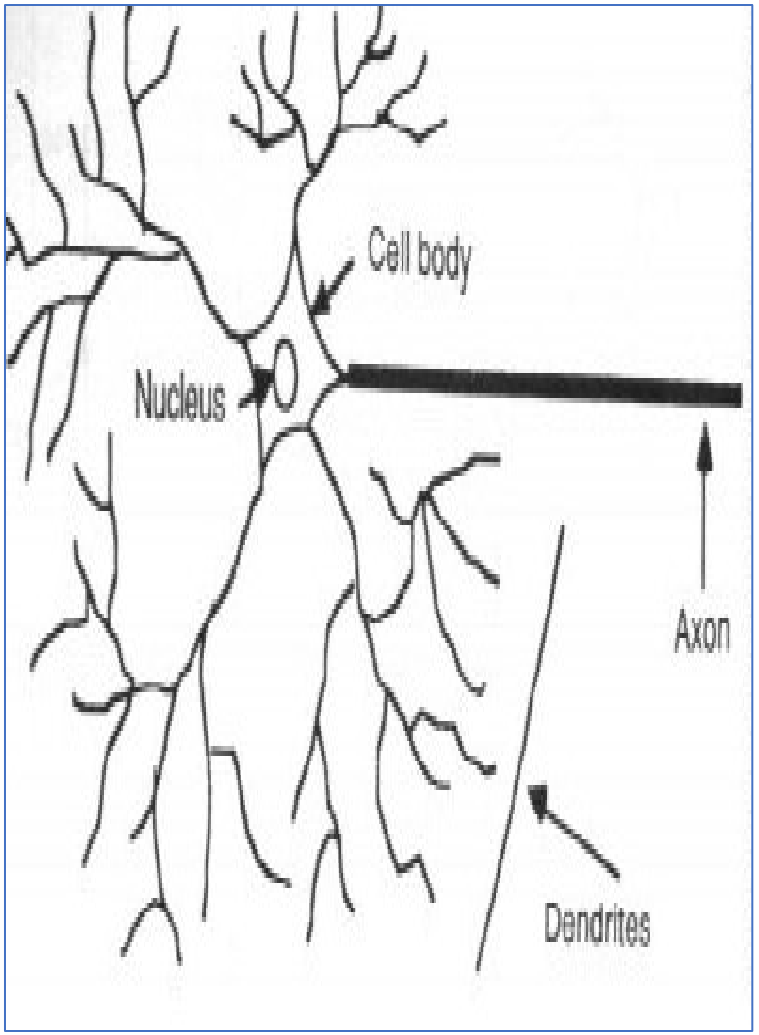
- In the human brain, a neuron collects signals from others through fine structures called **dendrites.**
- The neuron sends out spikes of electrical activity thru a long, thin **axon,** which splits into thousands of branches.
- At the end of each branch, a structure called a **synapse** converts the activity from the axon into electrical effects that inhibit or excite activity in the connected neurons.



Components of a neuron

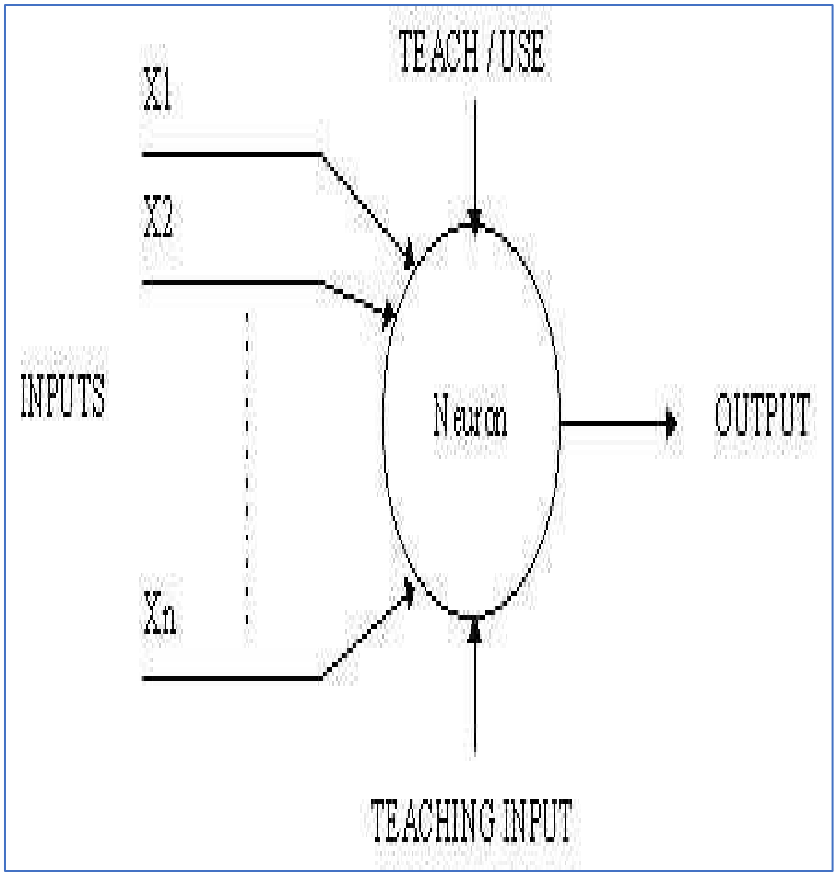
- When a neuron receives excitatory input that is sufficiently large compared with its inhibitory input, it sends a spike of electrical activity down its axon.

Learning occurs by changing the effectiveness of the synapses so that the influence of one neuron on another changes.



1.Artificial neuron

- The basic unit of ANN is the neuron (node).
- It receives input from some other nodes, or from an external source and computes an output.
- Each input has an associated weight (w), which is assigned on the basis of its relative importance to other inputs.
- The node applies a function (f) to the weighted sum of its inputs.



Artificial neuron

- An artificial neuron is a device with many inputs and one output.
- The neuron has two modes of operation; the **training mode** and the **using mode**.
  - In the **training mode**, the neuron can be trained to fire (or not), for particular input patterns.
  - In the **using mode**, when a taught input pattern is detected at the input, its associated output becomes the current output.
- If the input pattern does not belong in the taught list of input patterns, the firing rule is used to determine whether to fire or not.

2. Fuzzy Systems

- Fuzzy logic seems closer to the way our brains work.
- Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0).
- We aggregate data and form a number of partial truths which we aggregate further into higher truths which triggers as motor reaction.
- The idea of fuzzy logic was introduced by Dr. Lotfi Zadeh in the 1960s.
- Fuzzy logic includes 0 and 1 as extreme cases of truth but also includes the various states of truth.

3. Evolutionary Algorithms

- Natural Intelligence is the product of millions of years of biological evolution.
- This involves Simulating complex biological evolutionary processes toward higher-level intelligence.
- Genetic Algorithm is an example which is based on evolutionary principle of natural selection.
- When a search space is too large, we have to use more efficient search techniques to find less-than –optimal solutions.
- GA is a candidate technique for this purpose.
- Simulated annealing is another candidate.

Thank you