

# AI gents

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# Lecture objectives

- By the end of this lecture, students should be able:
  - ✓ Explain the concepts related to AI: agents, intelligent agents, AI agents, etc.
  - ✓ Explain the high level description and properties of AI agents
  - ✓ Outline popular examples of intelligent agents
  - ✓ Explain the applications of AI agents
  - ✓ Explain various AI design rules
  - ✓ Explain the parameters for grouping AI environments

# What is an AI agent?

- An AI agent is an autonomous entity which observes the environment through sensors and acts upon it while directing its activity towards achieving goals.
  - It acts upon the information it perceives.
- It perceives an environment through sensors and acts upon it through effectors.
  - An effector is the AI agent component which actually affects the environment.
    - Effectors can be legs, wheels, arms, fingers, wings, fins, and display screen.

# AI agents...

- AI agents are also called “artificial autonomous intelligent agents”.
- Basically the focus of AI agents is on what an agent does in pursuit of its goals.
- An intelligent agent is capable of making decisions about how it acts, based on experience.

# But what is an intelligent system?

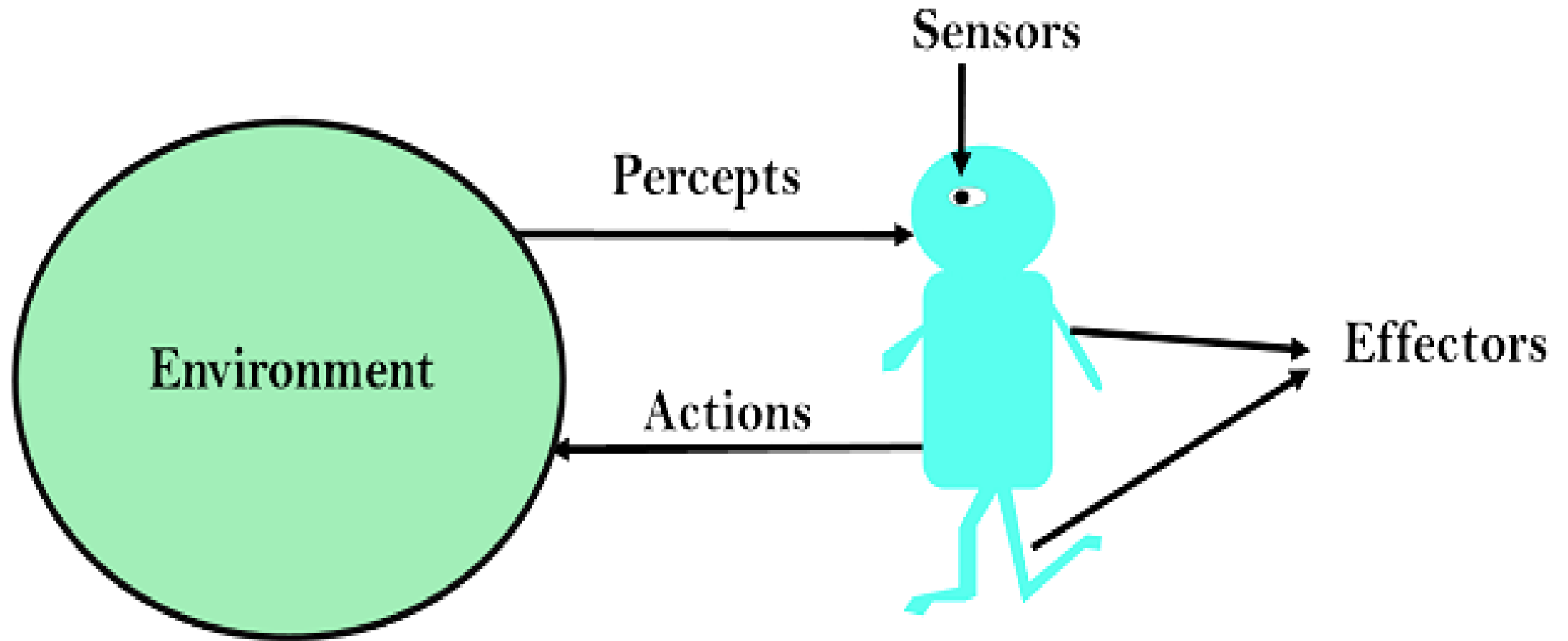
- An intelligent agent is an example of intelligent systems
  - An intelligent system is a machine that rationally processes data and information in order to do purposeful results.
- Popular general examples of intelligent systems includes computer systems, robots, AI intelligent software, etc.
  - Robotic Agent - a robotic agent has cameras, infrared range finder, etc. as sensors, and various motors as actuators.
  - Software Agent - a software agent has keystrokes, file contents as sensory input, and acts on those inputs to display output on the screen.
- A popular synonym for intelligent agents is the human-Agent
  - With eyes, ears, and other organs as sensors, and hand, legs, etc. as actuators.

# High level description of AI agents

- An autonomous agent can be specified by describing the following:
- **Performance Metrics** – measure of how the agent is doing what it's supposed to be do.
- **Environment** – the state of affairs that changes over time as real life situations do, in relation to the agent.
- **Actuators** – How the agent affects its environment i.e. actions, and action selection architecture e.g. electric motor, gears, rails, etc.
  - An **actuator** is a system component which is responsible for moving and controlling a mechanism or system.
  - An action is a change in the environment brought about by the agent.
    - Actions require the agent to update its model of the world, which in turn may cause the agent to change its immediate intention.

# High level description of AI...

- **Sensing capabilities** – How the agent gets information from its environment.
  - This includes the sort of data the agent is capable of receiving as input, and depends on the sensor component in use.
- ❖ The mnemonic **PEAS** is usually used to remember these.





# AI agent architecture

- An AI agent architecture is the base mechanism that an AI agent executes on.
  - The structure of an intelligent agent is a combination of architecture and the agent program.

**AI agent = Architecture + Agent program**

- An AI agent consists of AI architecture, agent function, and agent program.
  - **Agent Function:** Agent function is used to map a percept to an action.
  - **Agent program:** Agent program is an implementation of agent function.

# AI agent properties

- This is concerned with the match between the AI agent's properties and its environment properties.
- Agent properties include:
  - ✓ What the agent perceives
  - ✓ How it acts
  - ✓ What is it supposed to achieve – its goal

# Examples of intelligent agents

## Agent name: Car driver

- **Percepts:** Camera
- **Action:** Steer, accelerate, brake
- **Goals:** safe, fast, legal trip
- **Environment:**  
Streets, intersections,  
traffic signals, traffic  
lights, other vehicles,  
pedestrians, etc.

## Agent name: Mail sorting agent

- **Percepts:** array of pixel intensities
- **Actions:** Route email to inbox
- **Goals:** Route email correctly
- **Environment:**  
Conveyer belts of letters.



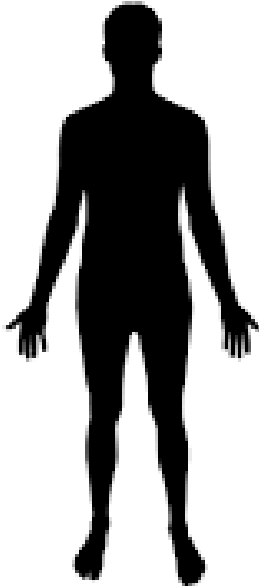
# Other popular intelligent agents

- ✓ Siri - a virtual assistant that is part of Apple Inc.'s iOS, watchOS, macOS, and tvOS operating systems.
- ✓ Centsys - for managing automatic gates
- ✓ Alexa - for marketing and advertising
- ✓ Quillbot – for paraphrasing statements, paragraphs, etc.
- ✓ AI-bots inside gaming platforms.
- ✓ Personal assistant in smartphones
- ✓ Intelligent interfaces on Facebook, YouTube, Google Ads, etc.

# Human vs Robot agents

## Human

- Sensors/percepts: Eyes, ears, and other organs.
- Actuators: hands, legs, etc



## Robot

- Sensors/percepts: cameras and infrared.
- Actuators: various motors



# Application of AI agents

- Intelligent agents are today being applied in a variety of areas, including:
  - ✓ Manufacturing e.g. packaging, etc.
  - ✓ Electronic commerce e.g. market intelligence.
  - ✓ Information retrieval e.g. data mining.
  - ✓ Distributed project management.
  - ✓ Medical field – as nursing aids the corona virus pandemic in 2020-2021.
  - ✓ Computer networking
  - ✓ The military – e.g. drones for surveillance.
  - ✓ Games – as ball boys and aids in Qatar World Cup of 2022.
  - ✓ Management of the COVID-19 pandemic in India, Rwanda, Morocco, USA, etc.



# AI agents at Qatar 2022 World Cup





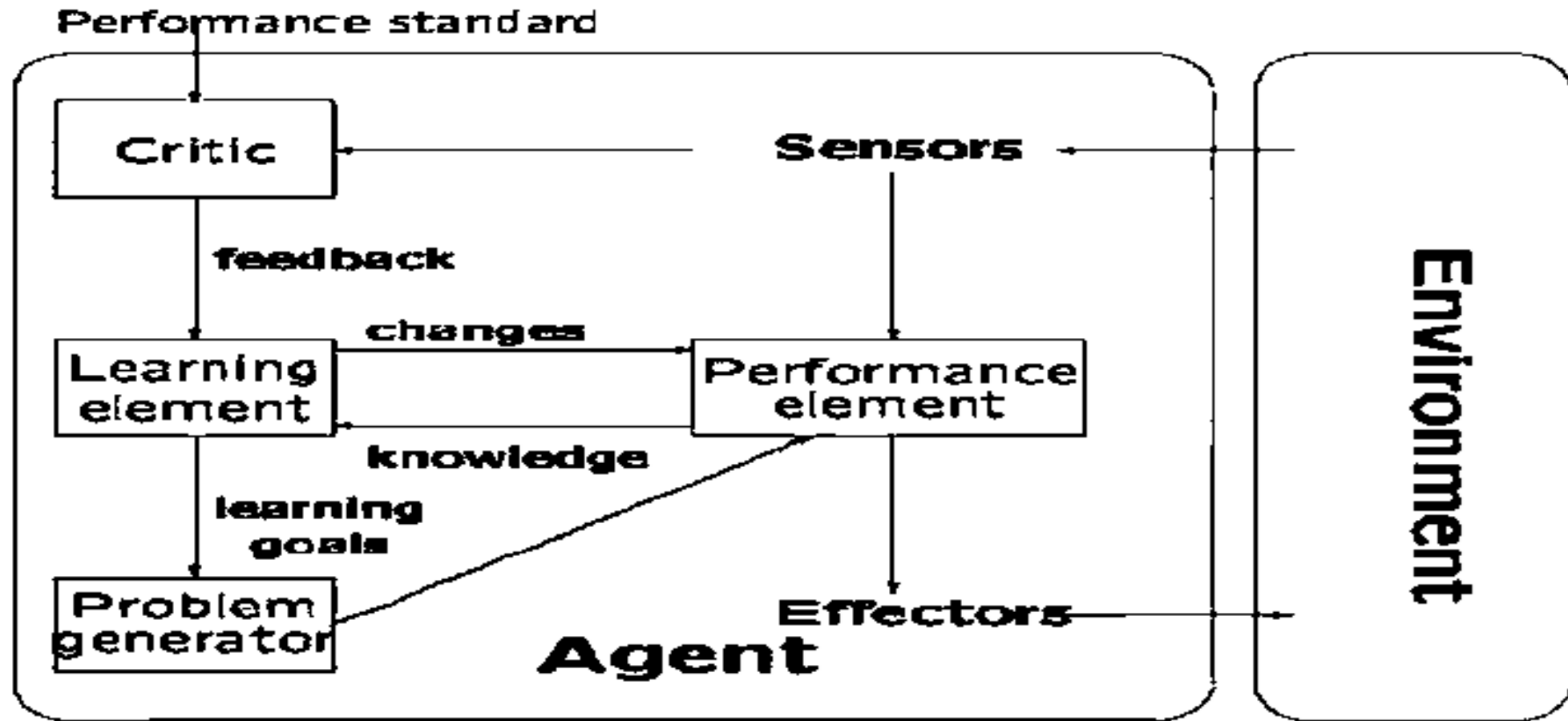
# AI agent design rules

- An AI system must obey the following rules:
  - An agent should be able to perceive the environment
  - Observations should be used to make decisions
  - Decisions must result into an action taken
  - Any decision made by a decision engine must be rational

# Applications of AI agents – robots 1



# General structure of AI agents



# Structure of AI agents

- **Sensors** are the tools employed by the agent to gather information from its environment.
  - Sensors of AI agents include microphones, cameras and other inputs that are used to perceive a request
- **Effectors** are the tools used by the agent to act on its environment.
  - Effectors of an AI agent may include a monitor, a printer, and a robotic arm.
- **Critic** is the tool that gives feedback
  - Describing how well the agent is doing with respect to a fixed performance standard.

# Structure of AI agents...

- **Learning element** - responsible for making improvements by learning from environment.
  - It does this by learning from the difference between performance standard and the feedback from critics.
  - It understands the expected behaviour and enhances its standards.
- **Performance element** – is responsible for choosing the appropriate actions on the external environment.
  - It is based on the current perception received from sensors and the input obtained by the learning element.

# Structure of AI agents...

- **Problem generator** - responsible for suggesting actions that will lead to new and informative experiences.
  - It suggests new or alternative actions.
  - It is based on the new goal learnt by the learning agent.

# The environment

- The term environment refers to the domain or perimeter “world” of the AI agent.
- These domains are usually limited to specific types of situations in order to avoid the unlimited possibilities of the every day world.
- It is important to distinguish the types of environments that impact on the computational challenges of agent programs.
  - If the environment is effectively accessible, then the agent's sensors give it complete information about the state of affairs that are relevant to the agent's goals.

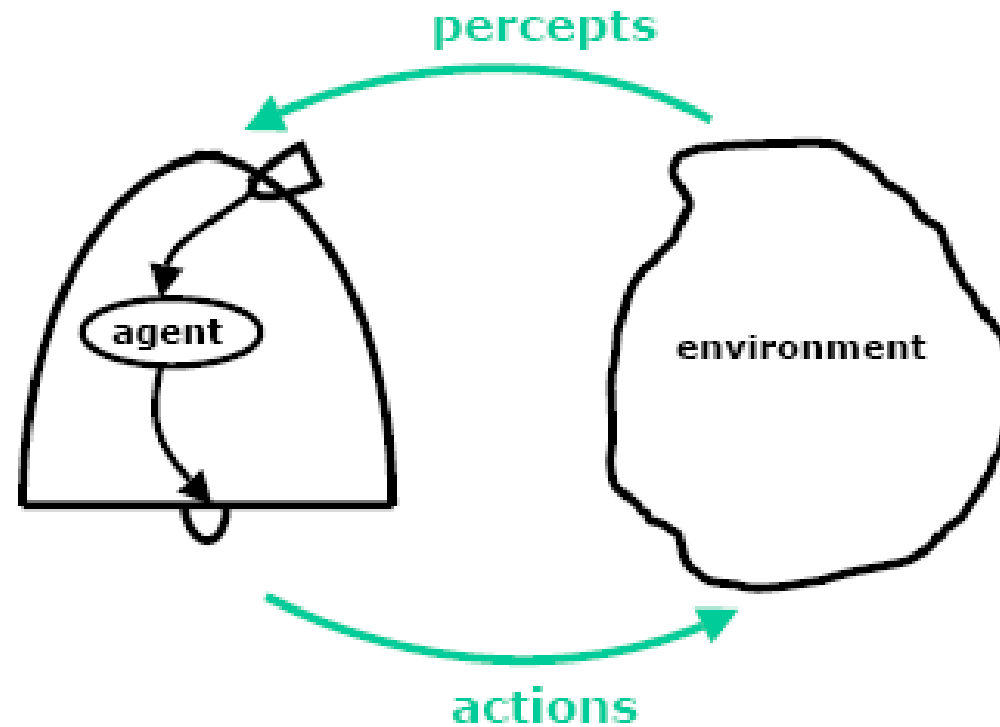
# AI environments

- AI environments can be distinguished, basing on the following:
  - ✓ The shape of the data – natural for of appearance of the data
  - ✓ The frequency of the data – rate at which individual data appears over a given period of time.
  - ✓ The nature of the problem – inherent characteristics of the data that can be used to solve the problem.
  - ✓ The volume of knowledge available at any given time – amount of things that can contribute to experience that is available at a period of time.



# The AI environment

- The AI environment works as a string of mappings from the action space to the percept space



# Types of environments

- Grouping of AI environments is based on the following:
  - ✓ Observability
  - ✓ Staticness
  - ✓ Completeness
  - ✓ Deterministicness
  - ✓ Episodicness
  - ✓ Discreteness
  - ✓ Agency
  - ✓ Knowledge

# Fully Observable vs. Partially Observable

- **Fully Observable AI environment**
- A fully observable AI environment has access to all required information to complete target task.
  - The agent can keep track of what was previously sensed, cannot be sensed now, but is probably still true.
    - i.e. the agent has access to all relevant information.
  - Often, if other agents are involved, their intentions are not observable, but their actions are
  - An image recognition agent operates in fully observable domains.

# Fully Observable vs. Partially Observable

- **Partially Observable**
- Partially observable environments deal with partial information in order to solve AI problems.
  - Could be due to noisy, inaccurate or missing sensors, or inability to measure everything that is needed
  - such as the ones encountered in self-driving vehicle scenarios

# Static vs. Dynamic environments

- **Static environment**
- Static AI environments rely on data-knowledge sources that don't change frequently over time.
  - nothing (other than the agent) in the environment changes while the agent deliberates.
  - Speech analysis is a problem that operates on static AI environments.
  - E.g. mowing a lawn (unless there is some moving object...), and expert systems (unless there are knowledge changes).

# Static vs. Dynamic environments

- **Dynamic environments**
- Dynamic AI environments is one that involves data sources that change quite frequently.
  - Other agents in an environment make it dynamic
  - The goal might also change over time e.g. playing football, where other players make it dynamic
  - For example, AI systems in drones

# Complete vs. Incomplete AI environments

- **Complete environment**

- A complete AI environment is one on which, at any give time, there is enough information to complete a branch of the problem.
  - Chess game is a classic example of a complete AI environment.

- **Incomplete environment**

- Is an environment where the AI agent can't anticipate many moves in advance and instead focuses on finding a good 'equilibrium' at any given time.
  - For example, playing card game is based on an incomplete environment.

# Competitive vs. Collaborative environments

- **Competitive environment**

- A Competitive AI environment is one where the AI agents contest against each other in order to optimize a specific outcome.

- Games, such as the Chess game, are examples of AI competitive environments.

- **Collaborative environment**

- Collaborative AI environment relies on the cooperation between multiple AI agents.

- An examples is smart home with a gate, and self-driving vehicles.



# Discrete vs. Continuous environments

- **Discrete environment**
- A discrete AI environment is one in which a finite set of possibilities can drive the final outcome of the task.
  - Here, time moves in fixed steps, usually with one measurement per step (e.g. action).
  - It has fixed locations or time intervals.
  - A Chess game is also classified to have a discrete AI environment.

# Discrete vs. Continuous environments

- **Continuous environment**

- A continuous AI environment is one that relies on unknown and rapidly changing data sources.
  - Signals constantly coming into sensors, actions continually changing.
  - This can be measured quantitatively to any level of precision.
  - Examples include environments for drones, and self-driving cars.

# Deterministic vs. Stochastic environments

- **Deterministic environment**

- A deterministic AI environment is that environment on which the outcome can be determined based on a specific state.
  - The next state of the environment is completely predictable from the current state and the action executed by the agent.
  - The next state is perfectly predictable given knowledge of the previous state and the agent's action.
  - Deterministic environments ignore uncertainty.
  - Example is brain warmer games.

# Deterministic vs. Stochastic environments

- **Stochastic environment**
- Is an environment that on which output classified as after considering all possibilities including existing uncertainties.
  - This takes care of uncertainty associated with it
    - Uncertainty could come from randomness, lack of a good environment model, or lack of complete sensor coverage
  - Most real world AI environments are actually stochastic, and not deterministic.
  - Robots and Self-driving vehicles are a classic example of stochastic AI processes.

# Single agent vs. multi agent

- **Single agent environment**
- An agent that is operating by itself in an environment is single agent!
- **vs. multi agent environment**
- Multi agent is when other agents are present!
  - If there is at least one other agent in the environment, then it is a multi-agent environment.
    - Note that the other agents may be apathetic, cooperative, or competitive.

# Known vs Unknown environments

- **Known environment**

- An environment is considered to be "known" if the agent understands the laws that govern the environment's behavior.

- Examples:

- In chess playing, the agent knows that when a piece is "taken" it is removed from the game.
    - In the self driving car on a street, the agent knows that when it rains, the streets get slippery.

- **Unknown environment**

- This does not understand the laws that govern the environment's behavior.

# Episodic vs. Sequential

- **Episodic environment**
- The agent's experience is divided into atomic episodes, where in each episode the agent perceives and then performs a single action, and choice of action in each episode depends only on the episode itself.
  - It is a series of one-shot actions, and only the current (or recent) percept is relevant.
    - Current actions do not affect future actions.
  - Examples:
    - In an expert advice system, an episode is a single question and answer
    - In processing radiology images to determine if there is a sickness, where each image has nothing to do with another.
    - In a mail sorting system, etc.

# Episodic vs. Sequential

- **Sequential environment**
- An environment is sequential if the current decisions by an agent affect its future decisions.
- Sequential environments require memory of past actions to determine the next best action.
  - That is, future decisions rely on previous ones.
  - Example is the chess game.



# AI systems versus other computer systems

- Artificial Intelligence differs from conventional computer systems in that the AI systems discover the solutions by themselves and then execute apply accordingly.
  - Other computer systems have the solution designed by the programmer and only execute the solution.

# The future of AI

- A few of the most long standing questions that have remained unanswered include:
  - ✓ Should artificial intelligence simulate natural intelligence by studying psychology or neurobiology?
  - ✓ Isn't human biology as irrelevant to AI research as bird biology is to aeronautical engineering?
  - ✓ Can intelligent behavior be described using simple and elegant principles such as logic or optimization?
  - ✓ Does it necessarily require solving a large number of completely unrelated problems?

# Group assignment 1

- In groups of five members each, prepare a presentation to discuss one of the following types of AI agents.
  - Group 1 : Goal-based agents
  - Group 2 : Simple Reflex Agent
  - Group 3 : Utility-based agent
  - Group 4 : Model-based reflex agent
  - Group 5: Hybrid intelligent systems
- Each group should prepare a Microsoft Word document of your work, and PowerPoint presentation. A softcopy of each of these must be emailed to [akogwal@gmail.com](mailto:akogwal@gmail.com) latest at 2359hrs on Sunday 3<sup>rd</sup> July 2022. Class presentation will follow immediately – you will be informed in class.

That's it on AI Agents