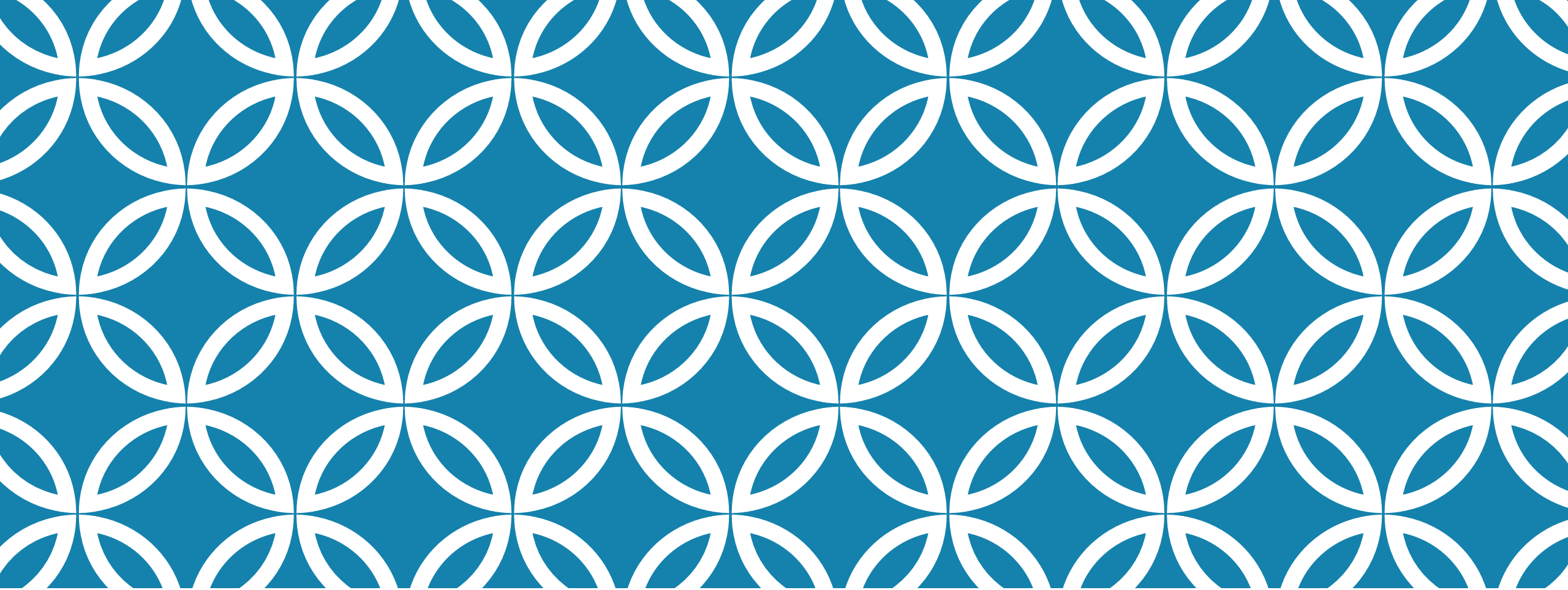


UNIT – 1
INTRODUCTION TO MACHINE INTELLIGENCE

By Vishvajit Bakrola

OUTLINE

- Introduction to AI
- Agent and Environment
- Types of Environment
- Agent Functions and Program
- Types of Agent
- Vacuum World Example

INTRODUCTION TO AI

AI – A BROAD VIEW

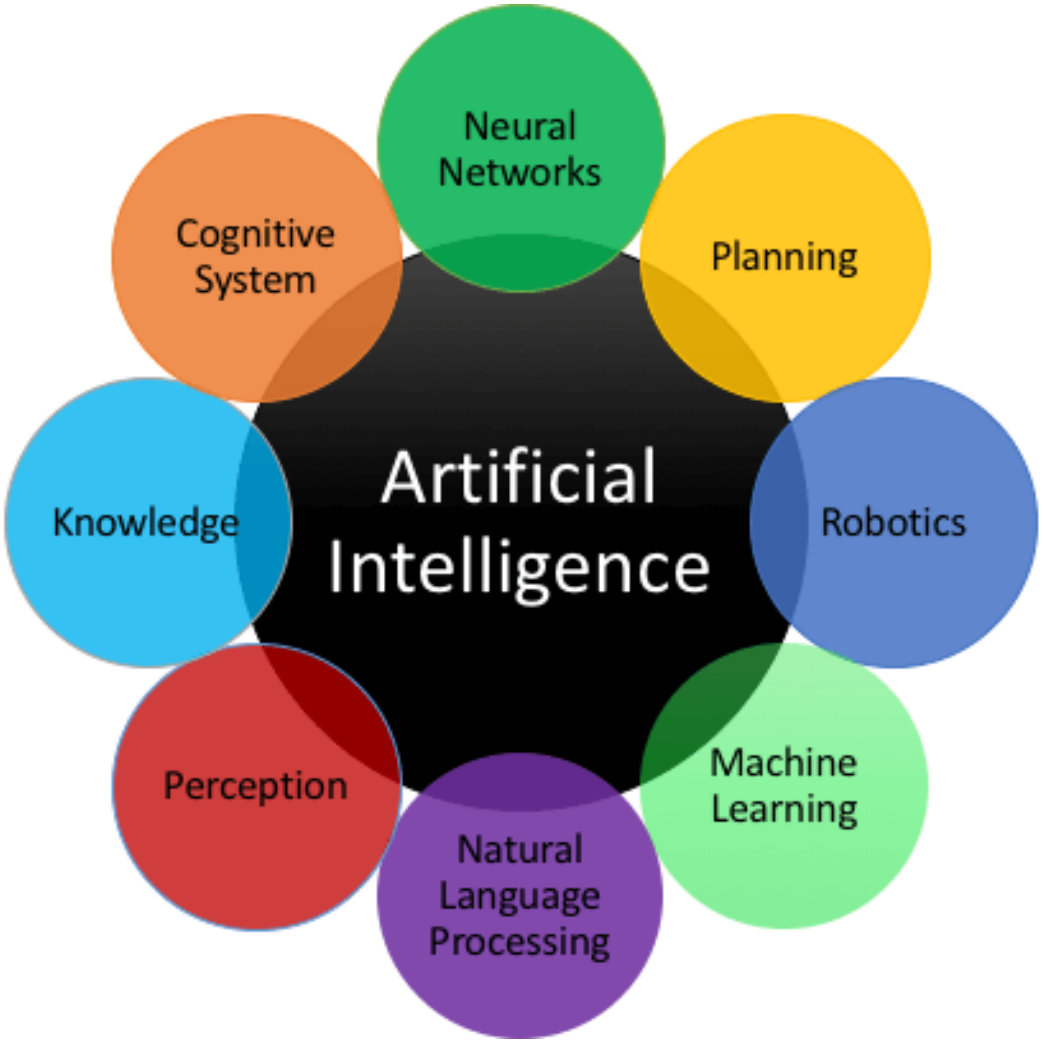


Figure 1: AI a Broad View[1]

AI BY GENERAL DEFINITIONS

- By dictionary meaning, Intelligence is the **"The ability to learn, reason and act"**

- **Artificial Intelligence** is a field of computer science, that enables machines/computers to **"Learn, Reason and Act"** like a Human being

CONTINUE…

- A branch of computer science dealing with the **simulation of intelligent behavior in computers.**
- The capability of a **machine to imitate intelligent human behavior.**
- Simulation of human intelligence processes by machines, these processes include **learning, reasoning, and self-correction.**

CLASSIFICATION OF AI

- In broad sense, AI can be classified into two categories:
  - Weak AI – Focused on one **narrow task** and never considered as general intelligence. Designed to **perform specific task using intelligence**. Examples – Apple SIRI, Amazon Alexa, etc.
  - Strong AI – **More similar to human** and so, it can perform task on its own. Capable of **all cognitive functions that human have**. There are multiple ways to achieve these – Machine Vision, Machine Learning, NLP, Reinforcement learning.

- Eight Definitions of AI organized into two different dimensions.
- On top – Thought processes and Reasoning
- On bottom – Addresses Behavior
- On left – Success in terms of human performances
- On right – Measures ideal performances, also called Rationality.

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Figure 2: Definitions of AI

ACTING HUMANLY – THE TURING TEST

- Proposed by famous mathematician and computer scientist **Alan Turing** in **1950.**

- Turing test is considered as, **Satisfactory operational definition of intelligence.**

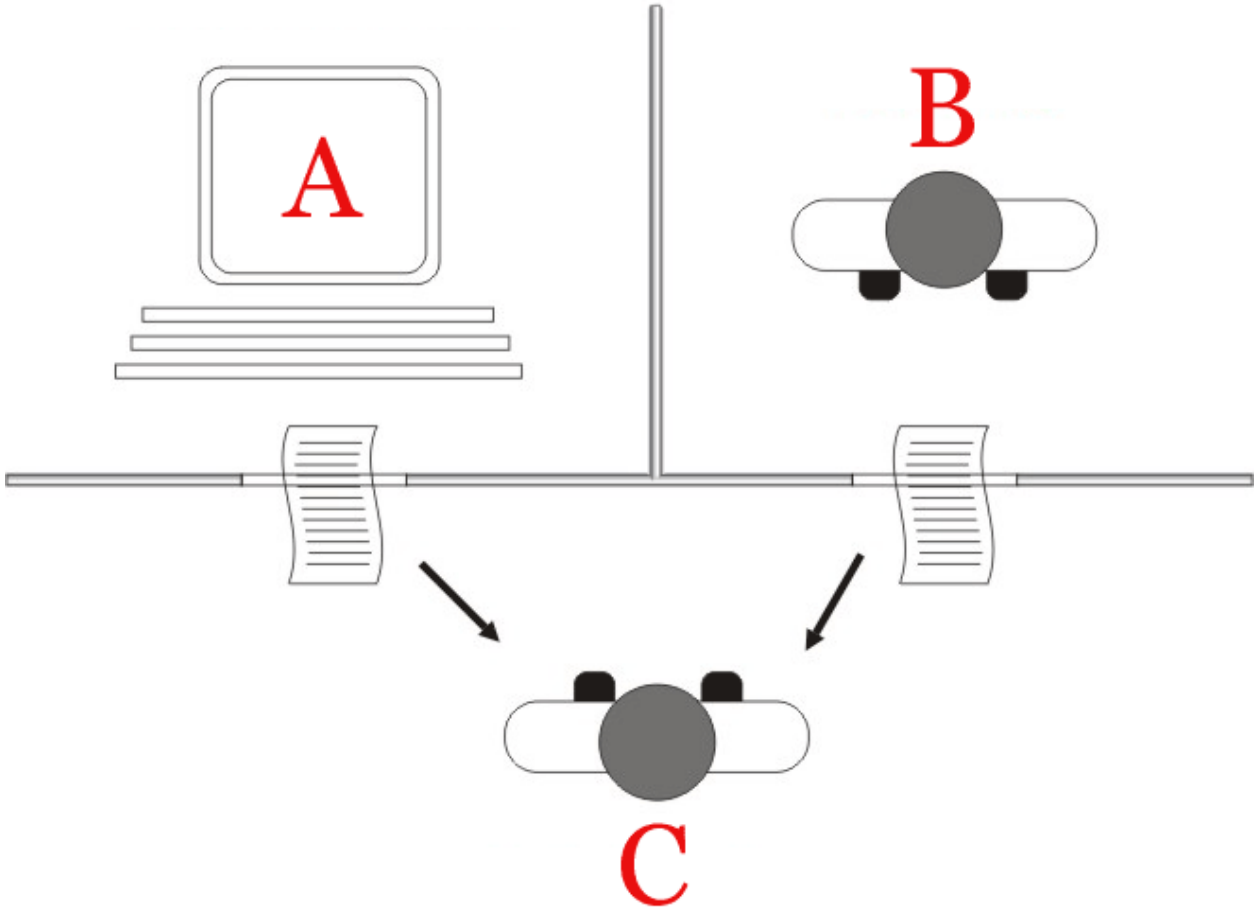
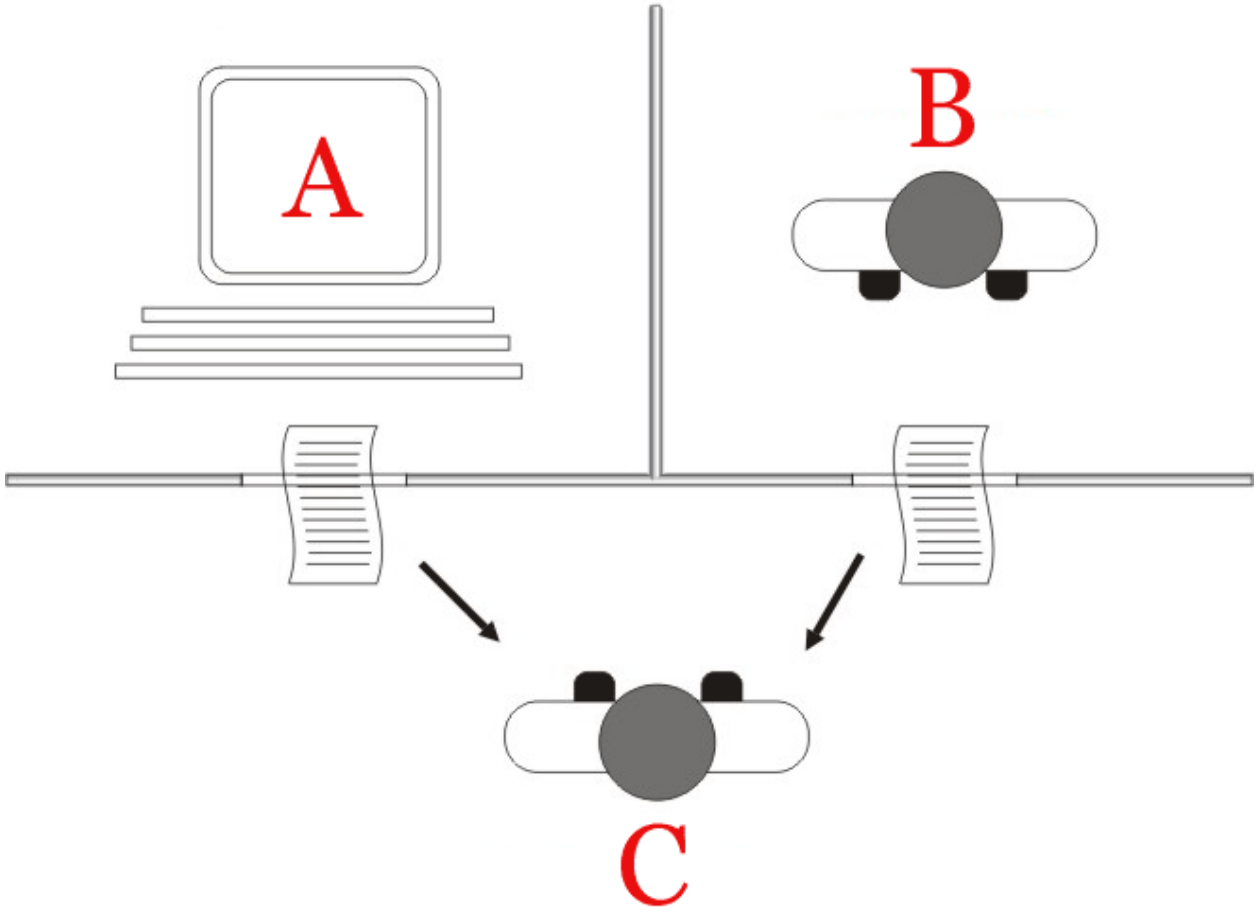


Figure 3: Turing Test

CONTINUE…

- To make this happen, computer will need to have following capabilities:
  - Natural Language Processing
  - Knowledge Representation
  - Automated Reasoning
  - Machine Learning



THINKING HUMANLY

- For thinking humanly, we need to understand how we, human thinks.
- The cognitive human thinking leads to cognitive modelling approach.
- The theory of human brain can be applied to express the cognitive modelling of computer program.

THINKING RATIONALLY

- **Thinking rationally** is also known as "**Laws of though approach**".
- The laws of thought is supposed to govern the operation of mind and their study represented as **Logic.**
- Example: Krishna was a king. All kings are brave. So, Krishna was brave.
- This old logic tradition raised a hope for development of AI program, but the problem is that just few thousands facts can exhaust our available computational resources.

ACTING RATIONALLY

- The rational computer program is expected to achieve the best outcome.
- If there is uncertainty in the problem environment, then it is expected to result in best possible way(s).
- It simply means, **Always doing the right things.**
- The Laws of Thought approach emphasis on **correct inferences.** This is part of being rational. As the correct **logical reasoning will lead to achieve best outcome.**

THE FOUNDATIONS OF AI

Philosophy	Knowledge Representation, Logic, Foundation of AI
Maths	Search, Analysis of searching algorithms, Logic
Economics	Expert systems, Decision theory, Principles of rational behavior
Psychology	Behavioristic insights into AI programs
Neuroscience	Learning, Neural networks
Control theory and Cybernetics	Information theory with AI, Entropy, Robotics
Computer Science	Systems for AI

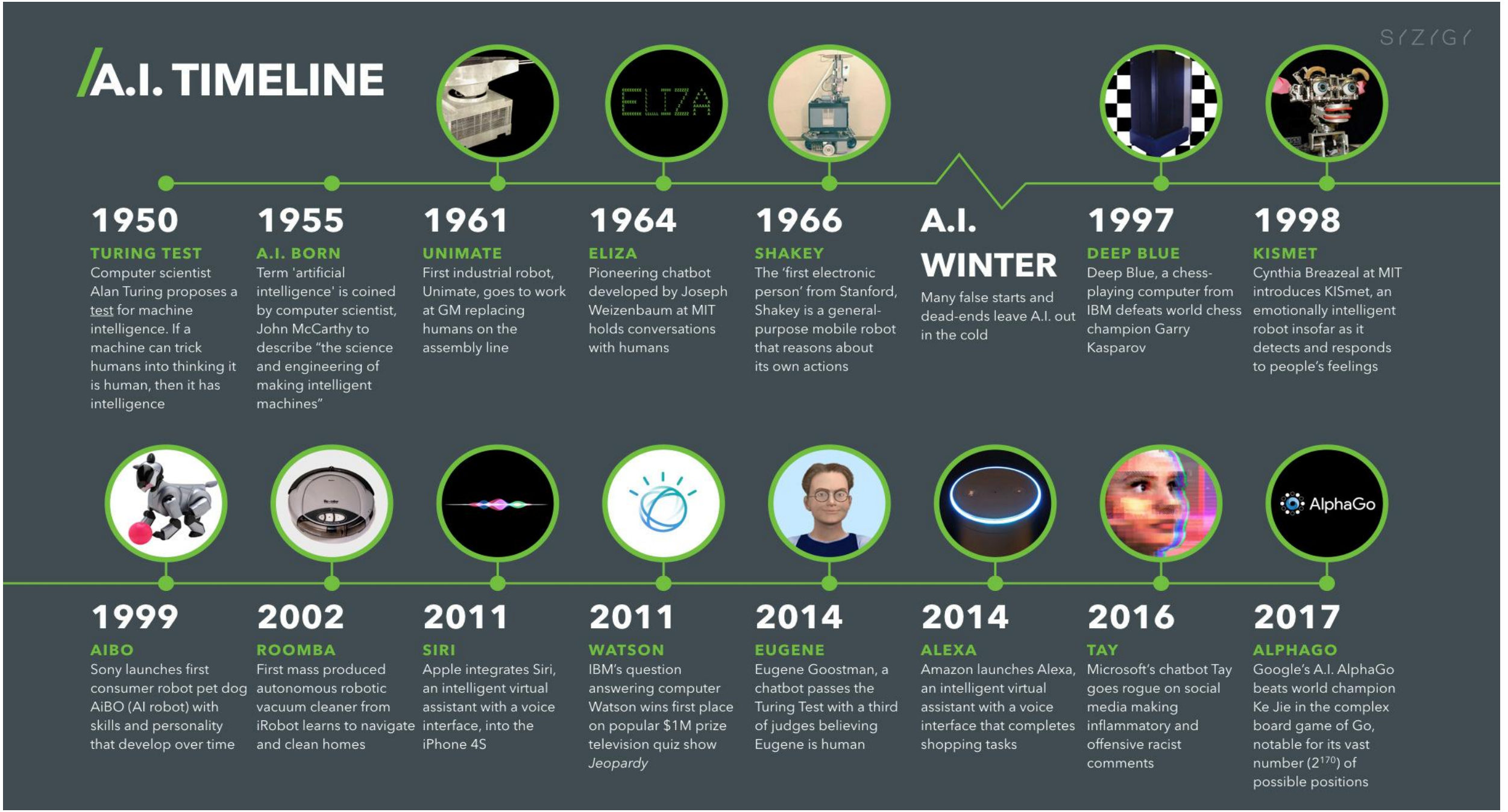


Figure 4: The History of AI [2]

AGENT AND ENVIRONMENT

AGENT AND ENVIRONMENT

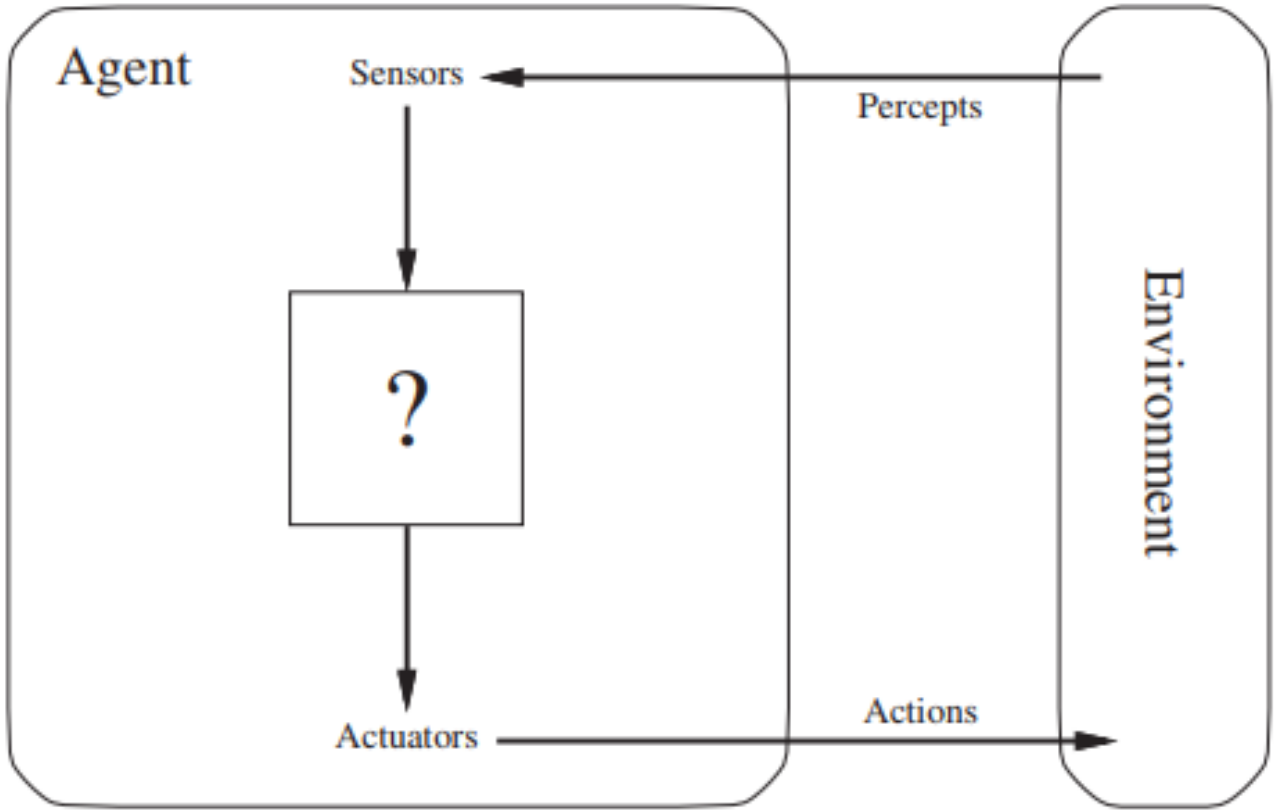


Figure 5: Block Diagram of an Agent

- The agent is anything that can perceive its environment through sensors and acting upon through actuators.
- The behavior of Agent in environment gives us the concept of PAGE.
- *Percept, Action, Goal, Environment.*
- The term **Percept** refers to the agent's inputs at any given instant.
- **Percept Sequence** is the set of individual percepts that agent has ever perceived.

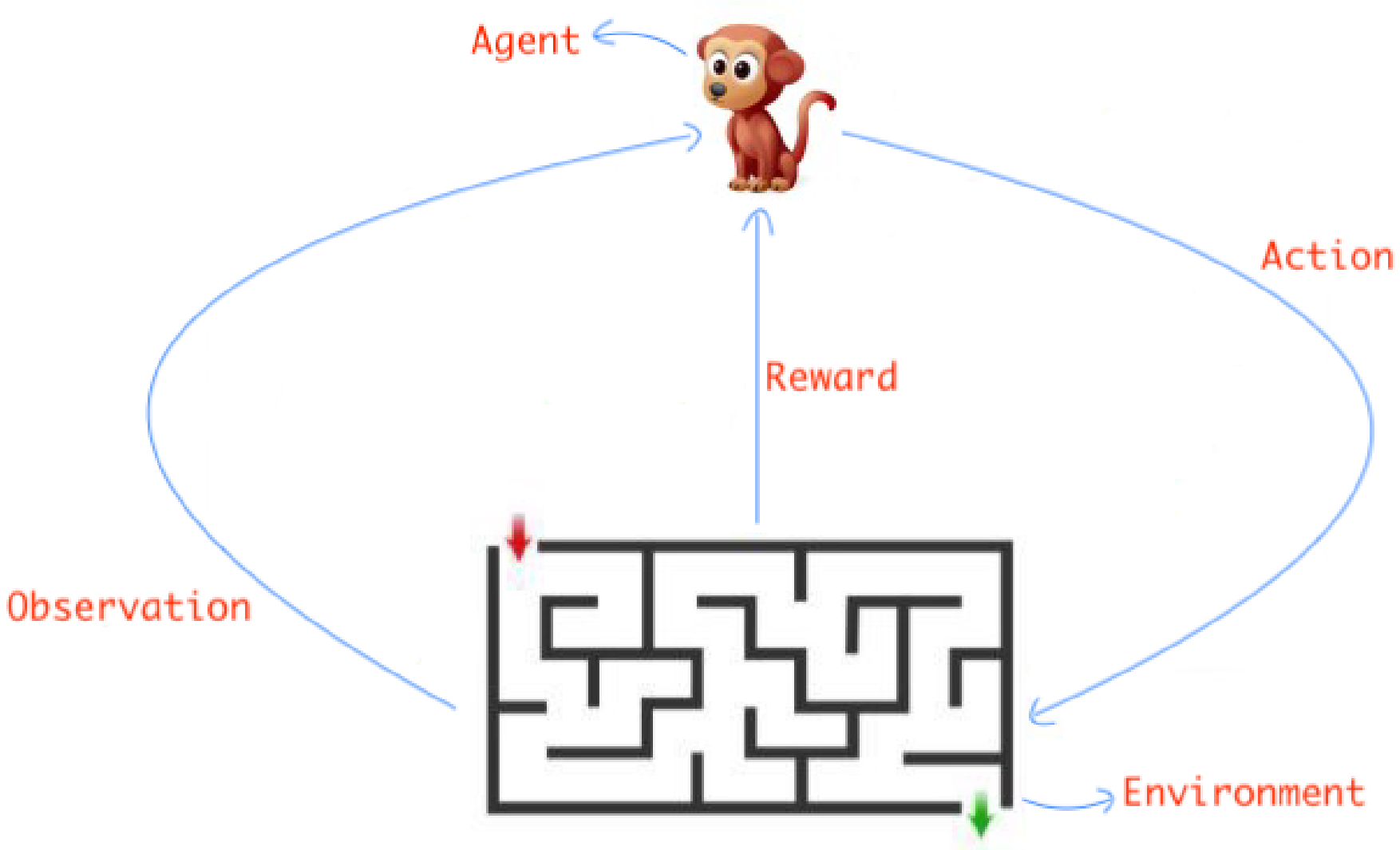


Figure 6: Agent Environment Interaction

AGENT FUNCTION

- Generally, the **action performed** by any agent is **depend on the entire percept sequence.**
- **Agent Function** maps the percept sequence to an action. Mathematically, the agents behavior is represent by **Agent Function.**

VACUUM CLEANER WORLD

- **Percepts:** Which square (A or B); dirt?
- **Actions:** Move right, Move left, suck, Do nothing.
- **Agent function:** Maps percept sequence into actions.
- **Agent program:** Function's implementation.

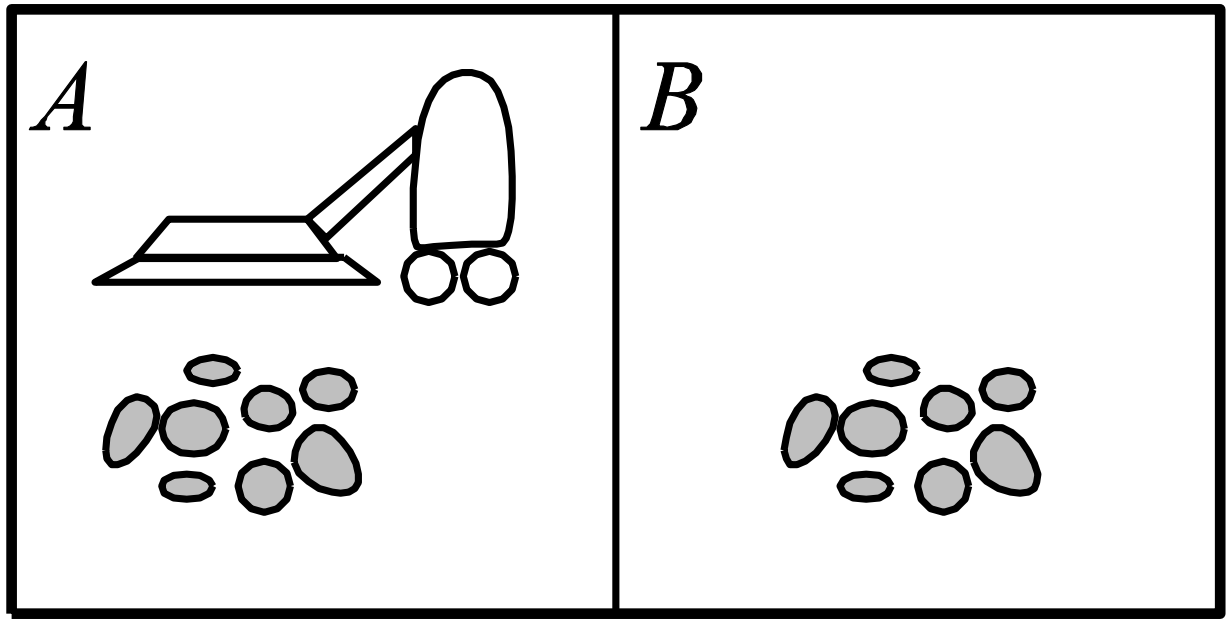


Figure 7: Vacuum Cleaner World

VACUUM CLEANER AGENT – PERCEPT SEQUENCE

Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean], [A, Clean]$	$Right$
$[A, Clean], [A, Dirty]$	$Suck$
⋮	⋮
$[A, Clean], [A, Clean], [A, Clean]$	$Right$
$[A, Clean], [A, Clean], [A, Dirty]$	$Suck$
⋮	⋮

Figure 8: Percept Sequence of Vacuum Cleaner Agent

THE CONCEPT OF RATIONALITY

- A rational agent is one that does the right thing.
- Conceptually, every entry in the table for the agent function is filled out correctly.
- When an agent is plunked down in an environment, it generates a sequence of actions according to the percepts it receives.
- This sequence of actions causes the environment to go through a sequence of states. **If the sequence is desirable, then the agent has performed well.**
- These can be achieved by **performance measure** that evaluates any given sequence of environment states.

Its's environment states and not agent states.

CONTINUE…

- The rationality is dependent on four things:

1. Performance measure that defines criterion for success.
2. Agent's prior knowledge of the environment.
3. Actions the agent can perform.
4. Agent's percept sequence to date.

- This gives us the definition of 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.

TASK ENVIRONMENT

- They are the “Problems”, for which we are designing the **rational agents** as “Solution”.
- **PEAS** Description of Task Environment

Performance Measure

Environment

Actuators (actions)

Sensors (what can be perceived from the give environment)

CONTINUE…

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

Figure 9: PEAS Description of "Taxi Driver Agent" Task Environment

PROPERTIES OF TASK ENVIRONMENT

- **Fully observable vs partially observable**
- **Single Agent vs Multi-agent**
- **Deterministic vs Stochastic**
- **Episodic vs Sequential**
- **Static vs Dynamic**
- **Discrete vs Continuous**
- **Known vs Unknown**

FULLY OBSERVABLE VS PARTIALLY OBSERVABLE

- Fully observable gives access to complete state of the environment.
- Complete state means aspects relevant to the action choices.
- Example: Multi-purpose mobile robot.

SINGLE AGENT VS MULTI-AGENT

- Single Agent – Crossword puzzle.
- Multi-agent – Chess, Taxi driving.
- Multi-agent means other agents may be competitive or cooperative and may require communication.
- Multi-agent may need communication.

DETERMINISTIC VS STOCHASTIC

- The next state is completely determined by current state and action on the current state.
- Uncertainty may arise because of defective actions or partially observable state *(i.e. Agent might not see everything in the environment that affects the outcome of an action)*.

EPISODIC VS SEQUENTIAL

- Episodic the agent's experience divided into atomic episodes
- Next episode not dependent on actions taken in previous episode. *(i.e. Assembly line)*
- Sequential – current action may affect future actions. *(i.e. playing chess, taxi driving)*
- Short-term actions have long-term effects.
- Must think forward in selection of an action.

STATIC VS DYNAMIC

- Does environment change while agent is deliberating?
- Static – crossword puzzle.
- Dynamic – taxi driver.

DISCRETE VS CONTINUOUS

- The state of the environment (*chess has finite number of discrete states*).
- The way time is handled (taxi driving continuous – speed and location of taxi sweep through range of continuous values).
- Percepts and actions (taxi driving continuous – steering angles).

KNOWN VS UNKNOWN

- This does not refer to the environment itself, but rather the agent's knowledge of it and how it changes.
- If unknown, the agent may need to learn.

Reinforcement Learning

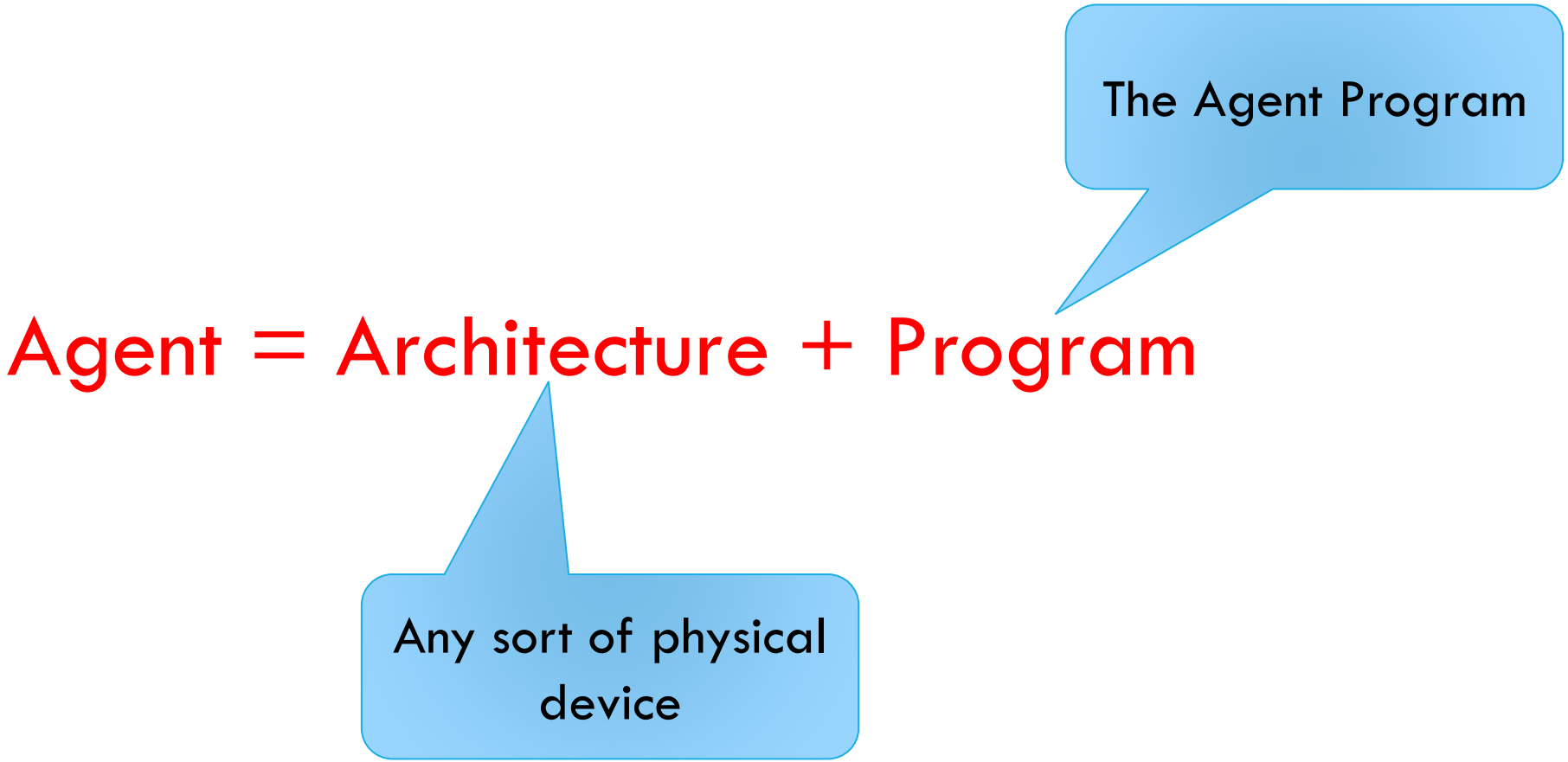
SUMMARY ON ENVIRONMENT

- Easy: Fully observable, Deterministic, Episodic, Static, Discrete, Single agent.

- Hard: Partially observable, Stochastic, Sequential, Dynamic, Continuous, Multi-Agent

THE STRUCTURE OF AGENT

THE STRUCTURE OF AN AGENT



AGENT PROGRAM

- Need to develop agent programs that take the current percept as input from the sensors and return an action to the actuators.
- We are expecting the improvements in performance measures in each action taken by the agent program.
- The key challenge for AI is to find out how to write programs that, to the extent possible, produce rational behavior from a small amount of code that can learn by its own.

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