WPI

CS 534
Artificial Intelligence

Week 1: Introduction to AI

By

Ben C.K. Ngan

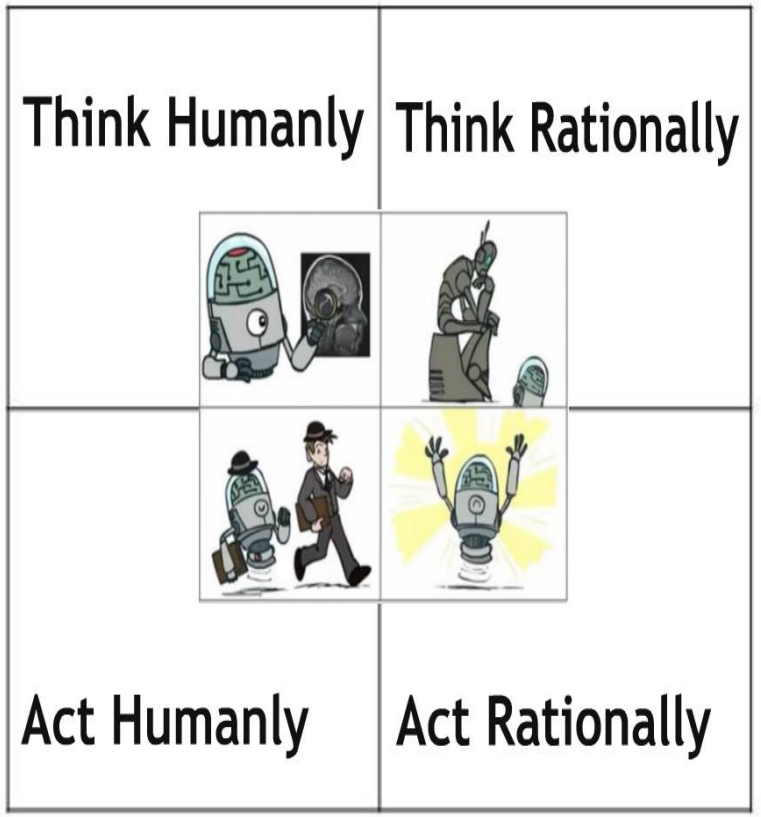
Worcester Polytechnic Institute

What is AI?

- **Definition:** It is an area of Computer Science that concerns not just understanding but also building a smart machine (a.k.a intelligent or software agent) that can do intelligent things to learn and solve problems. Those things may be:
  - Understand human language(s).
  - Have abilities of learning, reasoning, and problem solving.
  - Perform tasks or play games which typically require human intelligence.
  - Act effectively and safely in a wide variety of new environments.

- The capabilities of an intelligent machine are to **imitate** human behaviors and thoughts.

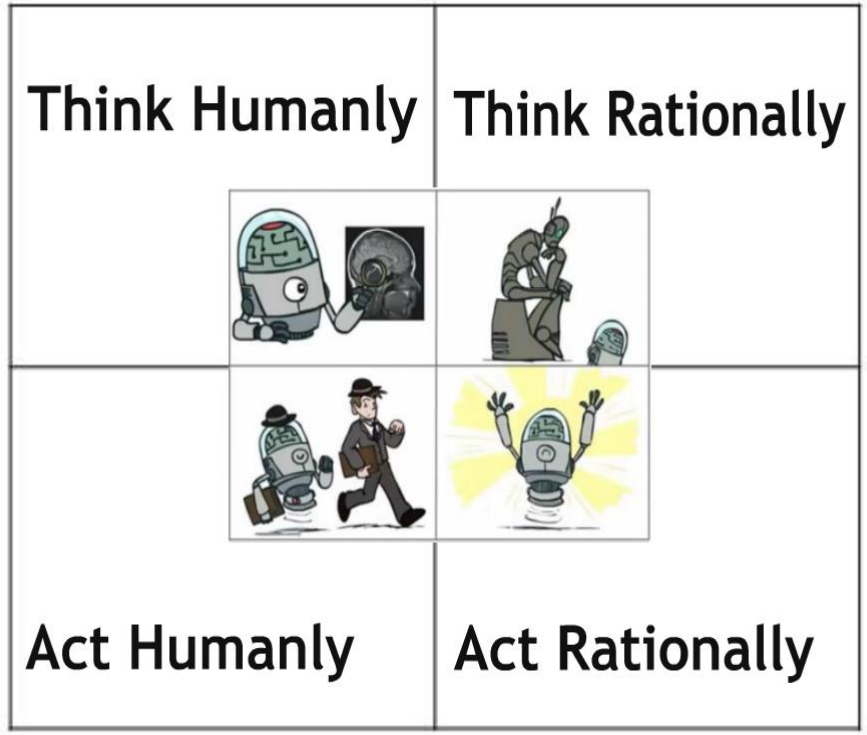
- Intelligence = **Perceive** + **Analyze** (Think Humanly and Rationally) + **React** (Act Humanly and Rationally).



https://kartikkukreja.wordpress.com/2015/05/17/what-is-ai-and-what-can-we-do-with-it-today/

What is AI?

- Intelligent agents **should** include these four categories:
  - Act Humanly, i.e., acting like a person
  - Think Humanly, i.e., thinking like a person
    - The difference between "acting humanly" and "thinking humanly" is that the first is only concerned with the actions/behaviors, i.e., the outcome or product of the human's thinking process;
    - Whereas the latter is concerned with modeling human thinking processes.
  - Think Rationally, i.e., thinking as a logical process, where conclusions are drawn based on some type of symbolic logic.
  - Act Rationally, i.e., performing actions that increase the value of the state of the agent or environment in which the agent is acting



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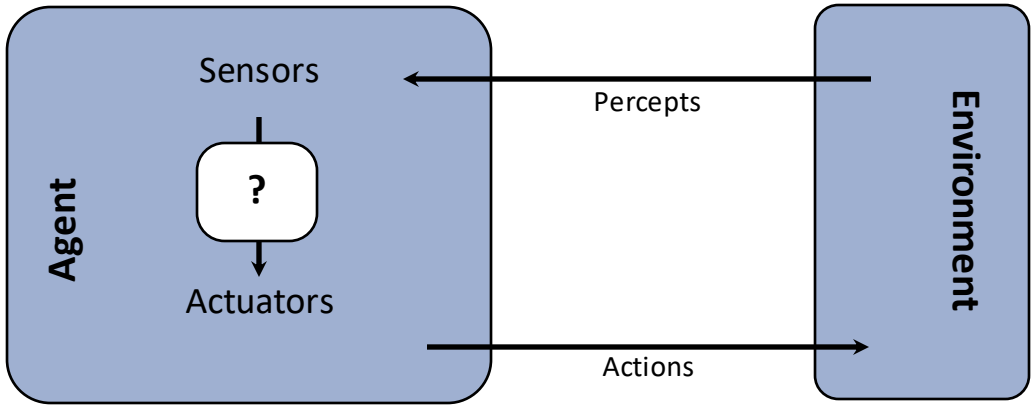
- An **intelligent agent** is an entity that perceives (i.e., to see, hear, or touch) information from the environment, then understands and thinks humanly/rationally (i.e., performs computations), and finally decides to takes the actions humanly/rationally/autonomously that maximize its expected utility, i.e., achieve the goal.



- Characteristics of the sensors, actuators, and environment dictate techniques for selecting rational actions.

Thinking Humanly: "Cognitive Modeling" Approach

- Understand and model how the human mind works

- Learn about Human Thought, i.e., how humans find the answer to a question, in at least Two Possible Ways:

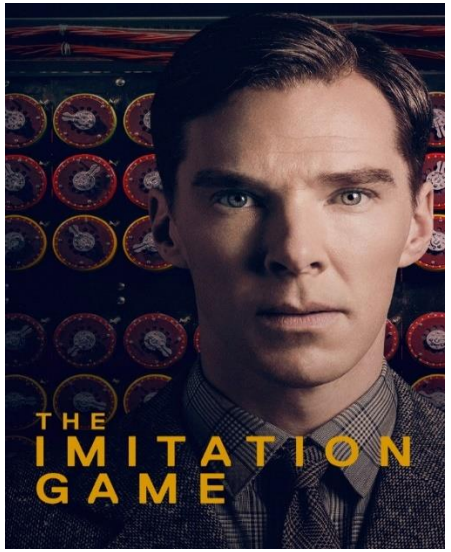
  - Introspection: Reason about it to find the answer, i.e., Deductive Reasoning.
  - Experiments: Conduct experiments to find the answer, i.e., Inductive Learning.

- Cognitive Science: It is the field of Modeling how humans think.

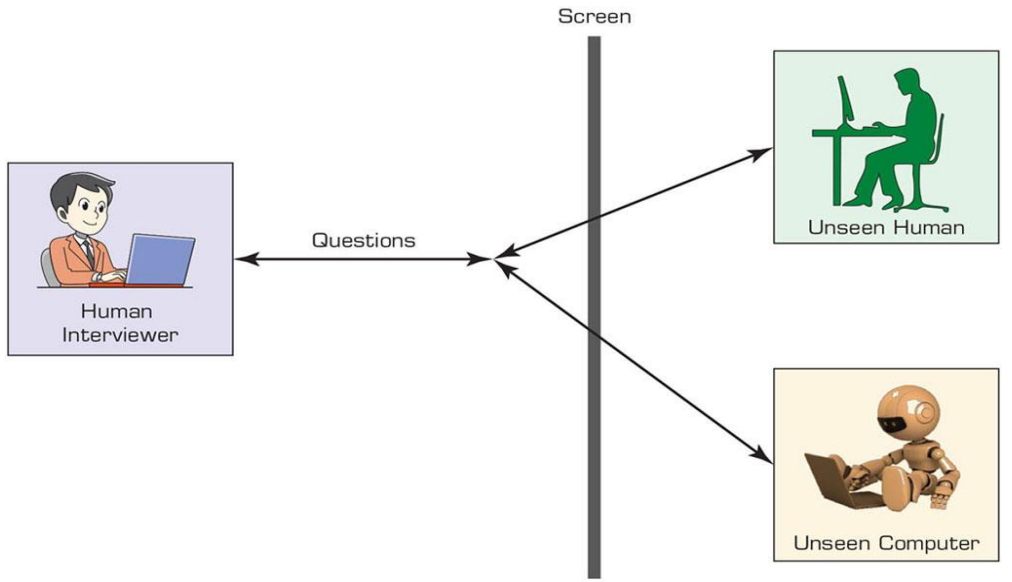
- How can we test the agent thinks humanly? Can you see or feel if the agent thinks like a human?

Acting Humanly: "Turing Test" Approach

- Alan Turing (1950): "*Computing Machinery and Intelligence*":
- The paper, published in 1950 in the journal, *Mind*
- He tried to answer the question: Can machines think? → Can a machine possess the capabilities like a human being?
- The "Turing Test (TT)": A computer can be considered smart only when a human interviewer asking the same questions to both an unseen human and an unseen computer **cannot determine which is which** ➔ The machine can be considered intelligent.
- The TT is designed to measure the performance of an intelligent machine against humans, for its intelligent behavior. Turing called it "Imitation Game".



It is the movie about how Alan Turing decrypted German intelligence messages for the British government during World War II, 1942



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What is Artificial Consciousness?

- Artificial consciousness (also known as machine consciousness, synthetic consciousness or AI consciousness):
  - Refer to a non-biological, human created machine that is aware of **its own existence**.
  - Implies more than just intelligence – it implies **sentience** and being **self-aware**.

- New research shows that babies display consciousness and memory **as early as 5 months old**.

- Does a non-biological, human created machine know if it is "alive" or not, it is male or female, its response is a true or a lie, etc.?
  - Intelligence can (arguably) be quantified through **IQ tests**
  - Testing whether artificial consciousness has been achieved will be **a philosophical question rather than a technical approach**.

Acting Humanly: "Turing Test" Approach

- To pass the Turing test, an AI machine will need to be capable of:

    1. Represent knowledge, i.e., to store what it has known already.
    2. Reason automatically, i.e., to answer questions and to draw new conclusions.
    3. Learn by itself, i.e., to adapt a new environment and to detect and extrapolate patterns.
    4. Process natural language, i.e., to communicate successfully in a human language.

- Turing viewed the ***physical simulation*** of a person as unnecessary to demonstrate a machine intelligence. ***Turing test only involves text input and text output in 1950.***

- For the "TOTAL Turing Test (TTT)" proposed by other researchers, ***a robot*** requires physical interaction with objects and people in the real world. To pass the TTT, a machine will also need to:

    5. "See" and "Hear" the world, i.e., Computer Vision and Speech Recognition, to perceive the world
    6. "Move itself and manipulate objects and interact with humans", i.e., Robotic Engineering

- These six disciplines compose most of AI.

Thinking Rationally: "Laws of Thought" Approach

- Understand how humans actually think and model how we should think and reason in an ideal world.

- Draw justifiable conclusions from data, rules, and logic.

- Syllogisms: Uses symbolic logic to capture the laws of rational thought
  - Socrates is a man. All men are mortal.
  - Therefore, Socrates is mortal

Acting Rationally: "Rational Agent" Approach

- Acting Rationally means an agent acts to achieve one's goals, given one's beliefs or understanding about the world.

- An agent is a system that perceives an environment and acts within that environment. An intelligent agent is one that acts rationally with respect to its goals.

- An agent is **a function *F*** from percept environments to actions, i.e., F: $P^* \rightarrow A$
  - Rational behavior: doing the right thing
  - The right thing: that which is expected to maximize goal achievement, given the available information

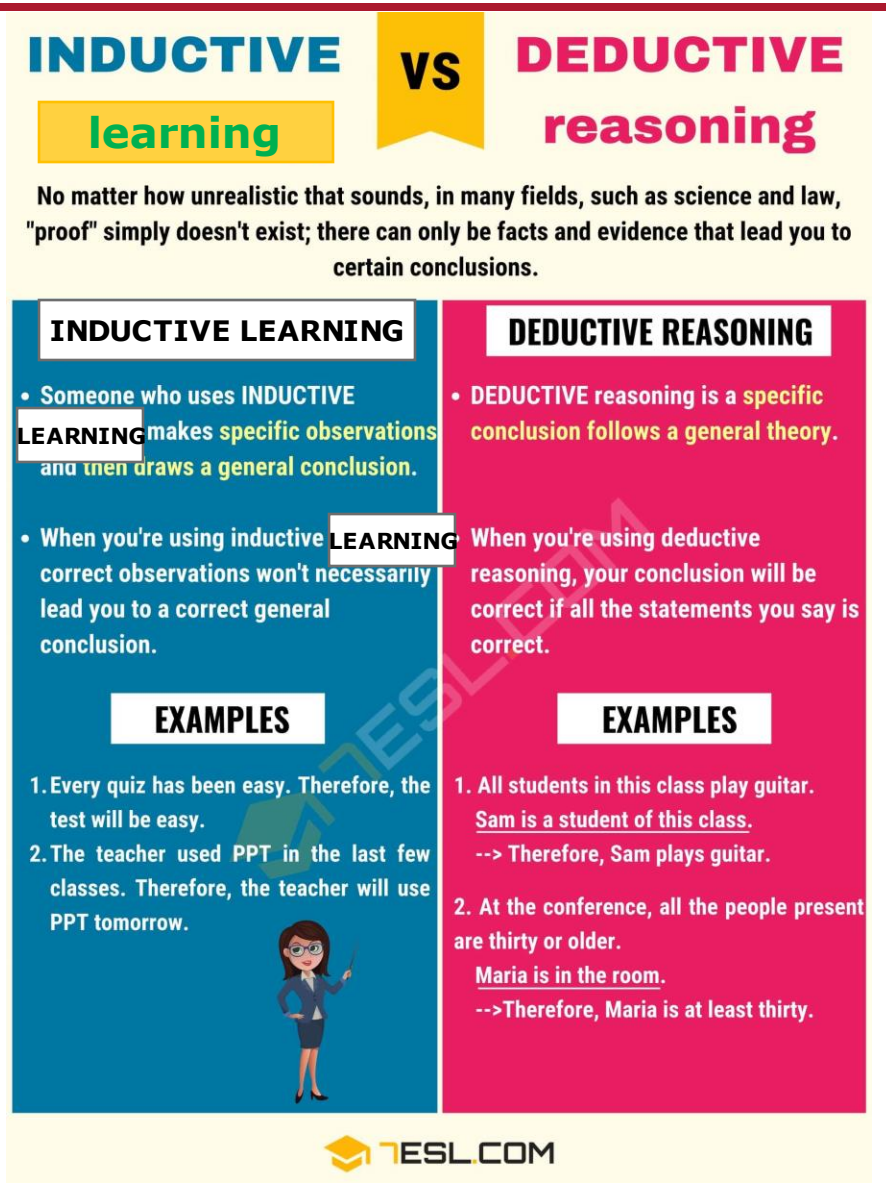
Deductive Reasoning vs. Inductive Learning

- These two approaches form the dominant themes of artificial intelligence: **Deductive Reasoning** and **Inductive Learning**

- **Deductive Reasoning (Generalization → Specification)**: From general facts/hypotheses to specific facts/examples
  - Start with a knowledge base of general facts and hypotheses and then uses logical inferences/rules to reason about unknown facts **to make specific conclusions**
  - Methods: Search-based Algorithms
  - Week 1 ~ Week 4 Topics

- **Inductive Learning (Specification → Generalization)**: From specific facts/examples to general facts/hypothesis
  - Learn from data instances and specific examples **to build general facts/hypotheses** that are used to make predictions about new examples.
  - Methods: Machine/Deep Learning
  - Week 5 ~ Week 10 Topics

- The future of AI largely depends on **integrating these two approaches** to make intelligent choices.

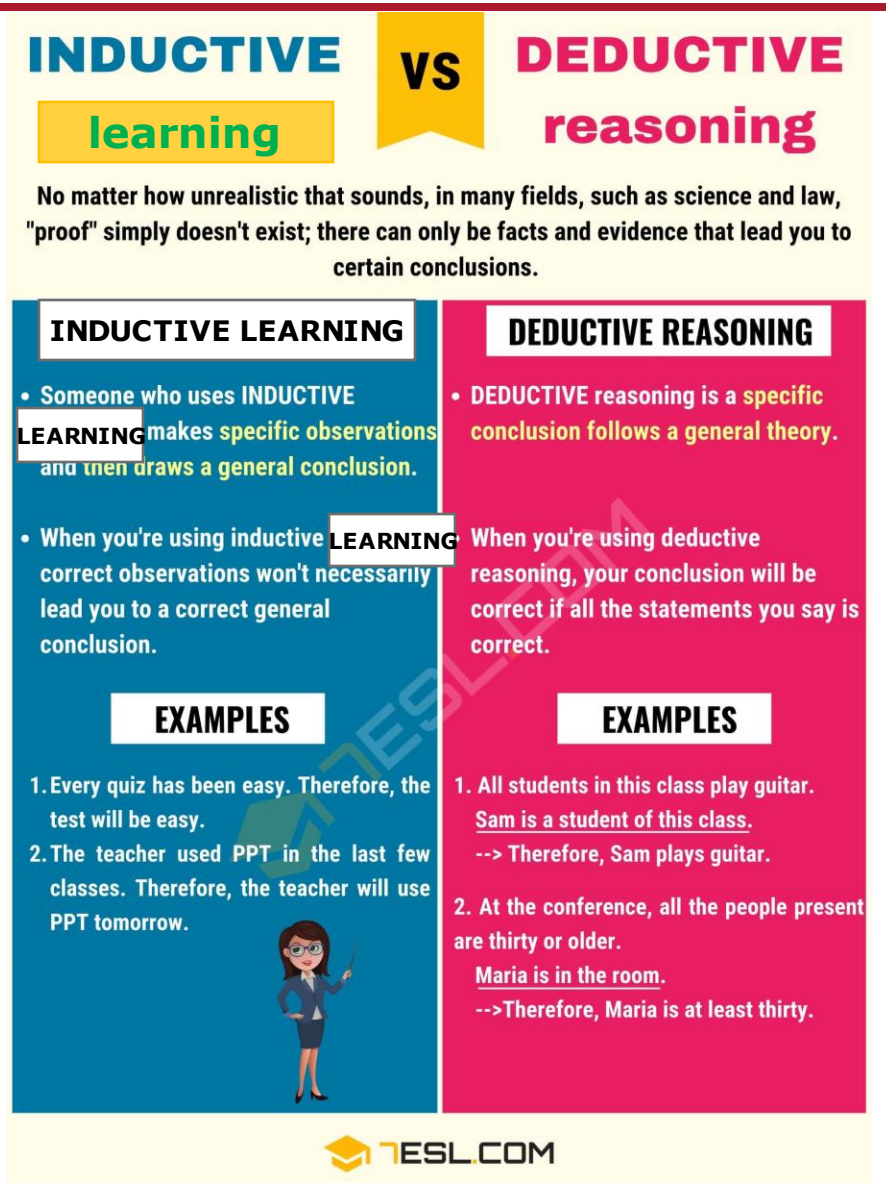


Deductive Reasoning vs. Inductive Learning

- **Deduction versus Induction**
  - Deduction:
    - Move from the general to the specific.
    - All canine animals have four legs. All dogs have four legs. Therefore, dogs are canines.
  - Induction:
    - Move from the specific to the general.
    - I saw a couple of dogs yesterday. Both had four legs. Therefore, all dogs have four legs.

- **Reasoning versus Learning**
  - Reasoning: A chain of assertations are connected.
  - Learning: Statistical inference on many examples are used to make conclusions.

- Deductive methods are reasoning methods; Inductive methods are learning methods.



Deductive Reasoning vs. Inductive Learning

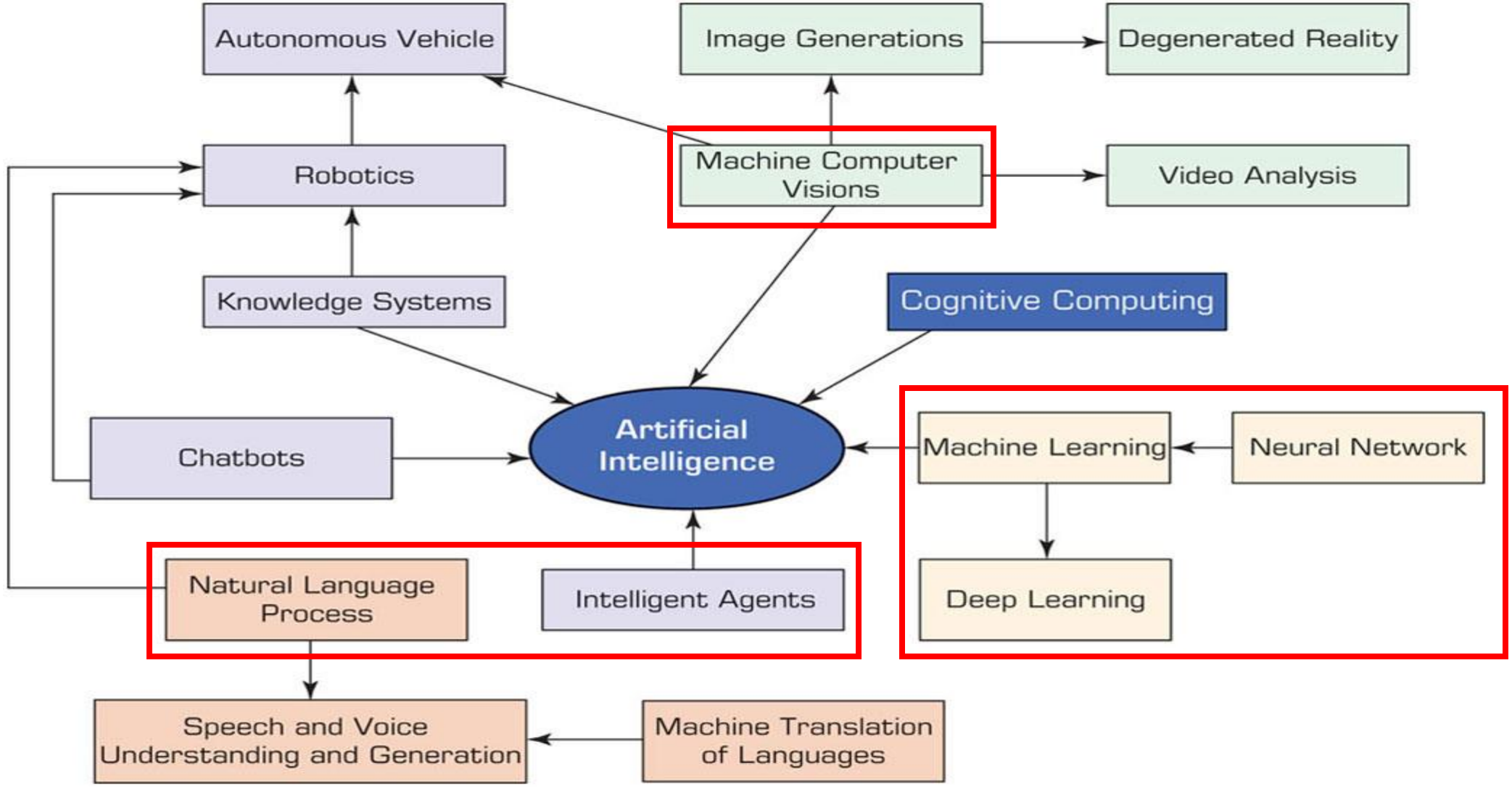
System	Inductive learning or deductive reasoning?
TurboTax	Deductive reasoning
WebMD symptom checker	Deductive reasoning
Deep Blue chess	Deductive reasoning
AlphaZero chess	Inductive learning
Flag all emails from blacklisted senders as spam	Deductive reasoning
Flag spam by comparing email content with that of previous spam/non-spam emails	Inductive learning
Using a grammar book to learn a language	Deductive reasoning
Picking up a language by conversation	Inductive learning
Combining a grammar book with conversational practice	Combining induction and deduction
Perusing the mathematical rules of algebraic manipulation	Deductive reasoning
Perusing a worked example to learn algebraic manipulation	Inductive learning
Using prior knowledge to reduce data requirements in machine learning (also called *regularization*)	Combining induction and deduction

Overview of Topics in this Course

- Deductive Reasoning (Generalization → Specification): Week 1 ~ Week 4
  - Intelligent Agents
  - Problem-Solving Techniques
  - Different Searching Algorithms

- Inductive Learning (Specification → Generalization): Week 5 ~ Week 10
  - Supervised Machine Learning
  - Deep Learning
  - Natural Language Processing

The Major AI Technologies



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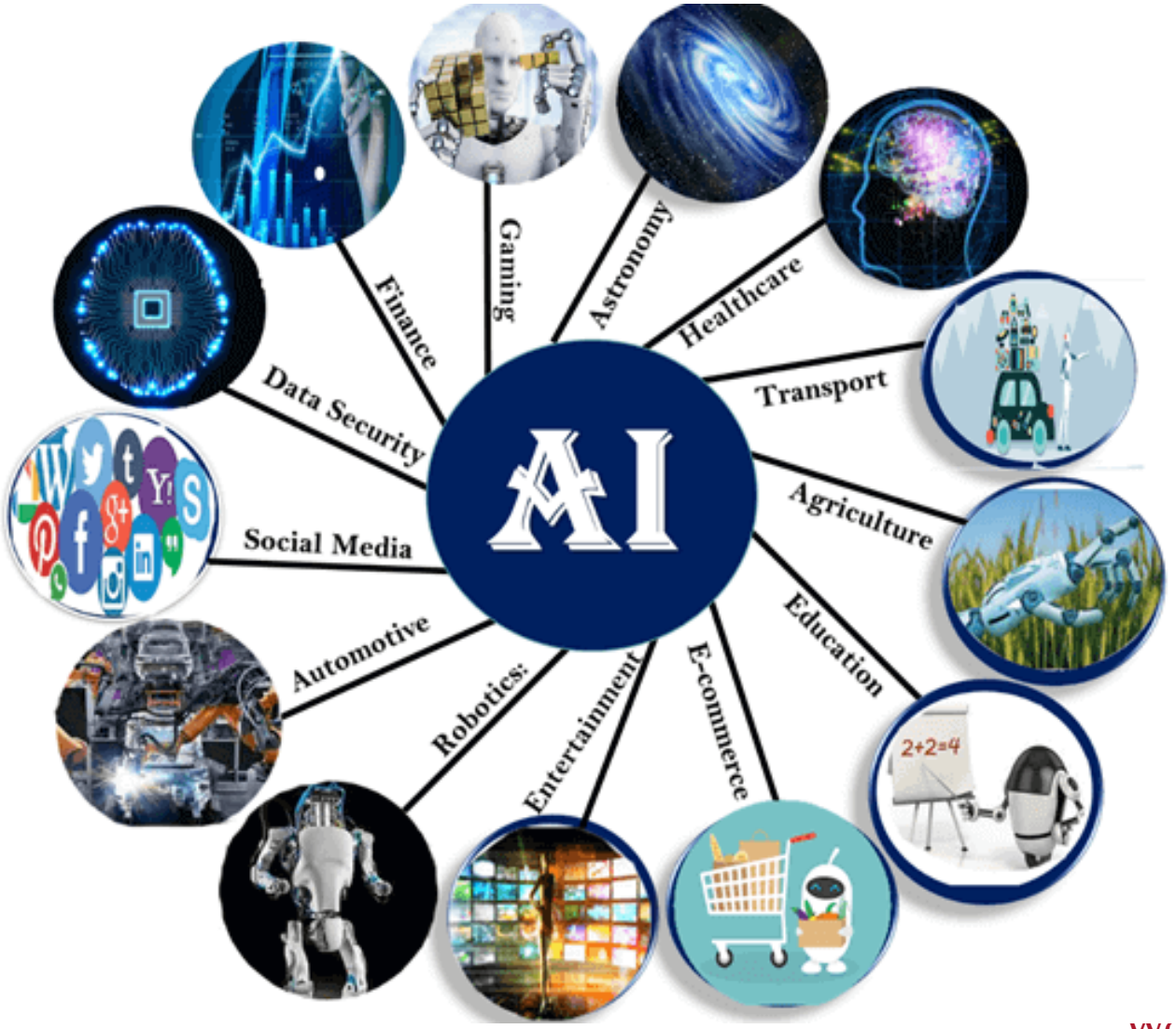
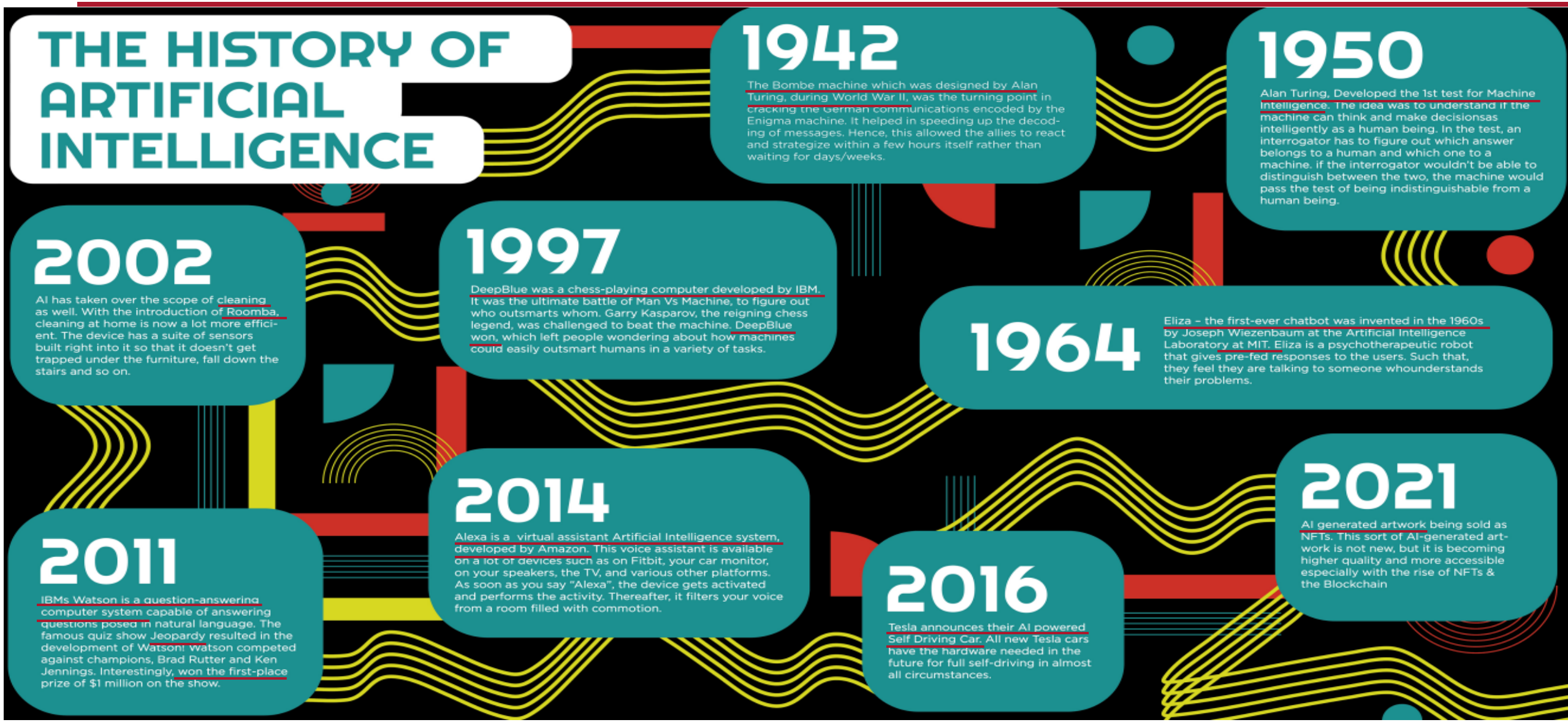
AI in Everyday Life

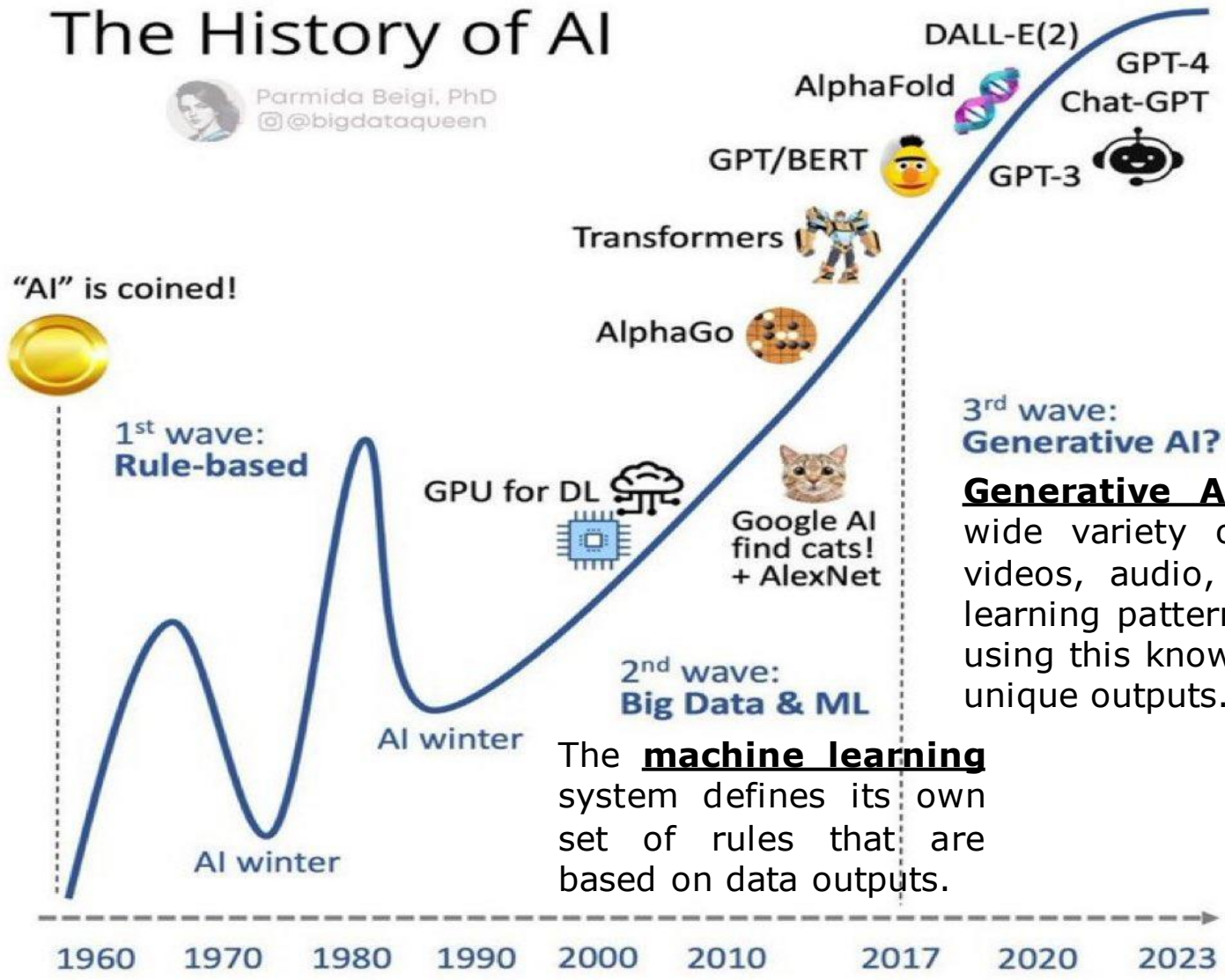


History of AI



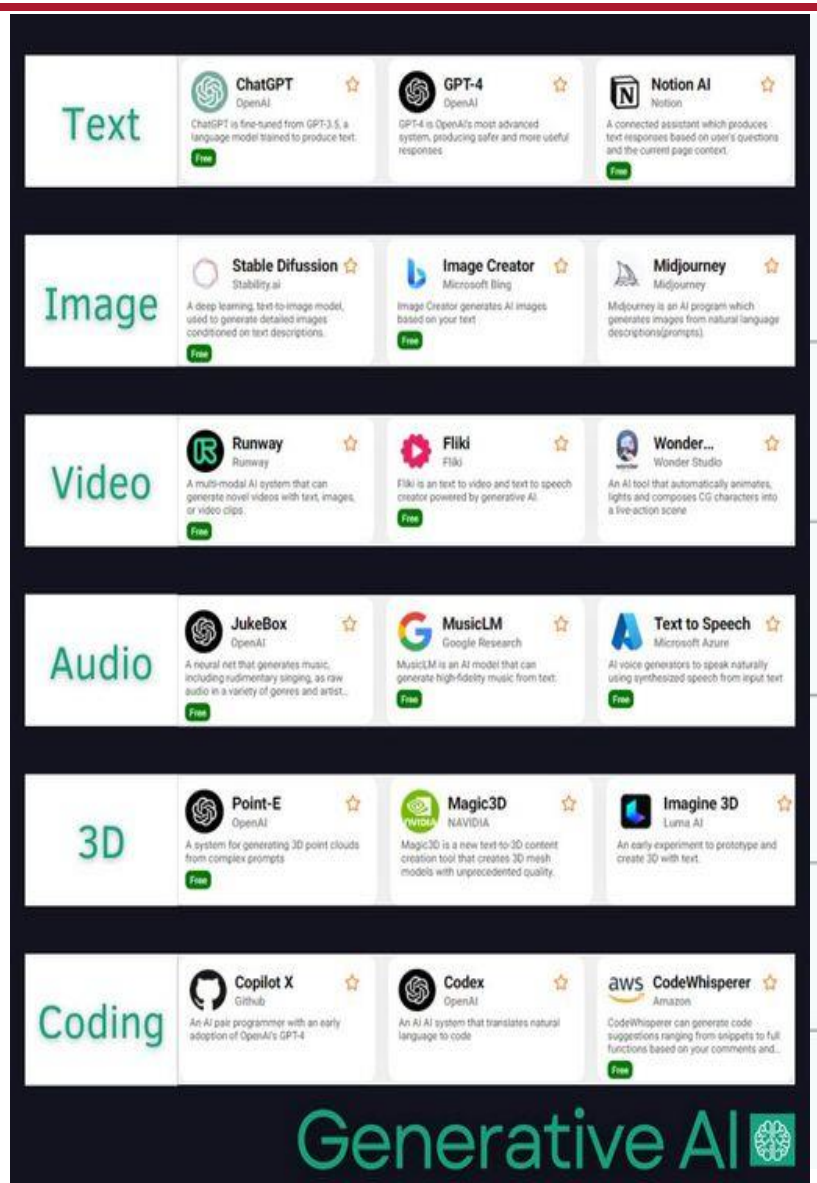
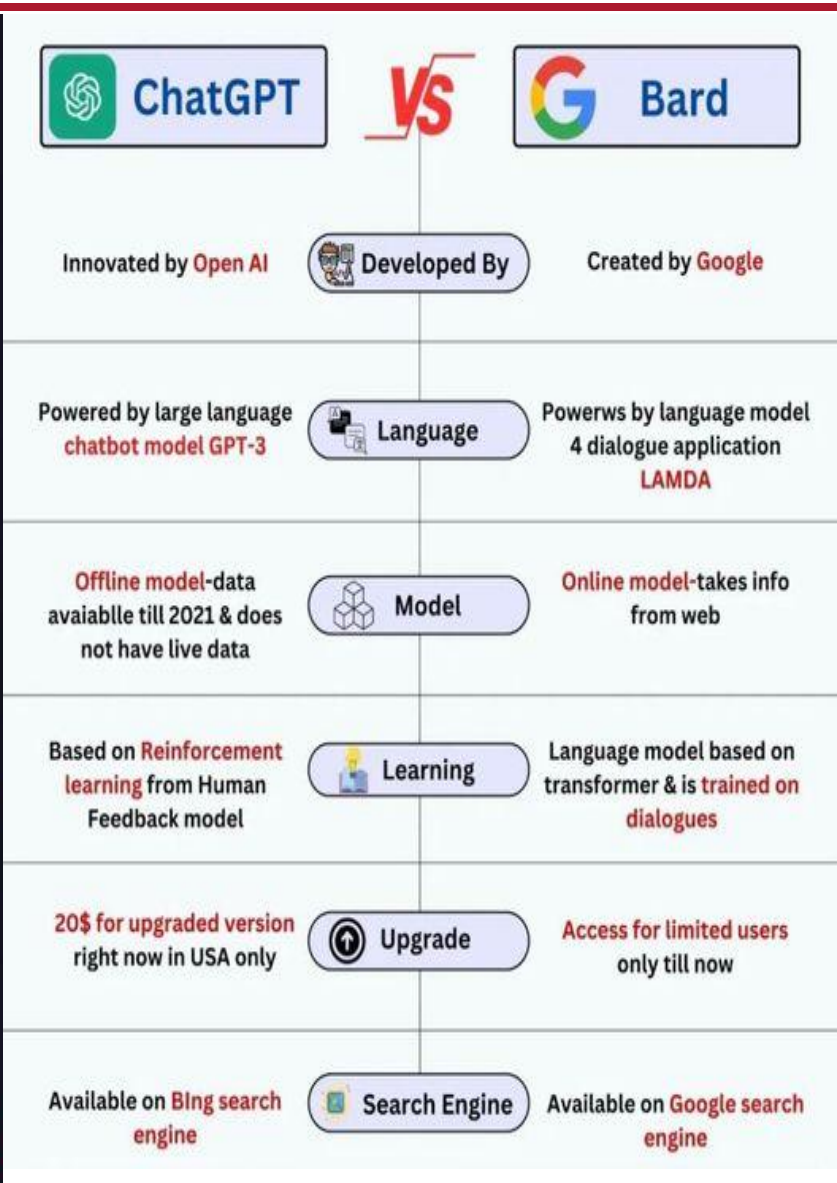
History of AI

- A **rule-based** artificial intelligence produces pre-defined outcomes that are based on a set of certain rules coded by humans.
- These systems are simple artificial intelligence models which utilize **the rule of if-then coding statements**.
- The two major components of rule-based artificial intelligence models are **"a set of rules"** and **"a set of facts"**.



The **machine learning** system defines its own set of rules that are based on data outputs.

Generative AI (GenAI) can create a wide variety of data, such as images, videos, audio, text, and 3D models, by learning patterns from existing data, then using this knowledge to generate new and unique outputs.

Generative AI Technologies

- Generative AI is a type of artificial intelligence technology that can produce various types of content, including text, imagery, audio and synthetic data.
- Generative AI starts with a prompt that could be in the form of a text, an image, a video, a design, musical notes, or any input that the AI system can process.
- Various AI algorithms then return new content in response to the prompt. Content can include essays, solutions to problems, or realistic fakes created from pictures or audio of a person.
- OpenAI ChatGPT and Google Bard are popular generative AI interfaces.