CS 4341
Introduction to Artificial Intelligence
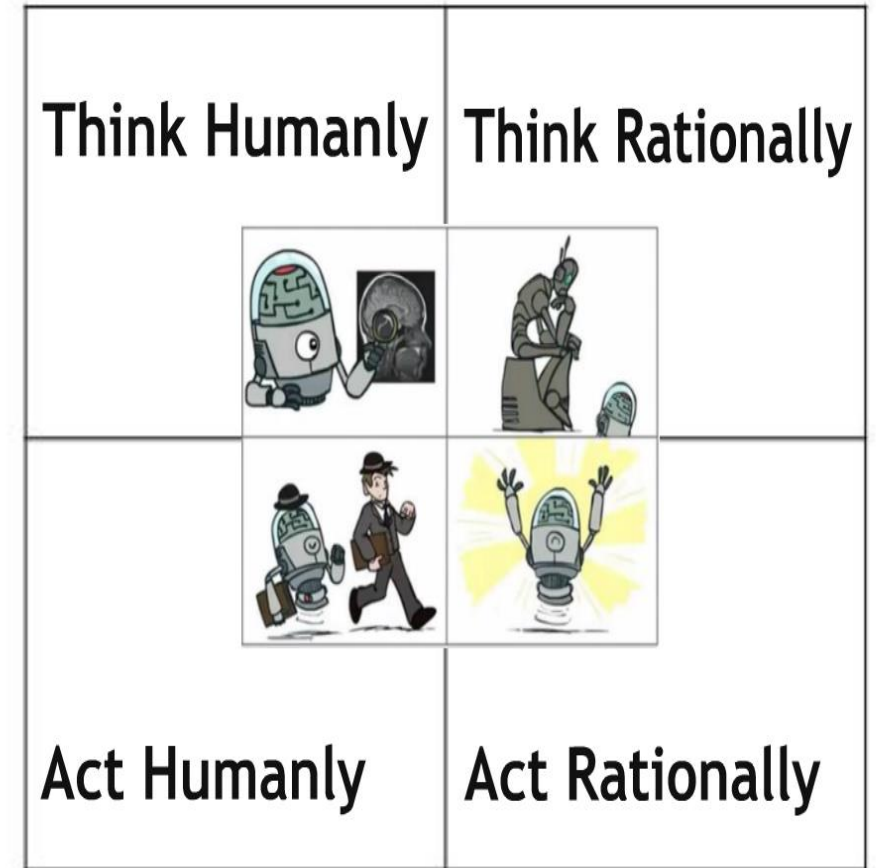
Lecture 1: Introduction to AI

By

Ben C.K. Ngan

What is AI?

- **Definition:** It is a specialized branch of Computer Science that not only 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 **autonomously** and **adaptively**. Those things may be:

  — Understand human language(s).

  — Have abilities of learning, problem solving, and reasoning.

  — Perform tasks or play games, like humans, which typically require human intelligence.

  — Act effectively and safely in a wide variety of new environments.

- **Autonomous** means that something does not need to be provided constant instructions by human beings.

- **Adaptive** means that it can change its behavior/action as the environment or problem space changes.
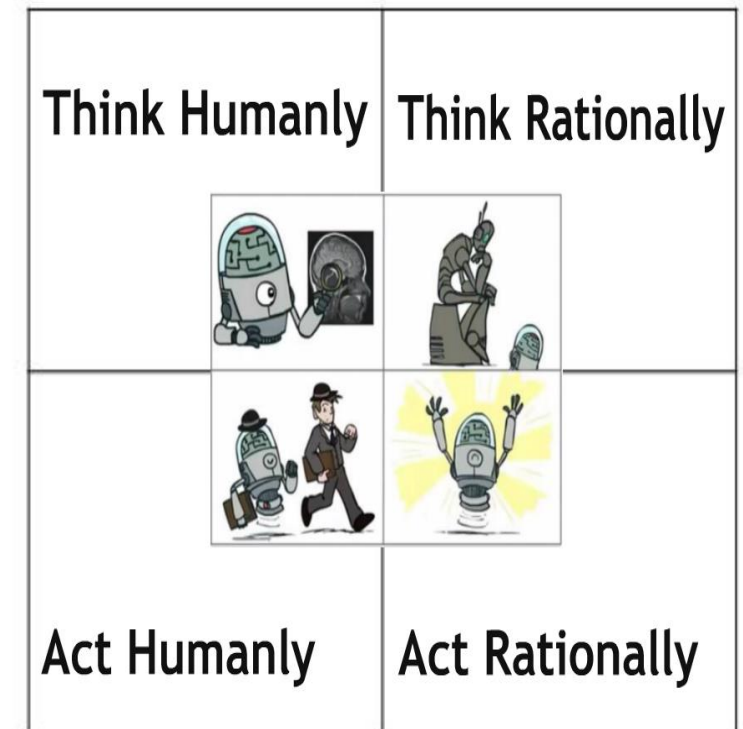
What is AI?

- In summary, AI is to build machines/agents to do intelligent things, that is, learn and solve problems **autonomously** and **adaptively**, **similar to the natural intelligence** of humans, that results in the capabilities of an intelligent machine/agent to **imitate** human behaviors and thoughts.

- In short, AI Agent = **Perceive** + **Analyze** (Think Humanly and Rationally) + **React** (Act Humanly and Rationally) **autonomously** and **adaptively**.

Think Humanly	Think Rationally
Act Humanly	Act Rationally

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

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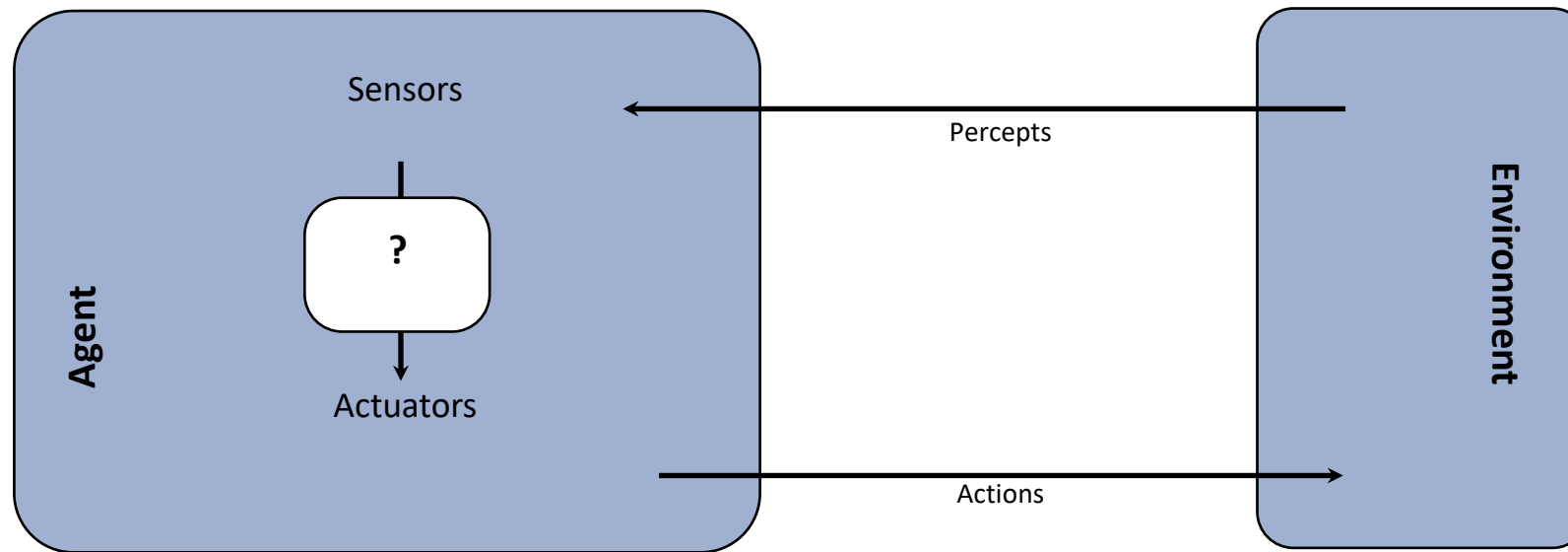
What is AI?

- AI agents **should** include these four categories:

  - **Analyze**

    - Think Humanly, i.e., thinking <u>like</u> a person that is concerned with modeling human thinking processes, i.e., Cognitive Science.
    - Think Rationally, i.e., thinking as a logical process, where conclusions are drawn based on some type of **symbolic logic that is a way to represent logical expressions and ideas by using symbols and variables in place of natural language, such as English, Chinese, Japanese, etc.**.

  - **React**

    - Act Humanly, i.e., acting <u>like</u> a person. The difference between "acting humanly" and "thinking humanly" is that the first is only concerned with the <u>actions/behaviors</u>, i.e., the outcome or product of the human's thinking process.
    - Act Rationally, i.e., performing actions that **increase the value of the state of the agent/machine or environment** in which the agent is acting.

Think Humanly	Think Rationally
Act Humanly	Act Rationally

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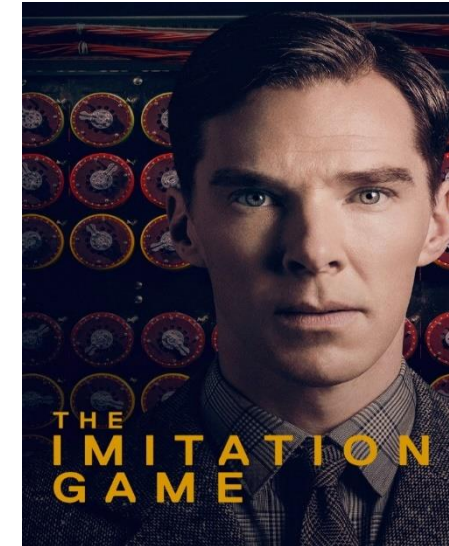
What is AI?

- An **AI agent/machine** is an entity that perceives (i.e., to see, hear, smell, taste, 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/adaptively** that maximize its expected utility, i.e., achieve the goal.

- Characteristics of the **sensors**, **actuators**, and **environment** dictate techniques for selecting rational actions.
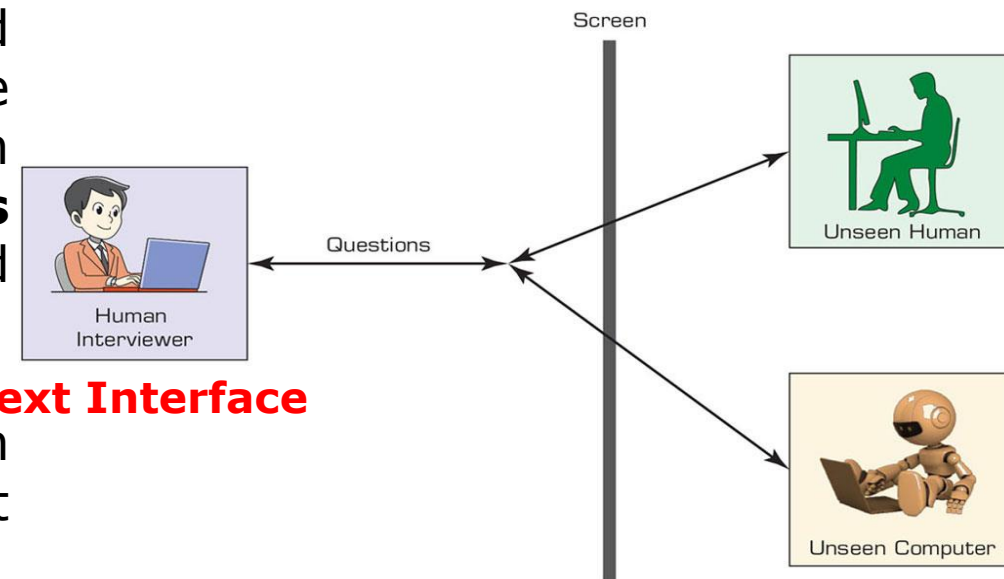
"Turing Test" Approach

- 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 "humanly"? → 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
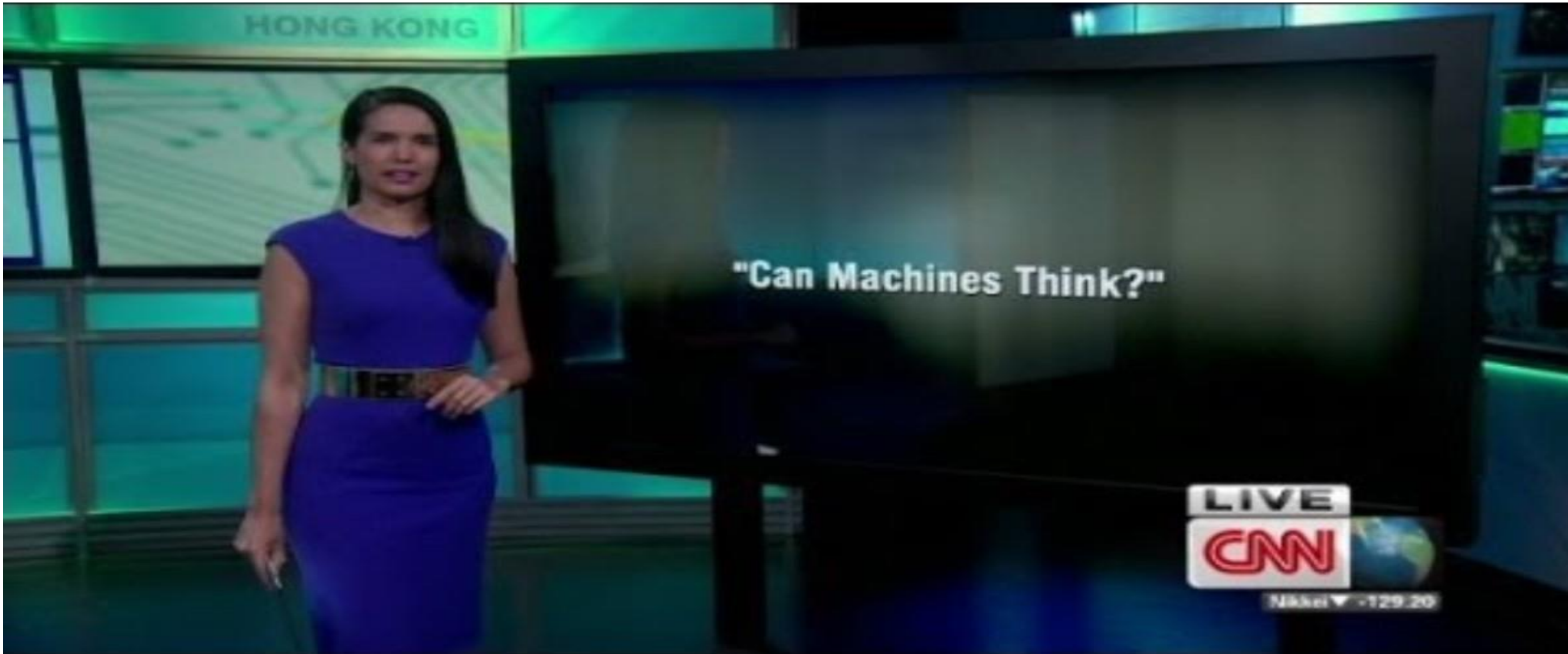
Text Interface

Screen

Questions

Human Interviewer

Unseen Human

Unseen Computer

"Turing Test" Approach

2014 (after 64 years): Eugene Goostman Chatbot

What is Artificial Consciousness?

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

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

- Does a non-biological AI machine know whether it is "alive" or not, its response is a true or a lie, etc.?
  — Intelligence can (arguably) be quantified through **IQ tests and Exams: GPT-4 Technical Report - OpenAI**.
  — Testing whether artificial consciousness has been achieved will be **a philosophical question rather than a technical approach**.

What is Artificial Consciousness?

GPT-4 Technical Report by OpenAI

Exam	GPT-4	GPT-4 (no vision)	GPT-3.5
Uniform Bar Exam (MBE+MEE+MPT)	298 / 400 (~90th)	298 / 400 (~90th)	213 / 400 (~10th)
LSAT	163 (~88th)	161 (~83rd)	149 (~40th)
SAT Evidence-Based Reading & Writing	710 / 800 (~93rd)	710 / 800 (~93rd)	670 / 800 (~87th)
SAT Math	700 / 800 (~89th)	690 / 800 (~89th)	590 / 800 (~70th)
Graduate Record Examination (GRE) Quantitative	163 / 170 (~80th)	157 / 170 (~62nd)	147 / 170 (~25th)
Graduate Record Examination (GRE) Verbal	169 / 170 (~99th)	165 / 170 (~96th)	154 / 170 (~63rd)
Graduate Record Examination (GRE) Writing	4 / 6 (~54th)	4 / 6 (~54th)	4 / 6 (~54th)
USABO Semifinal Exam 2020	87 / 150 (99th - 100th)	87 / 150 (99th - 100th)	43 / 150 (31st - 33rd)
USNCO Local Section Exam 2022	36 / 60	38 / 60	24 / 60
Medical Knowledge Self-Assessment Program	75 %	75 %	53 %
Codeforces Rating	392 (below 5th)	392 (below 5th)	260 (below 5th)
AP Art History	5 (86th - 100th)	5 (86th - 100th)	5 (86th - 100th)
AP Biology	5 (85th - 100th)	5 (85th - 100th)	4 (62nd - 85th)
AP Calculus BC	4 (43rd - 59th)	4 (43rd - 59th)	1 (0th - 7th)
AP Chemistry	4 (71st - 88th)	4 (71st - 88th)	2 (22nd - 46th)
AP English Language and Composition	2 (14th - 44th)	2 (14th - 44th)	2 (14th - 44th)
AP English Literature and Composition	2 (8th - 22nd)	2 (8th - 22nd)	2 (8th - 22nd)
AP Environmental Science	5 (91st - 100th)	5 (91st - 100th)	5 (91st - 100th)
AP Macroeconomics	5 (84th - 100th)	5 (84th - 100th)	2 (33rd - 48th)

What is Artificial Consciousness?

Some Philosophical Questions

- What is the meaning of life or death?

- If a perfect simulation of life is possible, would you choose to live in it?

- Do we have free will, or is everything predetermined?

- Can an AI be moral or have a conscience?

- What should be done with autonomous weapons and how can we prevent AI from being used for harm?

- If an AI were to act "unethically," who would be responsible?

- How should an AI be programmed to align with human values, especially when those values are conflicting?

- Can machines have a mind or consciousness?

- Is intelligence the same as consciousness? Can a machine be intelligent without being conscious?

- Is AI a new kind of mind, or a tool that mimics the mind?

"Turing Test" Approach

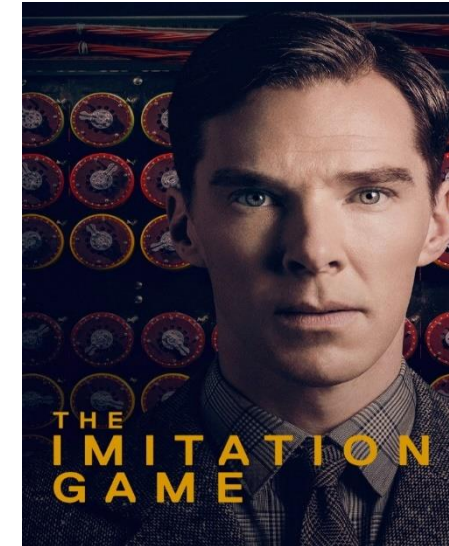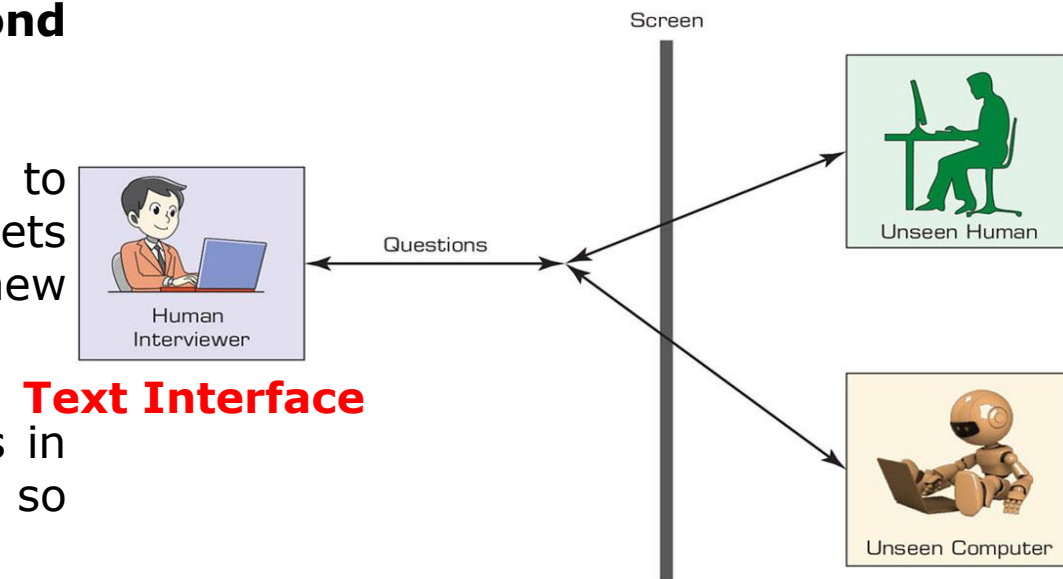**2022 (after 72 years): LaMDA - Is Google's AI sentient?**

"Turing Test" Approach

- To pass this Turing test, the machine needs to master the following thing:

  — **Natural Language Processing**: The machine needs to parse the human-language sentence, extract the context, and give an appropriate answer.

  — **Knowledge Representation**: The machine needs to store the information provided before the interrogation. It also needs to keep track of the information being provided during the conversation so that it can **respond appropriately** if it comes up again.

  — **Reasoning**: It is important for the machine to understand how to interpret the information that gets stored so that it can answer questions and draw new conclusions.

  — **Learning**: The machine can adapt to new conditions in real time; and needs to analyze and detect patterns so that it can draw inferences.

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Text Interface

Screen

Questions

Human Interviewer

Unseen Human

Unseen Computer

THE IMITATION GAME

"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. That is, the *direct physical interaction* between the human and the machine *is not needed*. **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.

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Problem Types and Problem-solving Paradigms

- **1. Search problems: Find a path to a solution**
  - A search problem involves a situation that has multiple possible solutions, each of which represents a sequence of steps (path) toward a goal.
  - An example is determining the shortest path between cities on a map.

- **2. Optimization problems: Find a good solution**
  - An optimization problem involves a situation in which there are a vast number of valid solutions and the absolute-best solution is difficult to find.
  - An example is packing luggage in the trunk of a car in such a way as to maximize the use of space.

- **Local Best versus Global Best**
  - A local best solution is the best solution within a specific area in the search space
  - A global best is the best solution in the entire search space.
  - Usually, there are many local best solutions and one global best solution.
  - An example is finding the best restaurant in your local area, but it may not necessarily be the best restaurant in the country or the best restaurant in the world.

Problem Types and Problem-solving Paradigms

- **3. Regression and classification problems: Learn from patterns in data**
  - Regression problems are problems in which we have data about something and want to try to find patterns.

    - Examples are predicting house prices based on size and location, forecasting sales using historical data and advertising spend, or estimating a student's final course grade from their homework completion

  - Classification problems are problems in which we find patterns in the data that group examples into categories.

    - Examples are spam detection (categorizing emails as spam or not spam), image recognition (identifying objects like a cat or dog in a picture), medical diagnosis (predicting whether a tumor is malignant or benign), and fraud detection (classifying a transaction as fraudulent or legitimate)

Problem Types and Problem-solving Paradigms

- **4. Clustering problems: Identify patterns in data**
  - Clustering problems include scenarios in which trends and relationships are uncovered from data. Different aspects of the data are used to group examples in different ways.

  - <u>Examples</u> are market segmentation to group customers by behavior, image analysis to find patterns in visual data, gene sequencing to find genetic similarities, and document clustering to group similar articles.

- **Deterministic Machine Learning Models** are models that, given a specific input, return a consistent output in each time.

- **Stochastic/probabilistic Machine Learning Models** are models that, given a specific input, usually have an element of controlled randomness to return an outcome from a set of possible/different outcomes in each time.

AI in Everyday Life

Some Contemporary AI Applications in Our Lives

- **Personal Assistants/chatbots** rely on AI to understand what you have said and follow the instructions to perform tasks accordingly.

- **Online Entertainment Services** rely on AI to figure out what you might like and recommend songs and movies.
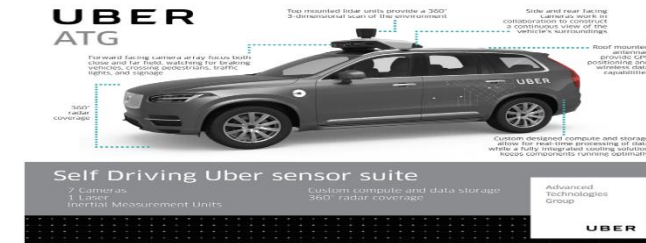

- **Recommendation Services** analyze your online activities to deliver targeted advertisement.

Some Contemporary AI Applications in Our Lives

- **Personal Chauffeurs** are the self-driving cars that can travel along a pre-established route with no human assistance.

- **Shipping and Warehouse Management** rely on AI agents to take customer orders and decide where to route merchandise. The robots act as mules carrying the pallets and inventory around the warehouse.

- **Knowledge Search** uses deep learning to assist in generating search query responses.

- In short, AI has been used in different domains, including healthcare, manufacturing, driverless cars, finance, agriculture, smart home, gaming, movie making, and more.

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Three Levels of AI

- **Narrow AI**
  - It also called *weak AI* or *artificial narrow intelligence (ANI)* that refers to the AI to solve **a specific problem**. Almost all AI applications today are narrow AI.
  - Some examples are Image Classification, object detection, speech recognition, translation, NLP, weather forecasting, sales predictions, face recognition, and more.
  - It is what we can focus on this course.

- **General AI**
  - It also called *strong AI* or *artificial general intelligence (AGI)* that refers to the AI to solve **general problems**.
  - It encompasses memory, spatial reasoning through visual inputs, use of knowledge, and more.
  - The example is more like a human being, which is able to learn, think, invent, and solve more complicated problems.

- **Super AI**
  - It also called *superintelligence* that refers to AI to integrate human and machine together through a brain chip interface.
  - All machines are connected, are able to reason about things beyond our understanding, and dominate humans.
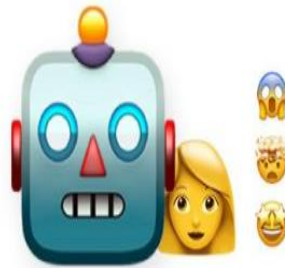

Narrow AI

Definition:
Technology that outperforms humans in some very narrowly defined task.
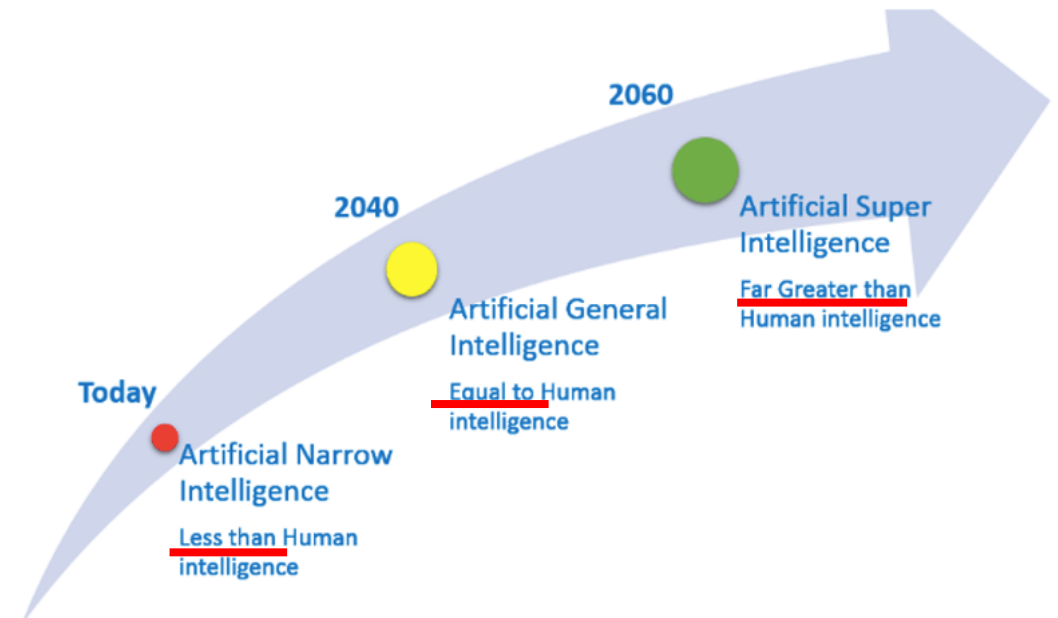
General AI

Definition:
Type of intelligence that really simulates the breadth of the human intellect, rather than focusing on more specific tasks.

Super AI

Definition:
When the capability of computers will surpass humans.

Today
Artificial Narrow Intelligence
Less than Human intelligence

2040
Artificial General Intelligence
Equal to Human intelligence

2060
Artificial Super Intelligence
Far Greater than Human intelligence
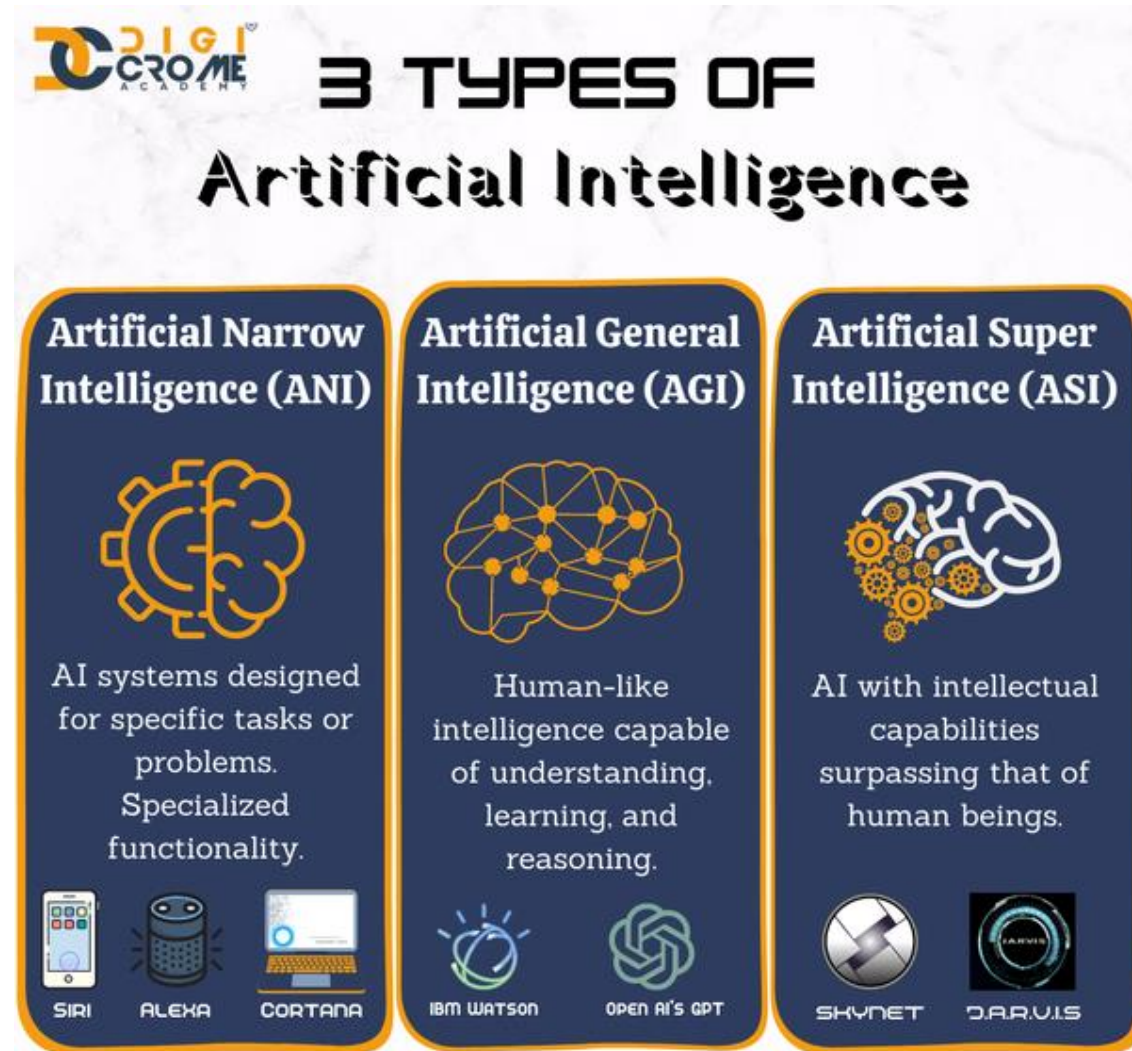
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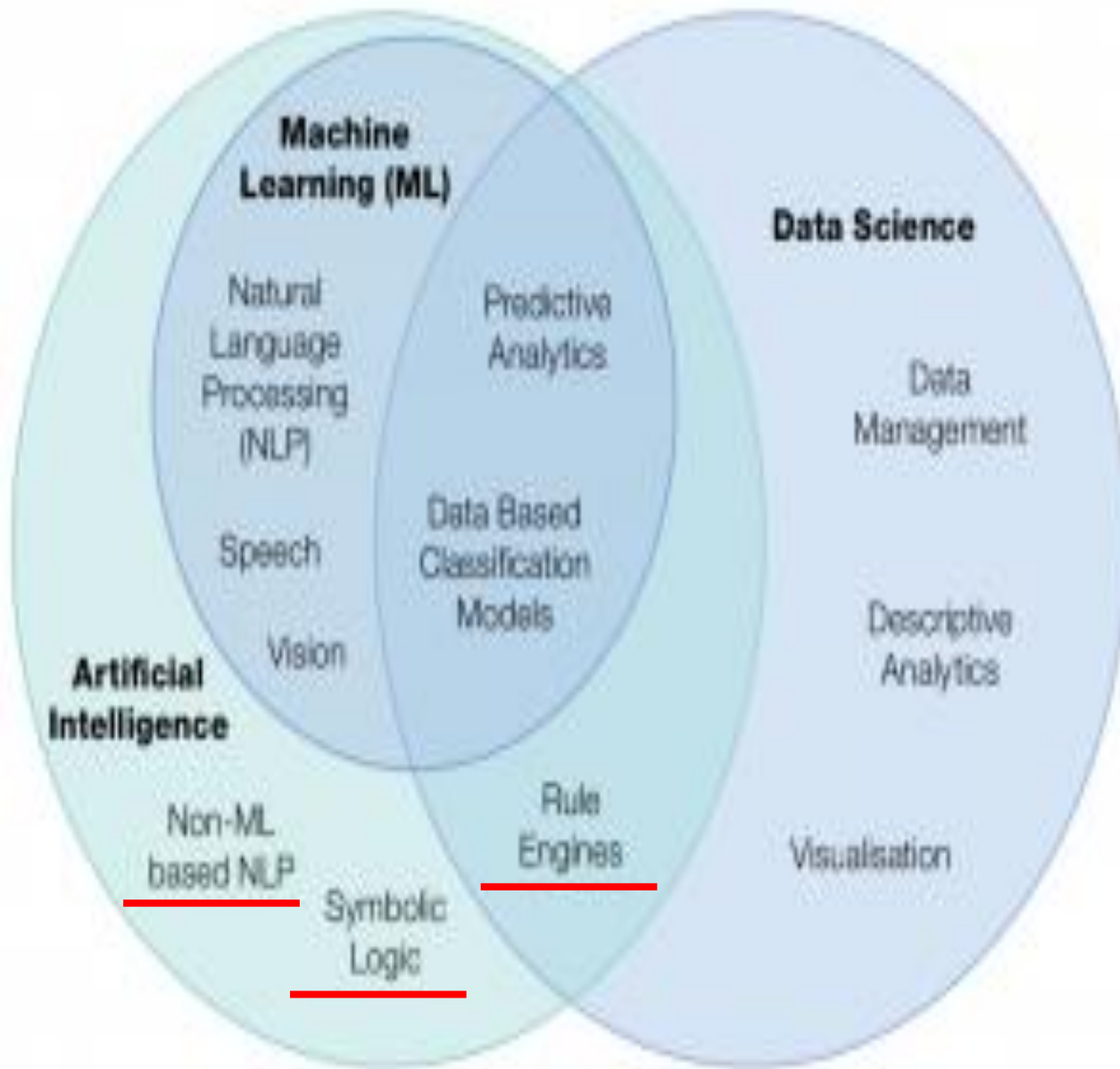

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The State of AI and AI Resources

- The AI Index Report, Standard: https://aiindex.stanford.edu/wp-content/uploads/2023/04/HAI_AI-Index-Report_2023.pdf

- State of AI Report, Cambridge - https://docs.google.com/presentation/d/1WrkeJ9-CjuotTXoa4ZZlB3UPBXpxe4B3FMs9R9tn34I/edit#slide=id.g164b1bac824_0_2748

- Google Scholar: https://scholar.google.com/

- State-of-the-Art Page at Paper with Code: https://paperswithcode.com/sota

- And More

AI Public Datasets

- UCI Machine Learning Repository: https://archive.ics.uci.edu/datasets

- CIFAR-10/100: https://www.cs.toronto.edu/~kriz/cifar.html

- ImageNet: https://www.image-net.org/

- COCO: https://cocodataset.org/#home

- Kaggle: https://www.kaggle.com/datasets

- Google's Open Images: https://storage.googleapis.com/openimages/web/index.html

- Labeled Faces in the Wild: http://vis-www.cs.umass.edu/lfw/

- Quandl: https://demo.quandl.com/

- Financial Time Market Data: https://markets.ft.com/data

- US Data.Gov: https://data.gov/

- US Healthcare Data: https://healthdata.gov/browse?limitTo=datasets

- EU Open Data Portal: https://data.europa.eu/en

- The UK Data Service: https://ukdataservice.ac.uk/

- World Bank Open Data: https://data.worldbank.org/

The AI Universe

Generative AI Technologies

- Generative AI is a type of artificial intelligence technology that can produce various types of content, including text, imagery, audio, video, synthetic data, and more.

- 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, Google Gemini, Microsoft CoPilot, and more are popular generative AI interfaces.

Feature	ChatGPT	CoPilot	Gemini
Developer/Developer Teams	OpenAI	GitHub & OpenAI	Google
Architecture	GPT (Generative Pre-trained Transformer)	GPT (Generative Pre-trained Transformer)	Hybrid model combining GPT and other architectures
Conversational AI	✓	✓	✓
Code Generation	✓	✓	✓
Integration	API	GitHub Integration	API
Use Cases	Chatbots, Customer Support	Coding Assistance, Software Development	Chatbots, Coding Assistance
Fine-tuning	✓	✓	X
Programming Languages Recognized	Supports multiple Languages	Supports multiple languages	Supports multiple languages
Training Data	General text data	Code repositories, Stack Overflow data	Combination of text and code data
Natural Language Understanding	✓	✓	✓
Code Understanding	Limited	Intelligent	Intelligent
Output	Text-based responses	Code suggestions, completions	Text-based responses, code generation
Model Complexity	High	High	High
Customization	Fine-tuning for specific domains possible	X	Fine-tuning for specific domains possible
Versatility	Limited to text-based interactions	Focused on coding-related tasks	Offers both conversational and coding capabilities
Deployment	API integration into various platforms	Integrated into GitHub's coding workflow	API integration into various platforms

Deductive Reasoning vs. Inductive Learning

- These two types of models form the dominant themes of artificial intelligence: **Deductive Reasoning (Classical AI)** and **Inductive Learning (New AI)**

- **Deductive Reasoning (Generalization → Specification) also called Analytical Models**: <u>From general facts/true hypotheses to specific facts/examples</u>
  - Start with a knowledge base of general facts and true hypotheses and then uses <u>logical inferences/rules</u> to reason about **unknown facts to make specific conclusions**

  - Specifically, the models were derived using **a mathematical formulation**, which is basically a sequence of steps followed to arrive at a final equation.

  - Such models often involved **prolonged derivations and long periods of trial and error** before a working formula was arrived at.

  - Example Methods: **Search-based Algorithms**

  - <u>Week 1 ~ Week 4 Topics</u>

INDUCTIVE learning VS DEDUCTIVE reasoning

No matter how unrealistic that sounds, in many fields, such as science and law, "proof" simply doesn't exist; there can only be facts and evidence that lead you to certain conclusions.

INDUCTIVE LEARNING
- Someone who uses INDUCTIVE LEARNING makes specific observations and then draws a general conclusion.
- When you're using inductive LEARNING correct observations won't necessarily lead you to a correct general conclusion.

EXAMPLES
1. Every quiz has been easy. Therefore, the test will be easy.
2. The teacher used PPT in the last few classes. Therefore, the teacher will use PPT tomorrow.

DEDUCTIVE REASONING
- DEDUCTIVE reasoning is a specific conclusion follows a general theory.

When you're using deductive reasoning, your conclusion will be correct if all the statements you say is correct.

EXAMPLES
1. All students in this class play guitar.
   Sam is a student of this class.
   --> Therefore, Sam plays guitar.

2. At the conference, all the people present are thirty or older.
   Maria is in the room.
   -->Therefore, Maria is at least thirty.

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- **Inductive Learning (Specification → Generalization) also called Learned Models**: <u>From specific facts/examples to general facts/true hypothesis</u>

  — Learn from data instances and specific examples **to build general facts/hypotheses** that are used to make predictions about new examples.

  — These models are obtained through **the process of training** on many examples of inputs and outputs to arrive at the equation without needing us to derive the underlying mathematical formula.

  — Example Methods:
    - **Machine Learning (CS 4342/CS 539)**
    - **Deep Learning (DS 541)**
    - **Generative Artificial Intelligence (DS 552)**
    - **Natural Language Processing (DS 544)**

  — <u>Week 5 ~ Week 8 Topics *</u>

Deductive Reasoning vs. Inductive Learning

- **More Example:**

  — Deduction Reasoning:
    - All canine animals have four legs. All dogs have four legs. <u>Therefore, dogs are canines.</u>

  — Induction Learning:
    - I saw a couple of dogs yesterday. Both had four legs. <u>Therefore, all dogs have four legs.</u>

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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

Deductive Reasoning vs. Inductive Learning

Deep Blue Chess (Deductive Reasoning)
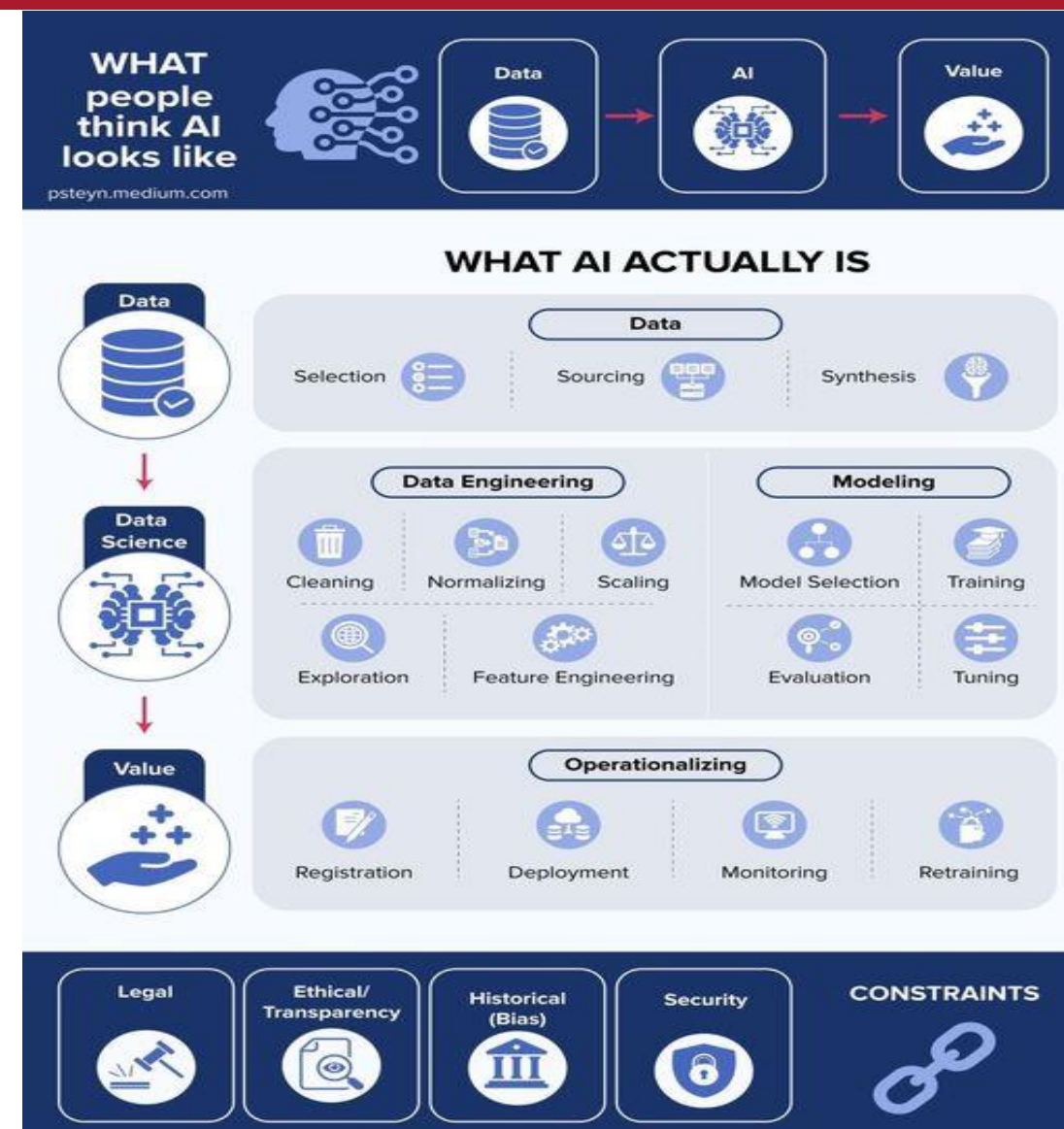
Deductive Reasoning vs. Inductive Learning

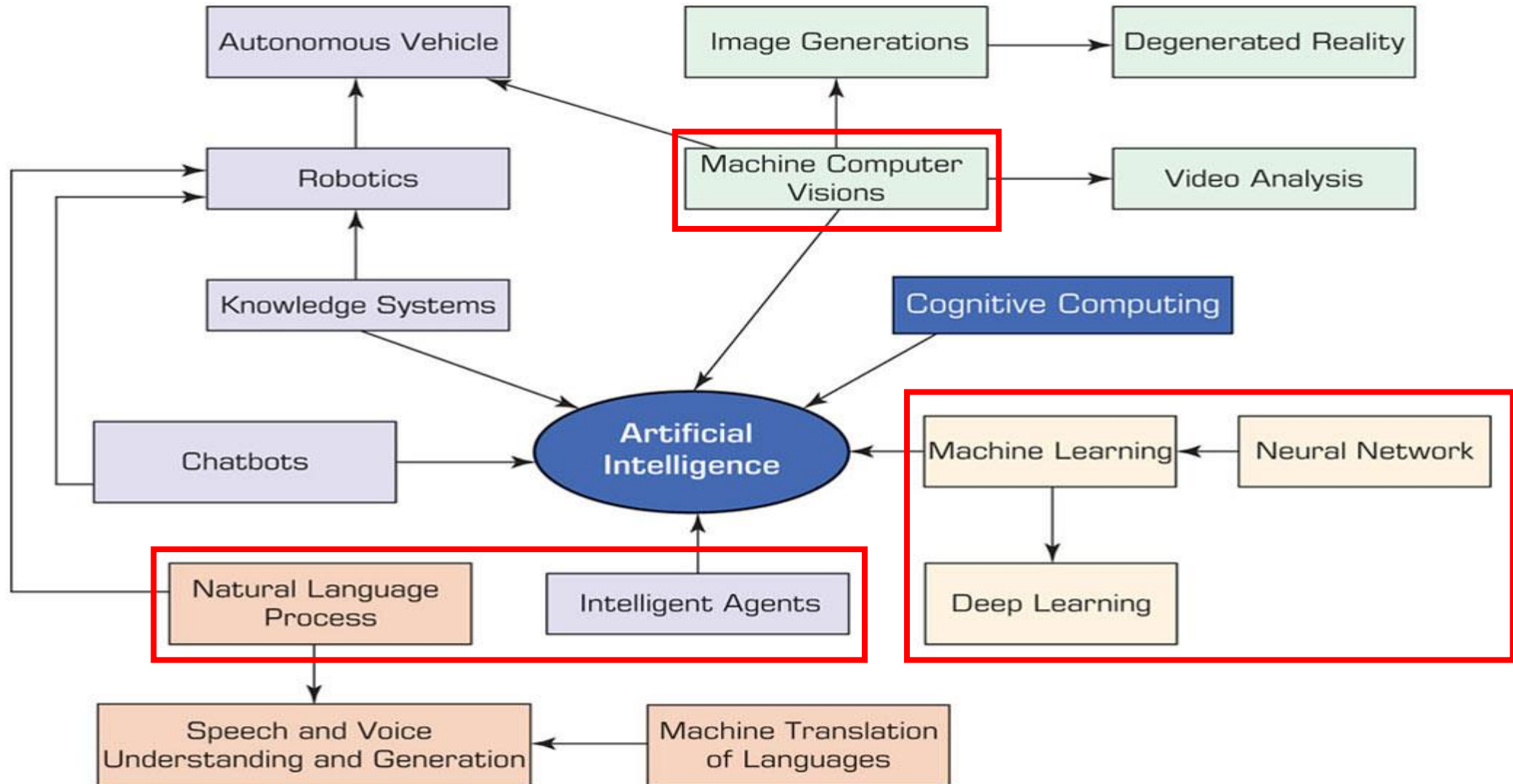**AlphaZero Chess (Inductive Learning)**

Summary of Topics in this Course

- Deductive Reasoning (Generalization → Specification), **Analytical Models**: Week 1 ~ Week 4

  — Intelligent Agents
  — Problem-Solving Techniques
  — Different Searching Algorithms

- Inductive Learning (Specification → Generalization), **Learned Models**: Week 5 ~ Week 8

  — Machine Learning
  — Deep Learning
  — Natural Language Processing

The Major AI Technologies

Institute

TOP AI ALGORITHMS
MADE EASY

Convolutional Neural Networks (CNNs)
Think of them as computer eyes that can recognize patterns and shapes in pictures.

Support Vector Machines (SVM)
Imagine drawing a straight line between two kinds of objects so you can tell them apart in the best possible way.

Recurrent Neural Networks (RNNs)
Like remembering one sentence to help understand the next, RNNs help with things that happen in order.

Principal Component Analysis (PCA)
It's like packing a suitcase, keeping only the most important items and leaving out extras to save space.

K-Nearest Neighbors (KNN)
It's like asking your closest friends for recommendations and following the majority opinion.

Decision Trees
Think of choosing between two paths by answering yes or no at each turn until you reach a final decision.

K-Means Clustering
It's like putting similar things into groups based on how close they are to each other, without being told which group they belong to.

Random Forests
Think of asking many different trees for advice and going with the answer most of them agree on.

Gradient Boosting
Imagine making guesses, learning from each mistake, and improving step by step until you get it right.

Neural Networks
Your brain has lots of cells that work together, and neural networks are computer models that do the same with data.

Autoencoders
Picture shrinking a large image into a small one and then stretching it back to the original, keeping the important parts.

Q-Learning
Think of solving a maze by trying different paths and learning the fastest route from rewards.

Genetic Algorithms
Imagine making a superhero by mixing the best traits from different heroes over several tries.

Bayesian Networks
Like guessing tomorrow's weather by looking at related clues and calculating the chances.

Reinforcement Learning
Imagine teaching a robot to play a game by rewarding good moves and correcting bad ones.

Linear Regression
Think of drawing a straight line through dots on a chart to predict what might happen next.

Logistic Regression
It's like predicting yes or no answers by looking at past patterns and finding the chance of each.

Transformer Models
Think of reading an entire story at once and understanding each part by focusing on important words.

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Summary: What is Artificial Intelligence?

AI Explained by NSF