# Artificial Intelligence

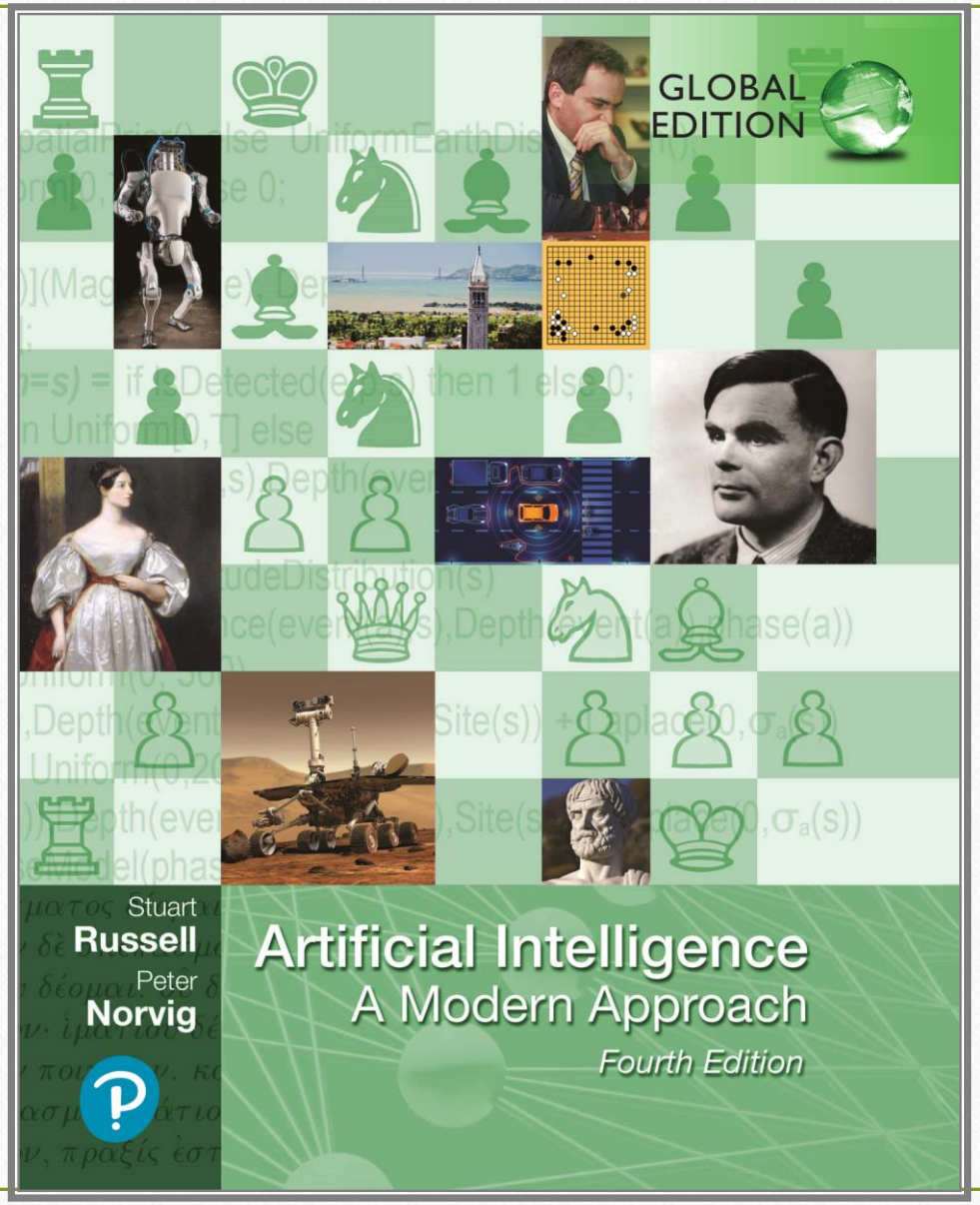
Introduction to AI

Courtesy of

Associate Prof. Dr. Ayman Elshenawy

eaymanelshenawy@azhar.edu.eg

# Reference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# Intelligence

For thousands of years, scientists tried to:

- Understand how the human think and act in an environment:
  - how our brain **Perceive – Understand - Predict and manipulate.**
- Build intelligent entities (machines) that compute and act effectively in different situations.

AI Currently include a huge variety of subfields ranging from:

- General (**learning and perception**).
- Specific ( **Playing chess, Proving mathematical theorems, Writing poetry, Driving a car on a crowded street, and Diagnosing diseases**).

AI is relevant to any intellectual task, and it is truly a universal field.

# What is artificial intelligence?

**Artificial Intelligence can be defined according to two the following approaches:**

- Rationality: intelligent action and doing the right things
- Behavior: Human Performance & internal thought processes and reasoning

**Human centric approaches:**

- Pertaining to psychology and involving observations and hypotheses about actual human behavior and thought processes.

**Rationalist approach:**

- Involves combination of mathematics and engineering, statistics, control theory, and economics.

**A system is rational if it does the right thing, given what it knows.**

# What is artificial intelligence?

- **Definition 1.** AI is the science and engineering of making **intelligent machines** (intelligent computer programs)
  - Using computers to understand human intelligence

- **Definition 2**. AI is the study of systems that act in a way that to any observer would appear to be intelligent.
  - Develop and implement methods based on the **intelligent behavior** of humans and other animals to solve complex problems.

# AI Categorical Definitions

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

# 1- Thinking humanly: The Cognitive Modelling approach

"a given computer program thinks like a human",

How to validate that?

We must determine how humans think ( get *inside* the actual workings of human minds).

**Introspection**: trying to catch our own thoughts as they go by;

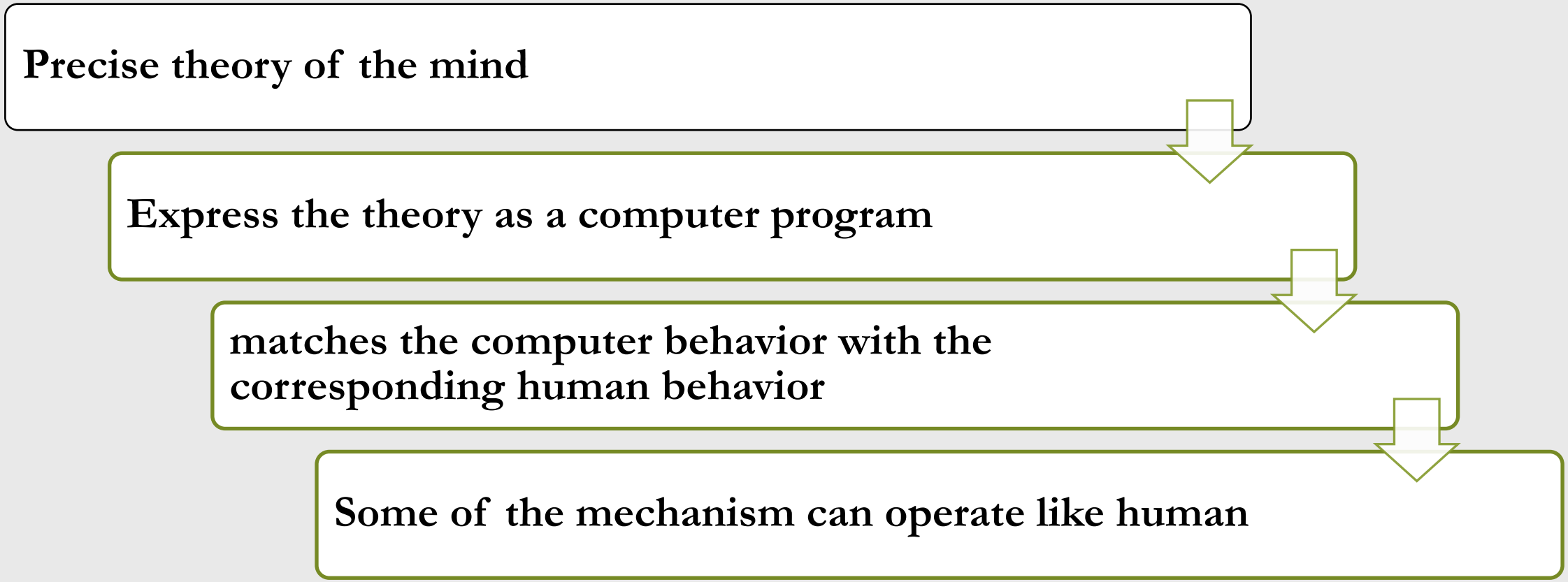

**Psychological experiments:**

observing a person in action;

**Brain imagine:**

observing the brain in action.

# 1- Thinking humanly: The Cognitive Modelling approach




- *If the program's behavior matches the human behavior*, that is evidence that some of the program's mechanisms could also be operating in humans.

# 1- Thinking humanly: The Cognitive Modelling approach

- GPS - General Problem Solver system: doesn’t mean to solve problems correctly. It’s mainly concerned concerned with *comparing the trace of its reasoning steps* to traces of human subjects solving the same problems.

ليس الغرض ان يقوم البرنامج بتقديم الحل الصحيح، ولكن لابد ان يشبه الانسان في طريقة الحل

- Cognitive science is focused on
  - Computer models from AI
  - Experimental techniques from psychology
  - Testable theories of the human mind.

# 2- Thinking rationally: The "*laws of thought*" approach

- Right thinking means we can **codify** logic
- Logic describes **statements** about all kinds of objects in the world and the relations among them.
  - 1965, Logicist were able to represent all knowledge, theoretically, programs will be able to solve *any* solvable problem described in logical notation.
  - Logicist hopes to build on such programs to create intelligent systems.
  - Obstacles to this approach:
    - It is not easy to represent all knowledge in logical notation( < than 100% certain).
    - A big difference between solving a problem "in theory" and "in practice".
    - A problems with a few hundred facts can exhaus the computational resources.

- Fact: Socrates is a man.

```
man(socrates).
```

- Rule: All men are mortal.

```
mortal(X) :- man(X).
```

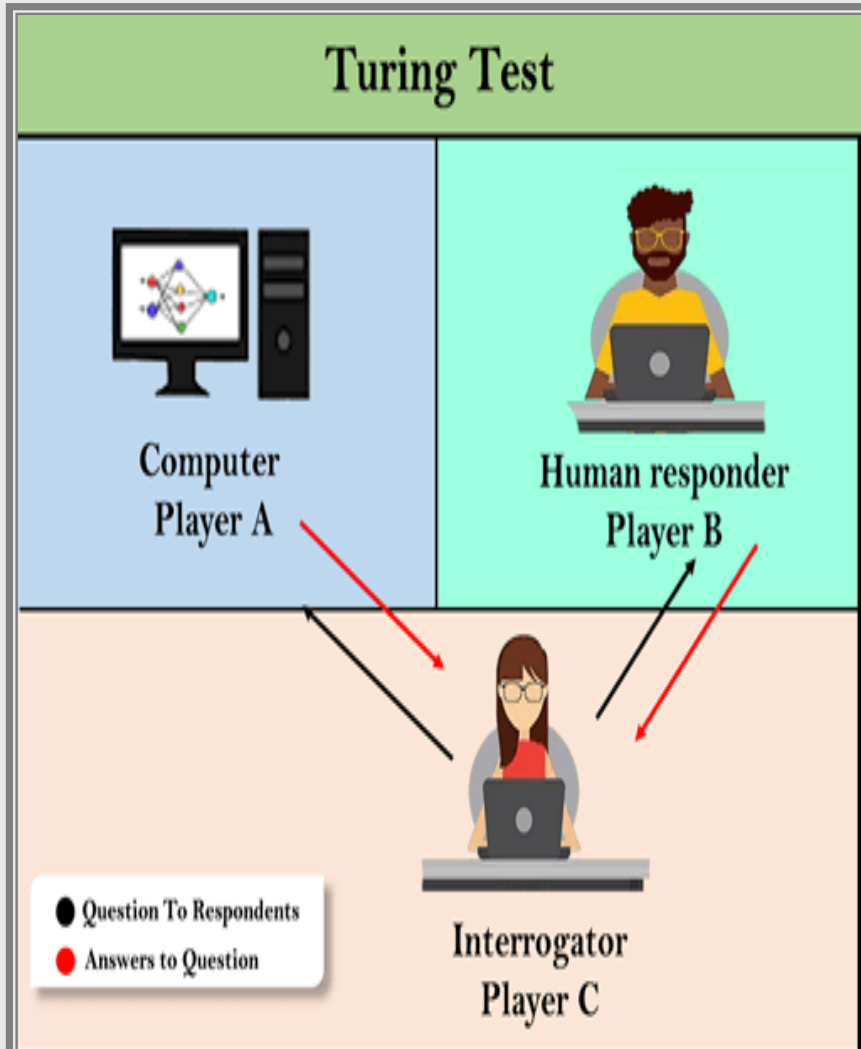
- Query: Is Socrates mortal?

```
mortal(socrates).
```

# 3- Acting humanly: The Alan Turing Test approach

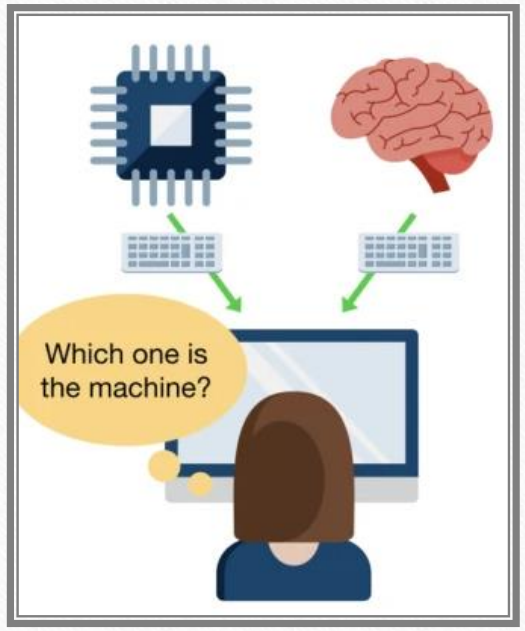
## Designed by Turing (1950) to provide a satisfactory definition of intelligence.

- A computer passes the test if a human interrogator, cannot tell whether the responses come from a person or a computer after asking some questions, .
- To pass the test, the computer must have:
  - Natural Language Processing (NLP) : can communicate in English.
  - Knowledge representation: store what it knows or hears;
  - Automated Reasoning: use the stored information to answer questions and to draw new conclusions.
  - Learning capabilities: adapt to new circumstances and to detect patterns.



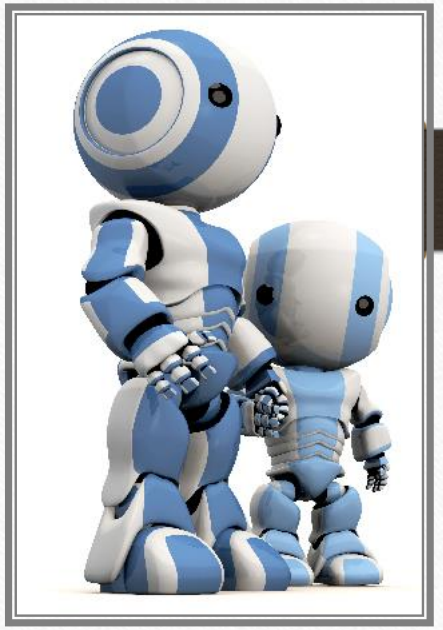
# 3- Acting humanly: Total Turing Test

- Total Turing Test includes a video signal so that the interrogator can test the subject's perceptual abilities, as well as the opportunity for the interrogator to pass physical objects "through the hatch."
- To pass the total Turing Test, the computer will need:
  - Computer Vision: perceive objects.
  - Robotics: manipulate objects and move around.



# 4- Acting rationally: Agent approach

- Agent: a program that acts.
- Agents are doing more than computer programs
  - Operate autonomously, perceive their environment, persist over a longed period.
  - Adapt to change, and create and achieve goals
  - Use knowledge representation and reasoning to take good decisions.
  - Generate comprehensible sentences in natural language to get by in a complex society.
- Advantages:
  - More general than the “laws of thought”.
  - Is more suitable to scientific development than approaches based on human behavior ( thought).
  - The standard of rationality is mathematically well defined and can be used to generate agent designs.



# Summary of previous definitions

1. Modeling exactly how humans think
   - cognitive models of human reasoning
2. Modeling exactly how humans act
   - models of human behavior (what they do, not how they think)
3. Modeling how ideal agents "should think"
   - models of "rational" thought (formal logic)
4. Modeling how ideal agents "should act"
   - i.e., more of a black-box/engineering approach

- Modern AI focuses on the last definition
  - we will also focus on this "engineering" approach
  - success is judged by how well the agent performs

  -- modern methods are also inspired by cognitive & neuroscience (how people think).

# Academic Disciplines important to AI.

- **Philosophy:**
  - **Can formal rules be used to draw valid conclusions?**
  - **How does the mind arise from a physical brain?**
  - **Where does knowledge come from?**
  - **How does knowledge lead to action?**

  ➢ Logic, methods of reasoning, mind as physical system, learning, language, rationality.

- **Mathematics:**
  - **What are the formal rules to draw valid conclusions?**
  - **What can be computed?**
  - **How do we reason with uncertain information?**
  - **The fundamental ideas of AI required a level of mathematical formalization in three fundamental areas:**
    - **Logic, Computation, Probability.**

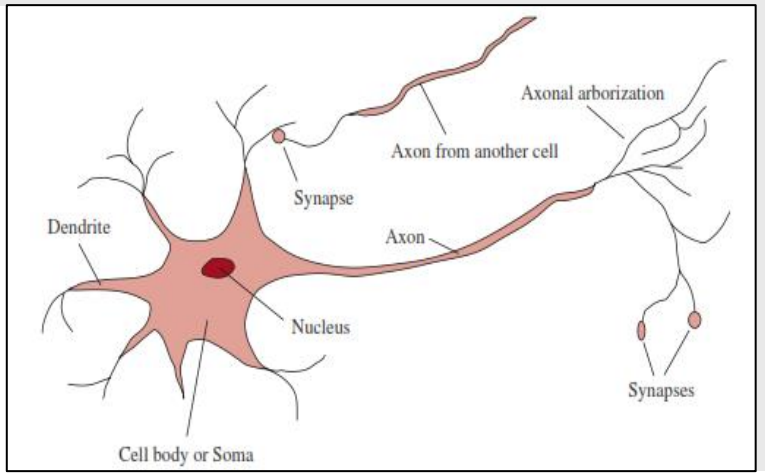
# Academic Disciplines important to AI.

- Economics
  - How should we make decisions to maximize payoff?
  - How should we do this when others may not go along?
  - How should we do this when the payoff may be far in the future?
- Decision Theory: based on probability theory
- Game, and Game Theory
- Operation research
- Markov decision processes

# Academic Disciplines important to AI

- **Neuroscience** (is the study of the nervous system, the brain)
- **How do brains process information?** neurons as information processing units.

| | Supercomputer | Personal Computer | Human Brain |
|---|---|---|---|
| Computational units | $10^6$ GPUs + CPUs | 8 CPU cores | $10^6$ columns |
| | $10^{15}$ transistors | $10^{10}$ transistors | $10^{11}$ neurons |
| Storage units | $10^{16}$ bytes RAM | $10^{10}$ bytes RAM | $10^{11}$ neurons |
| | $10^{17}$ bytes disk | $10^{12}$ bytes disk | $10^{14}$ synapses |
| Cycle time | $10^{-9}$ sec | $10^{-9}$ sec | $10^{-3}$ sec |
| Operations/sec | $10^{18}$ | $10^{10}$ | $10^{17}$ |




A comparison between a supercomputer, a PC of 2017, and human brain.

- Computers have a cycle time that is a million times faster than a brain.
- The brain makes up for that with far more storage and interconnection than even a high-end personal computer, although the largest supercomputers match the brain on some metrics.
- The brain's numbers are essentially **fixed**, whereas the supercomputer's numbers have **been increasing nearly by a factor of 10 every 5 years**, allowing it to achieve rough parity with the brain. The personal computer lags on all metrics except cycle time.

# Academic Disciplines important to AI

- **Psychology**
- perceive, process cognitive science information,  represent knowledge.
  - How do brains process information?
  - BEHAVIORISM
- **Cognitive psychology**
- **cognitive science**

# Academic Disciplines important to AI.

- Computer engineering ( Building Fast Computer Engineering)
  - How can we build an efficient computer?
  - For AI to succeed, it need intelligence and a tools (computer).
  - The computer industry passes many generations, each generation have:
    - An increase in speed and capacity and Decrease in price.
  - Computer Performance doubled every 18 months or so until around 2005.
  - When power dissipation problems led manufacturers to start multiplying the number of CPU cores rather than the clock speed.
  - Current expectations are that future increases in power will come from massive parallelism—a curious convergence with the properties of the brain.

# Academic Disciplines important to AI.

- Software engineering
- AI also owes a debt to the software side of computer science, which has supplied the
  - Operating systems,
  - Programming languages, and
  - Tools needed to write modern programs
  - Time sharing,
  - Interactive interpreters,
  - Rapid development
  - Environments, automatic storage management, and key concepts of symbolic, functional, declarative, and object-oriented programming.

# Components of intelligence

- Fast hardware
- Foolproof software
- Chess-playing at grandmaster level?
- Speech interaction
  - speech synthesis (Can Computer talk?)
  - speech recognition ( Can computer recognize human speech?)
  - speech understanding (Can computer understand human speech?)
- Image recognition and understanding ?
- Learning ( Can computer learn and adapt?)
- Planning and decision-making?

# Academic Disciplines important to AI.

- **Control theory (**systems that maximize an **objective function** over time).
  - How can artifacts operate under their own control?
  - Control theory
  - Objective function
- **Linguistics (knowledge representation, grammar)**
  - How does language relate to thought?
  - **computational linguistics** or **natural language Processing**
  - **knowledge representation**

# The State of the art

- **Publications**: AI papers increased 20-fold between 2010 and 2019 to about 20,000 a year. The most popular category was machine learning.
- **Industry**: AI startups in the U.S. increased 20-fold to over 800.
- **Vision**: Error rates for object detection improved from 28% in 2010 to 2% in 2017, exceeding human performance.
- Open-ended visual question answering (VQA) accuracy improved from 55% to 68% since 2015 but lags human performance at 83%.


- **Speed**: Training time for the image recognition task dropped by a factor of 100 in just the past two years. The amount of computing power used in top AI applications is doubling every 3.4 months.
- **Language**: Accuracy on question answering increased from 60 to 95 from 2015 to 2019; exceed human-level performance.
- **Human benchmarks**: By 2019, AI systems had reportedly met or exceeded human level performance in chess, Go, poker, Pac-Man, Jeopardy!, ImageNet object detection, speech recognition in a limited domain, Chinese-to-English translation in a restricted domain, Quake III, Dota 2, StarCraft II, various Atari games, skin cancer detection, prostate cancer detection, protein folding, and diabetic retinopathy diagnosis.

# What Can AI Do Today?

- **Robotic Vehicles:** In 2018, Waymo test vehicles passed the landmark of 10 million miles driven on public roads without a serious accident, with the human driver stepping in to take over control only once every 6,000 miles. Soon after, the company began offering a **commercial robotic taxi service**.
- **Drones**: have been providing cross-country blood deliveries in Rwanda since 2016.
- **Legged locomotion:** Atlas, a **humanoid robot**, not only walks on uneven terrain but jumps onto boxes and does backflips (Ackerman and Guizzo, 2016).
- **Autonomous planning and scheduling:** Ride hailing companies such as **Uber** and mapping services such as Google Maps provide driving directions for hundreds of millions of users, quickly plotting an optimal route considering current and predicted future traffic conditions.

# What Can AI Do Today?

- **Machine translation: e**nable the reading of documents in over 100 languages, including the native languages of over 99% of humans, and render hundreds of billions of words per day for hundreds of millions of users.
- **Speech recognition:** Alexa, Siri, Cortana, and Google offer assistants can answer questions and carry out tasks for the user; for example, the Google Duplex service uses speech recognition and speech synthesis to make restaurant reservations for users, carrying out a fluent conversation on their behalf.
- **Recommendations:** Amazon, Facebook, Netflix, Spotify, YouTube, Walmart, and others use machine learning to recommend what you might like based on your past experiences and those of others like you.
- **Game playing**
- **Image Understanding:** A person riding a motorcycle on a dirt road,

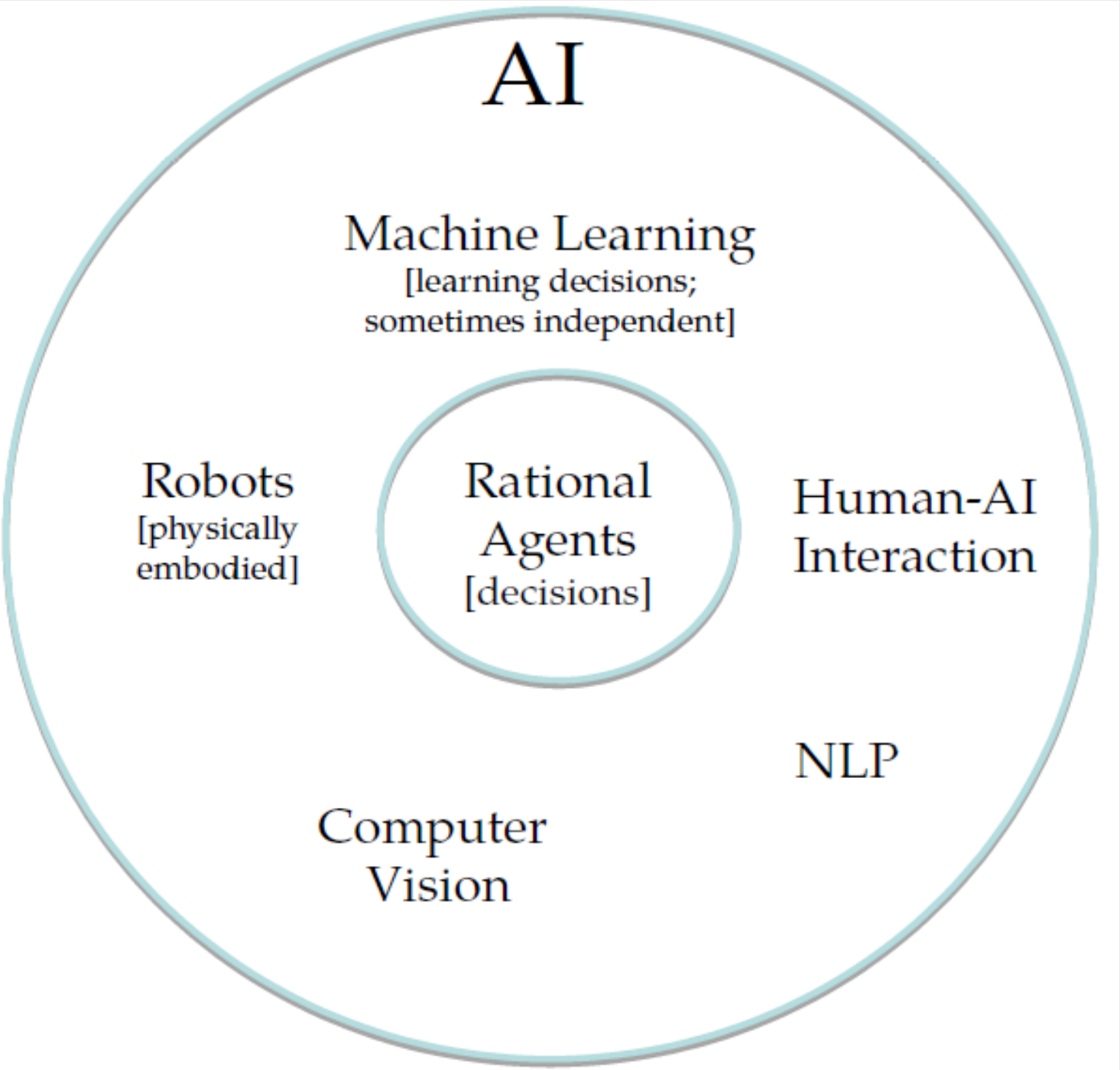
# What Can AI Do Today?

- **Medicine:** LYNA system achieves 99.6% overall accuracy in diagnosing metastatic breast cancer—better than an unaided human expert
- **Climate science:** A team of scientists won the 2018 Gordon Bell Prize for a deep learning model that discovers detailed information about extreme weather events that were previously buried in climate data.
- **Generative AI**: A type of AI technology that can produce various types of content, including text, imagery, audio and synthetic data. Major AI chatbots like OpenAI's ChatGPT and Google's Bard show the capabilities of generative AI to comprehend and produce human-like writing.

# Machine Learning Vs. Generative AI

| | Traditional ML | Generative AI/Foundation Models |
|---|---|---|
| Approach | supervised or unsupervised learning algorithms to make predictions based on patterns in training data | Generates new data based on patterns learned from training data |
| Purpose | Focuses on solving specific tasks, such as classification or regression | Primarily used for creative tasks, such as text generation, image synthesis, or music composition |
| Data Requirements | Requires labeled training data | Needs a large amount of training data |
| Limitations | Relies on explicit rules or predefined features | Capable of learning complex patterns and generating novel content, but may lack interpretability |
| Flexibility | Less flexible in adapting to new data or tasks | More adaptable and can generate diverse outputs |
| Training Time | Training time depends on the complexity of the ML model and the amount of data | computationally intensive and time-consuming |
| Output | Produces predictions or insights based on existing data | Generates new and unique content based on learned patterns |
| Use Cases | predictive analytics, fraud detection, and recommendation | Used in creative fields, language generation, virtual assistants, and content creation |

# Artificial Intelligence Domains



# Branches of AI

- Logical AI
- Search
- Natural language processing
- Computer vision
- Pattern recognition
- Knowledge representation
- Inference From some facts, others can be inferred.
- Reasoning
- Learning

- Planning To generate a strategy for achieving some goal
- Epistemology This is a study of the kinds of knowledge that are required for solving problems in the world.
- Ontology is the study of the kinds of things that exist.
- Agents
- Games
- Artificial life / worlds?
- Emotions?
- Knowledge Management?
- Socialization/communication?

# Risks of AI

- **Lethal autonomous weapons** that can locate, select, and eliminate human targets without human intervention (2014).
- **Surveillance and persuasion:** AI can be used in a scalable fashion to perform mass surveillance of individuals and detect activities of interest.
- **Biased decision making** biased by race, gender, or other protected categories. Often, the data themselves reflect pervasive bias in society.
- **Safety-critical applications:** The field of AI will need to develop technical and ethical standards where people's lives are at stake.
- **Cybersecurity:** reinforcement learning methods have been used to create highly effective tools for automated, personalized blackmail and phishing attacks.

# The End ☺