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IT3160E Introduction to Artificial Intelligence

Chapter 1 - Introduction

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Content of the course

- Chapter 1: Introduction
- Chapter 2: Intelligent agents
- Chapter 3: Problem Solving
  - Search algorithms, adversarial search
  - Constraint Satisfaction Problems
- Chapter 4: Knowledge and Inference
  - Knowledge representation
  - Propositional and first-order logic
- Chapter 5: Uncertain knowledge and reasoning
- Chapter 6: Advanced topics
  - Machine learning
  - Computer Vision

Outline

- **Chapter 1: Introduction**
  - What is AI?
  - Foundations of AI
  - Short history of AI
  - Application areas of AI
  - Current research in AI
  - Future of AI
  - Summary and ethical discussion

Goals of this Chapter

Goal	Description of the goal or output requirement	Output division/ Level (I/T/U)
M1	Understand basic concepts and techniques of AI	1.2
M4	Be able to identify research areas and potential developments of artificial intelligence	4.1-4.5

Chapter 1: Introduction

What is AI?

What is Artificial Intelligence (AI)?

- AI is:
  - a science attempting to *conceive* intelligent entities
  - one of the newest fields in science & engineering
    - so, many things are still to be discovered
    - many Galileo and Einstein to come!

What is AI?

- Views of AI fall into four categories (depending on the people / methods):

	Mimic humans	***Reach an ideal / rationality****
Reasoning	Think like humans	Thinking rationally
Behaviours	Act like humans	Acting rationally

** Different from mimicking humans, as humans sometimes make mistakes*

What is AI?

Some explanations, in chronological order

	Mimic humans	*Reach an ideal / rationality*
Reasoning	Think like humans	Thinking rationally
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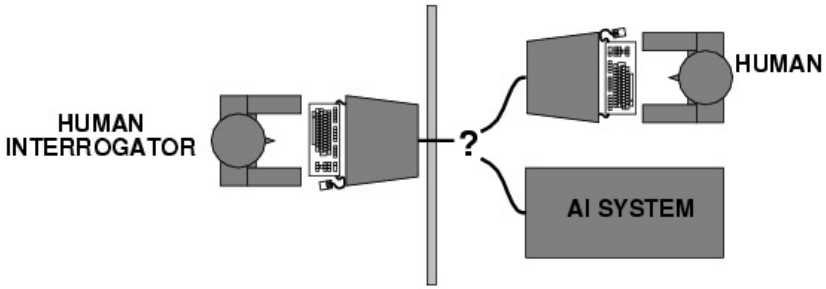
Act like humans

- Turing (1950) "Computing machinery and intelligence":
- "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game



- Test: is the machine able to fool the interrogator?
- This test remained relevant for 60 years afterwards
- Turing predicted that by 2000, a machine might have a 30% chance of fooling a human interrogator for 5 minutes
  - Nowadays, it's actually much better than that!

Act like humans

- To pass the Total Turing test (a later variation of the original Turing test), the computer needs to:
  - Reply questions in English, like a human would
    - Requires **Natural Language Processing**, to "understand" English
    - Requires **Knowledge Representation**, to store / structure the information it was provided with
    - Requires **Automated Reasoning**, using its knowledge in order to answer the questions
    - Requires **Machine Learning***, to "generalize" its knowledge to new / unexpected questions
  - Respond to a video signal
    - Requires **Computer Vision***, to perceive the information in the video (perceptual ability)
  - Manipulate objects and move them in a certain way
    - Requires **Robotics** (on top of computer vision, to actually "see" the objects)
  - **The 6 disciplines in bold constitute most of AI**

** My two fields of expertise as a researcher*

What is AI?

Some explanations, in chronological order

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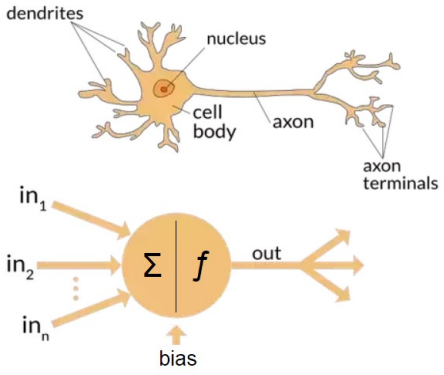
Think like humans

- 1960s "cognitive modeling"
- Objective: mimicking internal activities of the brain
  - Requires understanding how the brain works, either by
    - Introspection
    - Psychological experiments
    - Brain imaging (most recent)

    } **Cognitive science**
    } **Neuroscience**
  - Though each discipline benefit from each other,
    - Cognitive science is distinct from neuroscience
    - Cognitive science and neuroscience are distinct from AI

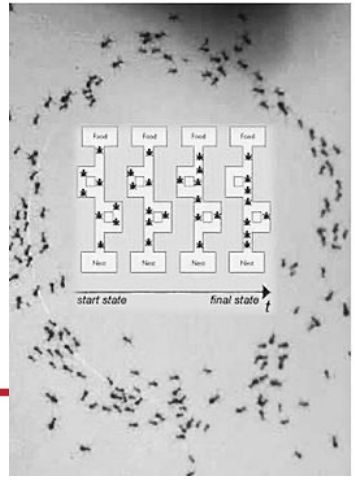
Think like humans (or insects ☺)

- Nowadays, many AI algorithms aim at mimicking the way the human brain thinks / learns
  - For instance, Artificial Neural Networks in Machine Learning (and in Deep Learning in particular)
    - Very effective for Computer Vision or Natural Language Processing, for instance



[https://towardsdatascience.com/]

- Other algorithms aim at mimicking the way other intelligent animals behave
  - For instance, ant colony optimization algorithms
    - Very effective for vehicle routing, internet routing…



The main quality of the colonies of insects, ants or bees lies in the fact that they are part of a self-organized group in which the keyword is simplicity.

Every day, ants solve complex problems due to a sum of simple interactions, which are carried out by individuals.

The ant is, for example, able to use the quickest way from the anthill to its food simply by following the way marked with pheromones.

[/https://en.wikipedia.org/]

What is AI?

Some explanations, in chronological order

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*Different from mimicking humans, as humans sometimes make mistakes

Thinking rationally

- The “Laws of Thought” approach (irrefutable reasoning process)
  - Example: Socrates is a man; all men are mortal; therefore, Socrates is mortal
  - Relies on maths + philosophy -> roots of the field of **logics**
  - Normative / prescriptive rather than descriptive
- By 1965, existing programs could solve (in theory) any **solvable** problems **described in logical notation**
- Difficulties:
  - Not all intelligent behavior is mediated by logical deliberation
  - Not everything can be expressed by rules (uncertainty)

Illustrative example

- One of my research projects (as a researcher in computer vision)
  - Led with geographers and historians
  - My task: automatic segmentation from the Vasserot maps of Paris (19th century)

What is AI?

Some explanations, in chronological order

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Acting rationally

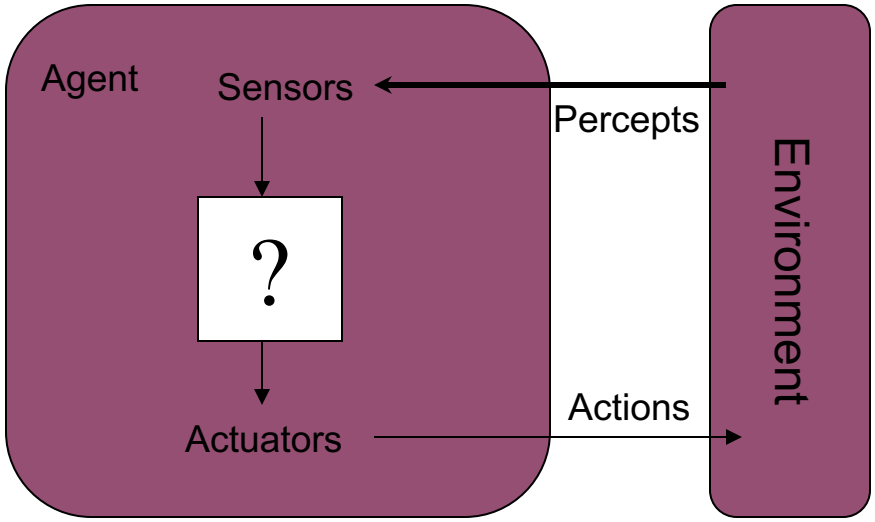
- Rational behavior: doing the “right thing”
  - The right thing: what is needed to reach the objective, given the available information
  - Doesn't necessarily involve thinking, (*e.g.*, humans blinking)
    - But, of course, thinking can serve rational action ;-)
  - The definition of a rational behavior depends on the objective(s)
  - Irrational ≠ insane, irrationality is just a sub-optimal action
  - Rational ≠ successful

- Relies on **rational agents**
  - Systems which make the best possible decisions given goals, the available knowledge / information, and problem constraints

Rational agents

- An **agent** is an entity that perceives and acts
- An agent function maps from percept histories to actions:

$$\mathcal{P}^* \rightarrow \mathcal{A}$$



- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Real-world complexity and uncertainty make perfect rationality unachievable
- So, we usually only approximate rationality (ideal)

Chapter 1: Introduction

Foundations of AI

Foundations of AI: from thinking to acting

- Philosophy
  - rationalism
  - reasoning methods
  - language
  - dualism
  - empiricism

Formalize

- Mathematics
  - logic
  - formal representation
  - (in)completeness / (in)tractability
  - probability & statistics (induction)
  - proofs

Understand

Implement

Thinking

- Psychology - cognitive science
- Neuroscience

Acting

- Computer engineering
  - building fast computers
  - programming effective and efficient algorithms

Foundations of AI

- Other disciplines contributed to the foundations of AI, including:

○ **Economics**	utility (preferred outcomes), decision theory, game theory
○ **Operations research**	the objective is achieved only after a sequence of actions (*e.g.* Markov decision processes)
○ **Economics + Operations research**	satisficing (making "good enough" decisions)
○ **Control theory**	design systems that maximize an objective function over time
○ **Linguistics**	knowledge representation

Chapter 1: Introduction

Short history of AI

Short history of AI

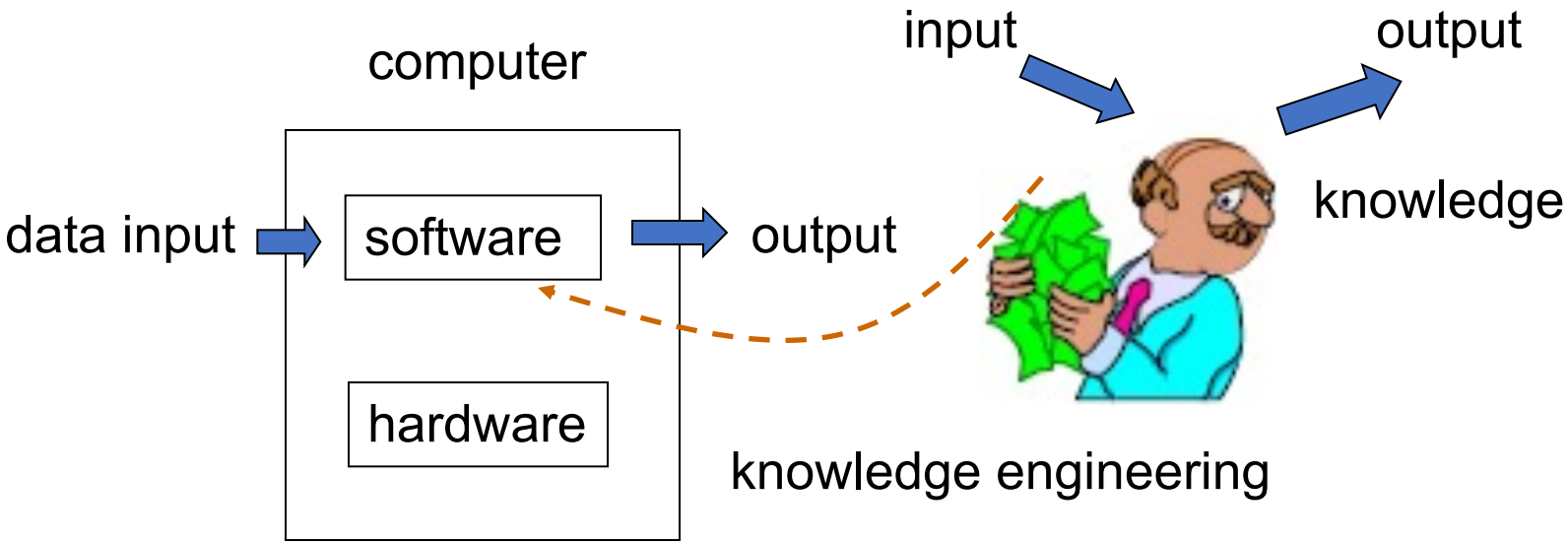
- **1940-1950 (soon after WW2): early days**
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
    - First neural network
  - 1950: Turing's article "Computing Machinery and Intelligence''

- **1950—70: Proving the intellectual establishment wrong**
  - 1950s: Early AI programs, including:
    - Samuel's checkers program

    - Newell & Simon's Logic Theorist
    - Newell and Simon's General Problem Solver (GPS)
    - Gelernter's Geometry Engine
  - 1956: Dartmouth meeting: the name "Artificial Intelligence" adopted
    - 10 attendees in all during that meeting!!!
  - 1965: Robinson's complete algorithm for logical reasoning (first-order logic)

Short history of AI

- **1970—88: Knowledge-based approaches (domain-specific)**
  - 1969—79: Early development of knowledge-based systems
  - 1980—93: Expert systems* boom



Expert system = Human Expertise + Inference / reasoning

* Some examples: DENDRAL, MYCIN, PROSPECTOR, MOLGEN, ICAD/ICAM

Short history of AI

- **1970—88: Knowledge-based approaches**
  - 1969—79: Early development of knowledge-based systems
  - 1980—93: Expert systems boom
    - Bottleneck: difficulties to express / store knowledge in a machine
    - Domain-specific

- **1988—: Statistical approaches**
  - Resurgence of probability (Bayes theory, Hidden Markov Models, etc.)
  - Neural networks made a come-back (invention of retro-propagation learning)
  - General increase in technological possibilities (storage / computational power)

- **1995—: the emergence of intelligent agents**
  - Especially in Web-based applications (*e.g.* bots)

- **2000—: Where are we now?** -> Some call it the “deep learning era”

Chapter 1: Introduction

Application areas of AI

Application areas of AI - *Some milestones*

- 1991: Gulf War
  - US forces deployed an AI logistics planning and scheduling program involving up to 50,000 vehicles, cargo, and people

Application areas of AI - *Some milestones*

- 1997: Deep Blue vs. Kasparov
  - First match won against world-champion
  - Kasparov said that he felt a “new kind of intelligence”
  - The value of IBM’s stock increased by $18 billion
  - Humans understood 99.9% of Deep Blue's moves

Application areas of AI - *Some milestones*

- 2000: NASA
  - NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft

Application areas of AI - *Some milestones*

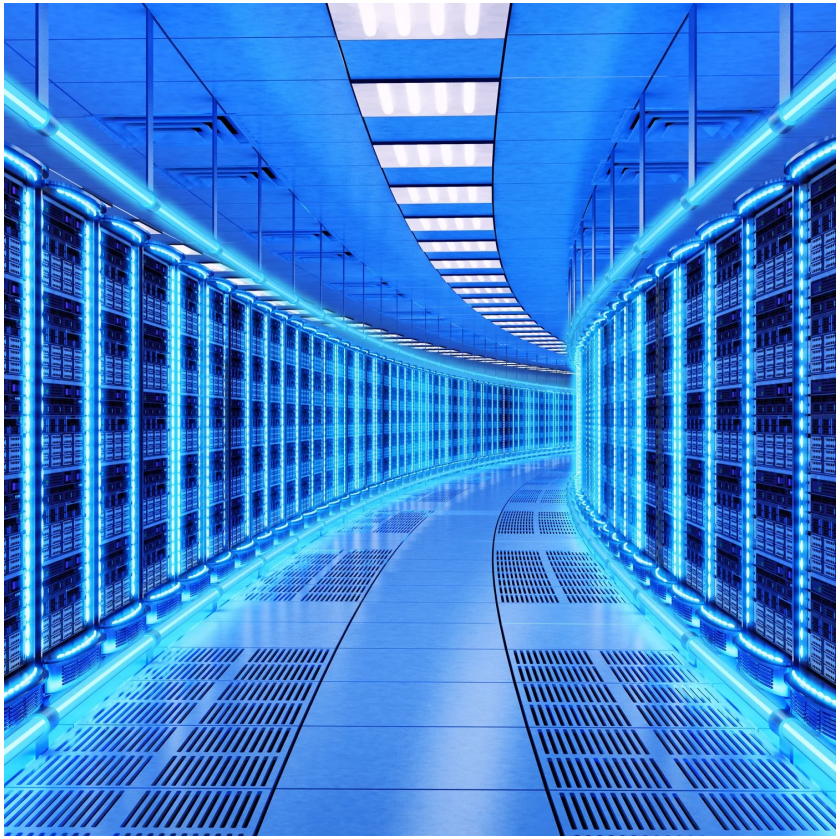
- 2000--now: Anti-spamming
  - Anti-spams constantly have to adapt to new tricks from spammers using machine learning and Natural Language Processing

Application areas of AI - *Some milestones*

- 2005: autonomous vehicle
  - STANLEY driverless robotic car won the DARPA Grand Challenge.

Application areas of AI - *Some milestones*

- 2013: automatic micro-finance
  - A major global bank achieved 1 billion transactions/second using AI



Application areas of AI - *Some milestones*

- 2014-2015: face recognition
  - Deep learning approaches surpassed human-level face recognition accuracy on very challenging and large face databases

Application areas of AI - *Some milestones*

- 2020: fight over COVID
  - The Vietnamese authorities used the multi-agent platform COMOKIT to prevent the spread of COVID and make the best decisions
    - Based on the GAMA platform, open-source, developed mainly in Hanoi (IRD)

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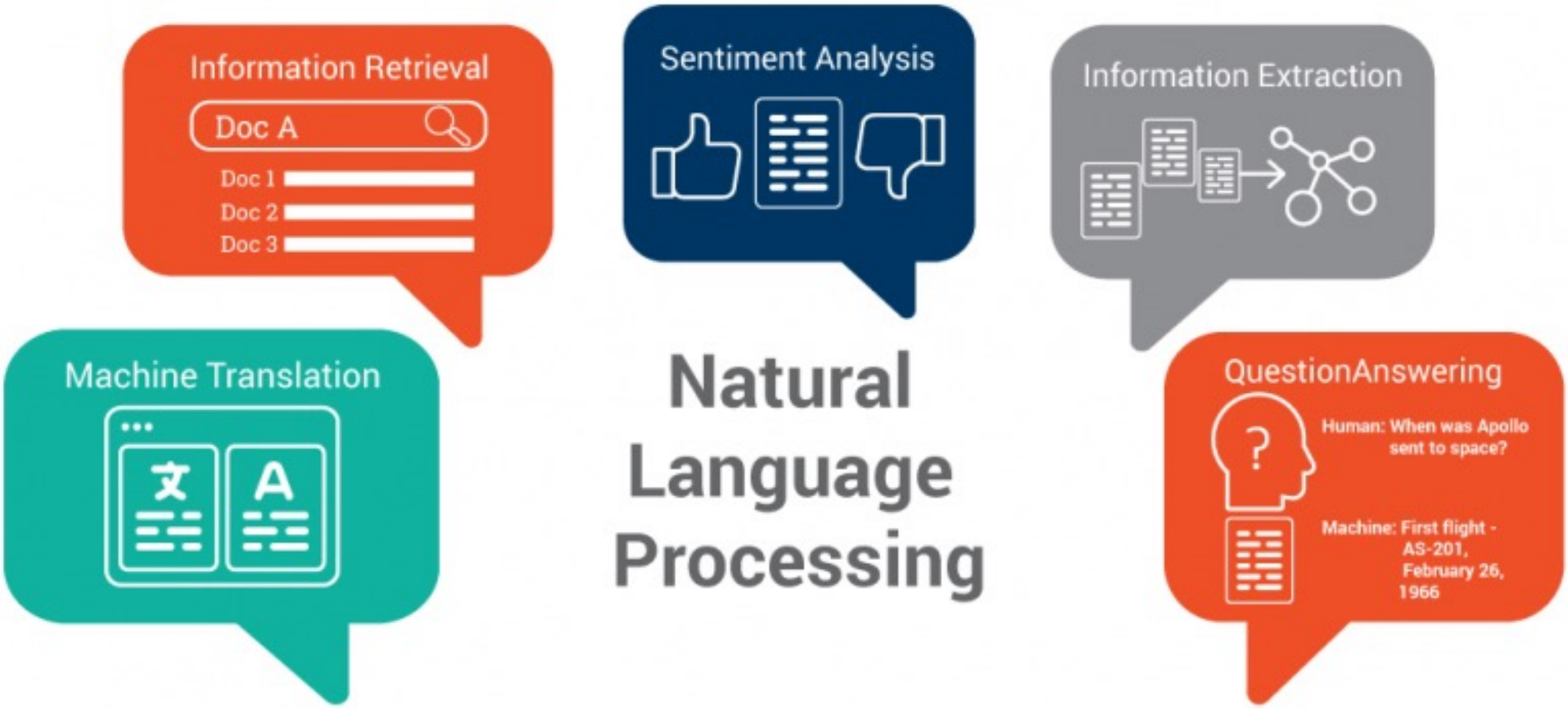
Current research in AI

Research areas of AI (recall)

- Natural Language Processing
- Knowledge Representation
- Automated Reasoning
- Machine Learning
- Computer Vision
- Robotics

Research areas of AI

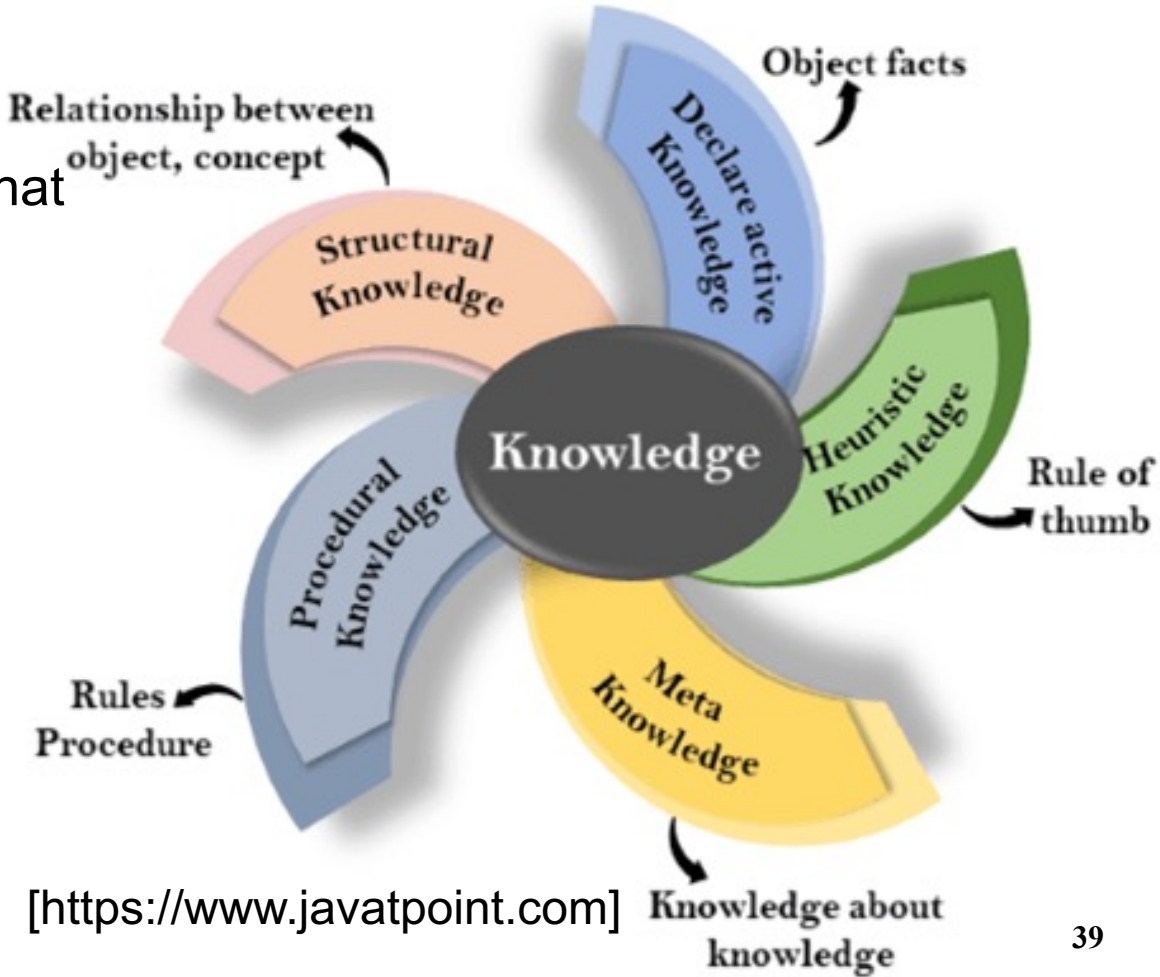
- Natural Language Processing



[https://www.pantechsolutions.net/]

Research areas of AI

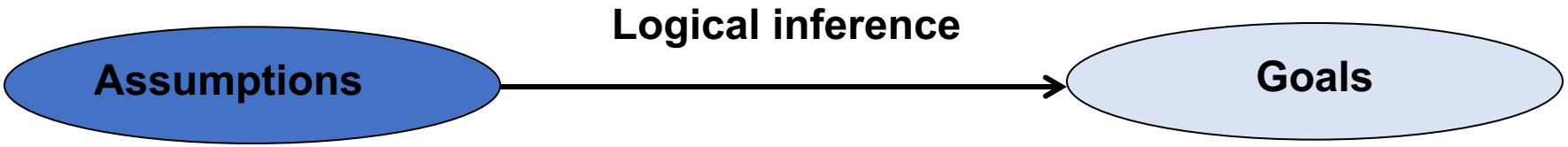
- Knowledge Representation
  - Objects are entities in our world domain (what we represent)
  - Facts are the truths about the world domain
    - *E.g.* Guitars contain strings
  - Events are the actions that occur in our world
    - *E.g.* The guitar is playing



[https://www.javatpoint.com]

Research areas of AI

- Automated Reasoning (in a nutshell)
  - Most often:

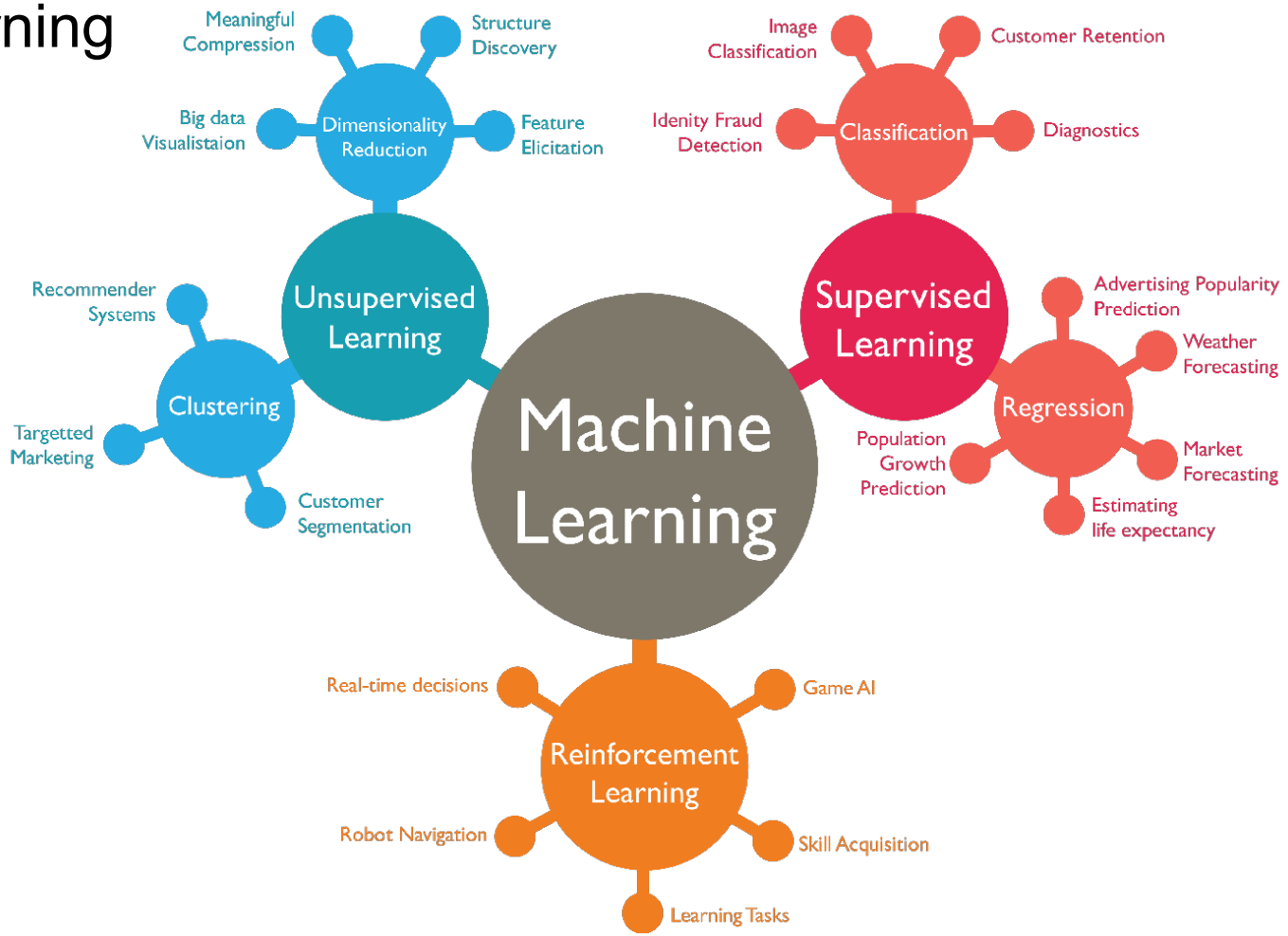


Examples of goals:
Proving theorems
Checking proofs
Designing circuits

  - But, sometimes logic can also be used in the form of
    - Analogy
    - Induction
    - Abduction
    - Non-monotonic reasoning

Research areas of AI

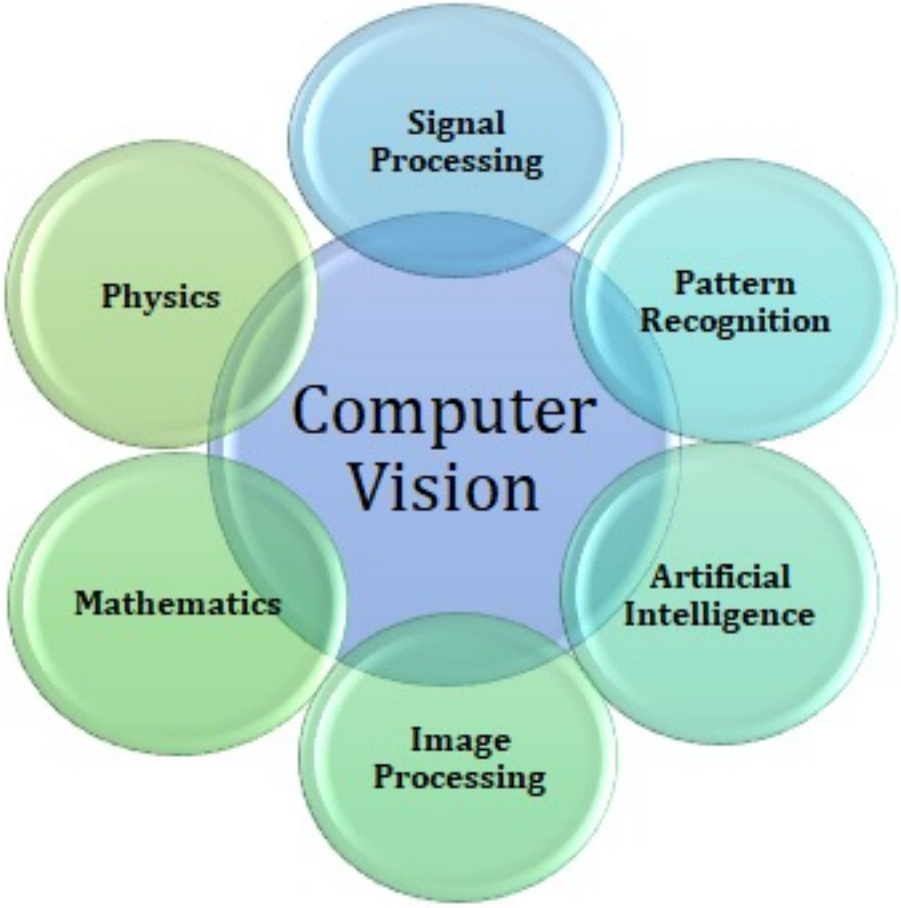
- Machine Learning



[https://www.slideshare.net/awahid/big-data-and-machine-learning-for-businesses]

Research areas of AI

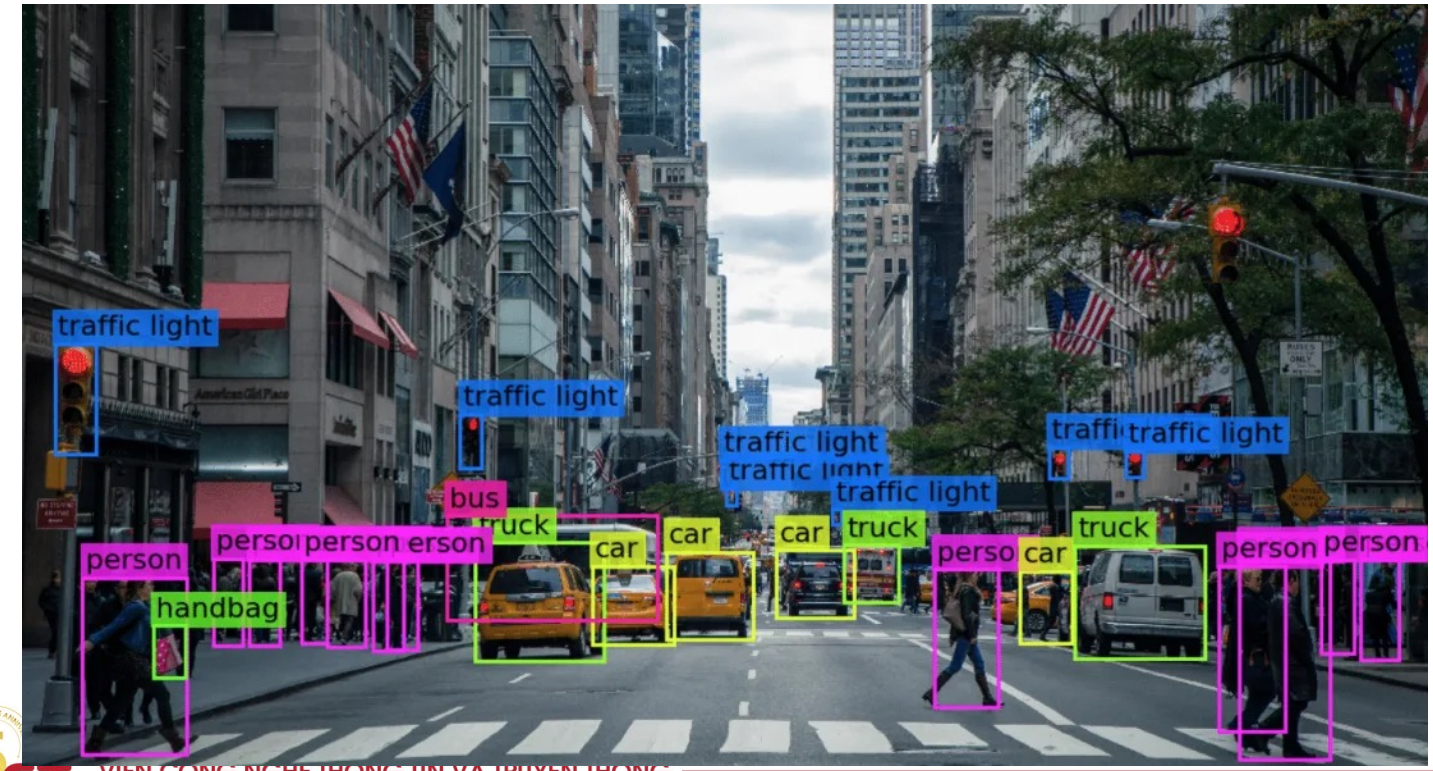
- Computer Vision



[https://aisummit.alliedacademies.com/]

Research areas of AI

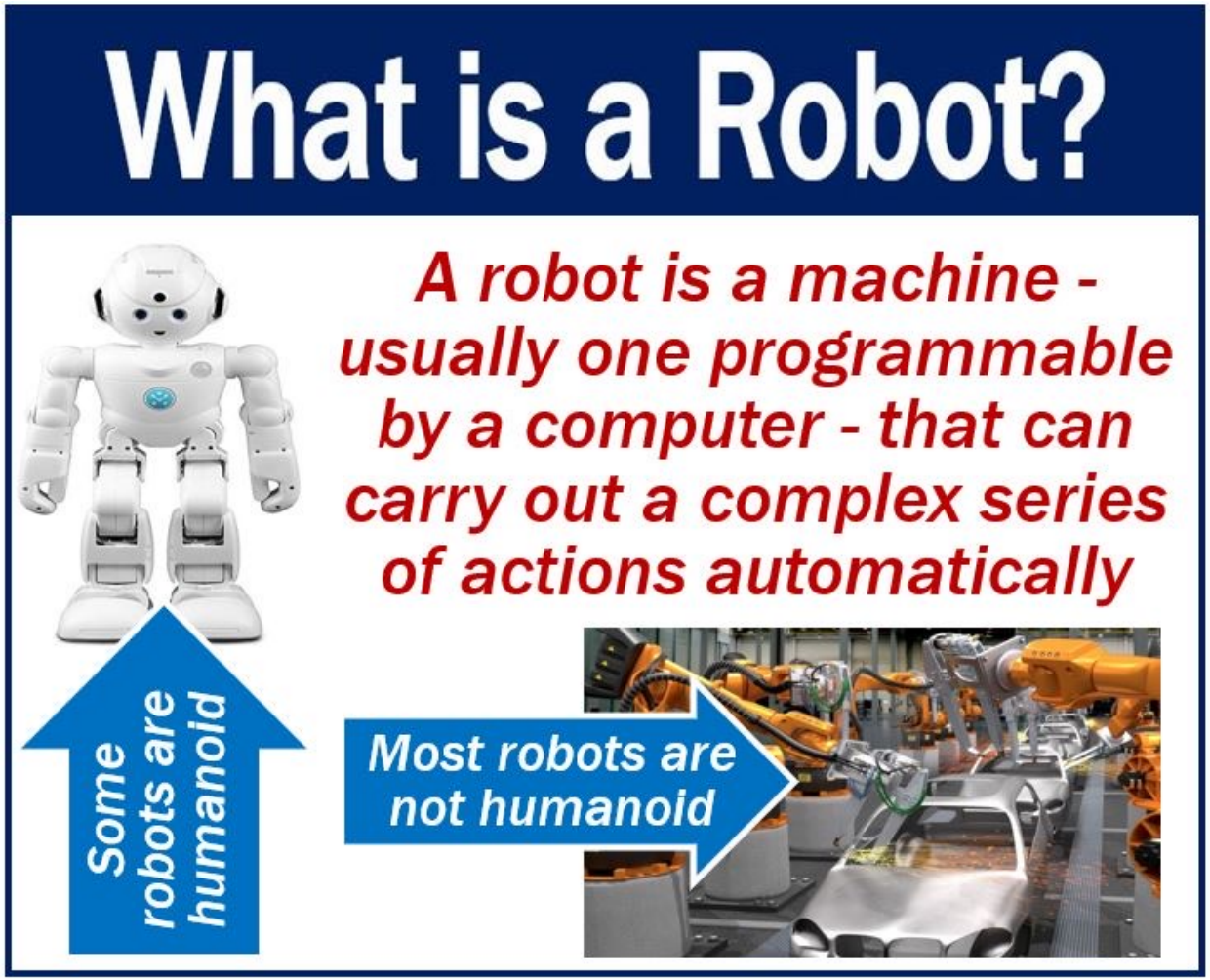
- Computer Vision
  - Can detect / recognize objects in photos / videos
  - Can go way beyond that: *e.g.* action / behavior recognition



[https://www.unite.ai/]

Research areas of AI

- Robotics



[https://marketbusinessnews.com/]

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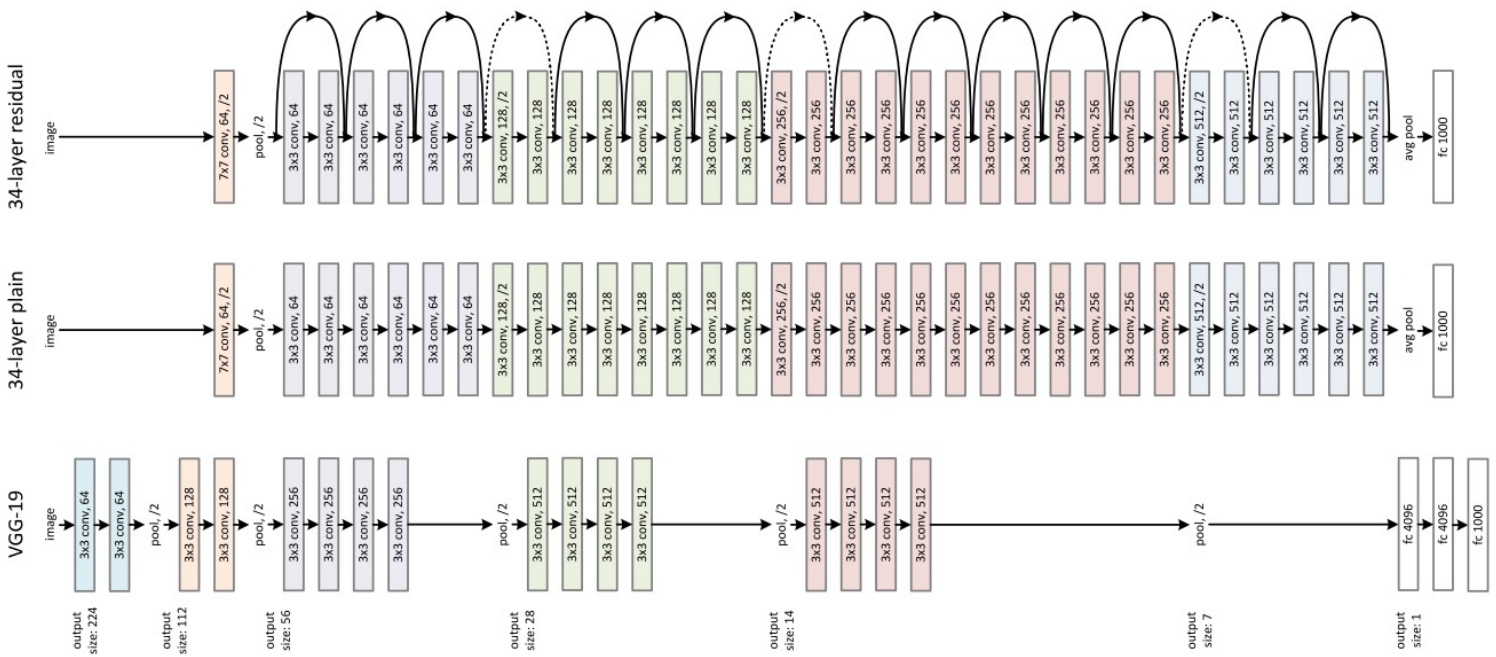
Future of AI

Future of AI – some current challenges

- In Natural Language Processing
  - Setting the context, extracting semantic meanings
- In Knowledge Representation
  - Transfer the knowledge from one domain to another
- In Automated Reasoning
  - Towards eXplainable Artificial Intelligence (XAI)
- In Machine Learning
  - Conceiving algorithms capable of learning their own parameters
- In Computer Vision
  - Transfer learning / domain adaptation
- In Robotics
  - Facilitating human-robot collaboration (reliability, user acceptance…)

Future of AI

- More generally, some of the main challenges in AI are:
  - For humans, to fully understand how AI newest technologies “reason”
    - Some deep neural networks have up to hundreds of neuron layers!
  - Tc



Future of AI

- Another challenge in AI is to learn how to fight against … AI!!!
  - *E.g.* DeepFakes [Source of the gif: Wikipedia]

Chapter 1: Introduction

Summary and ethical discussion

Summary

- AI can be applied to any field (smart cars, on-line selling, e-banking…)
- AI mainly consists of:
  - Natural Language Processing
  - Knowledge Representation
  - Automated Reasoning
  - Machine Learning
  - Computer Vision
  - Robotics
- AI is linked to several other disciplines, including psychology, neuroscience, philosophy, economics, etc.
- Different kinds of approaches can be used for AI
  - Knowledge-based approaches
  - Statistical approaches
  - Agent-based approaches

Ethical issues with AI

- People might lose their jobs to automation
- People might lose their sense of purpose / usefulness
- People are losing some of their privacy rights
  - “Data is the new oil”
- AI makes it easier for an imposter to impersonate someone else
- The use of AI systems might result in a loss of accountability
- …

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Questions

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