Introduction to Artificial Intelligence

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Course Details

- Subject Code: CS3613
- Number of Credits : 3
- Lecturers:
  - Dr. Thanuja Ambegoda (thanuja@cse.mrt.ac.lk)
  - Dr. Sandareka Wickramanayake (sandarekaw@cse.mrt.ac.lk)
  - Dr. Chathuranga Hettiarachchi (chathuranga@cse.mrt.ac.lk)
- Main textbook
  - Artificial Intelligence: A Modern Approach, 4th Edition by *Stuart Russell and Peter Norvig*

Syllabus

Week 1	Introduction to Artificial Intelligence (AI)
Week 2	Intelligent Agents
Week 3	Solving problems by searching
Week 4	Local Search and Optimization Problems
Week 5	Constraint satisfaction problems and Revision
Week 6	Introduction to Logical Agents
Week 7	Logical Reasoning
Week 8	Knowledge representation
Week 9	Planning

Syllabus

Week 10	Quantifying uncertainty
Week 11	Probabilistic reasoning
Week 12	Making simple decisions
Week 13	Introduction to Reinforcement Learning and Robotics
Week 14	Introduction to NLP and Computer Vision

Evaluation

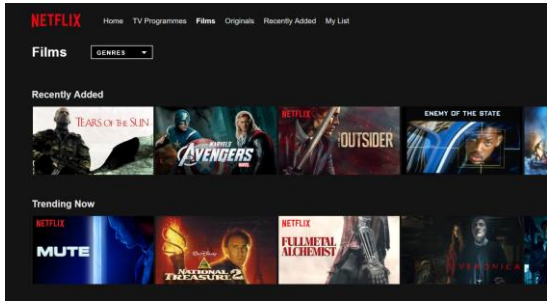
	% out of final marks
Assignment 1 - Problem Solving	5%
Assignment 2 - Knowledge, Reasoning and Planning	10%
Assignment 3 - Uncertain Knowledge and Reasoning	10%
Labs/quizzes	5 %
10-minute presentation on a given AI topic / application - Groups of 5 students	10%
End-semester Examination	60%

Have You Used AI in Your Day-to-day Life?

Have You Used AI in Your Day-to-day Life?

AI has Influenced Almost All Aspects of Human Life!

Entertainment



[netflix-techblog]

Retail

[amazon.com]

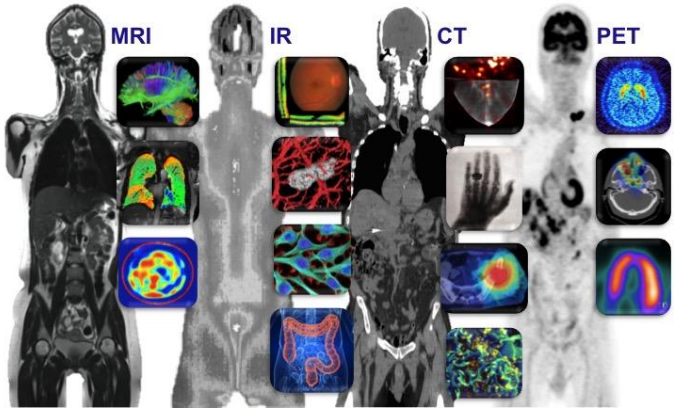
Manufacturing

[techemergence.com]

Transportation

[venturebeat.com]

Healthcare



Agriculture

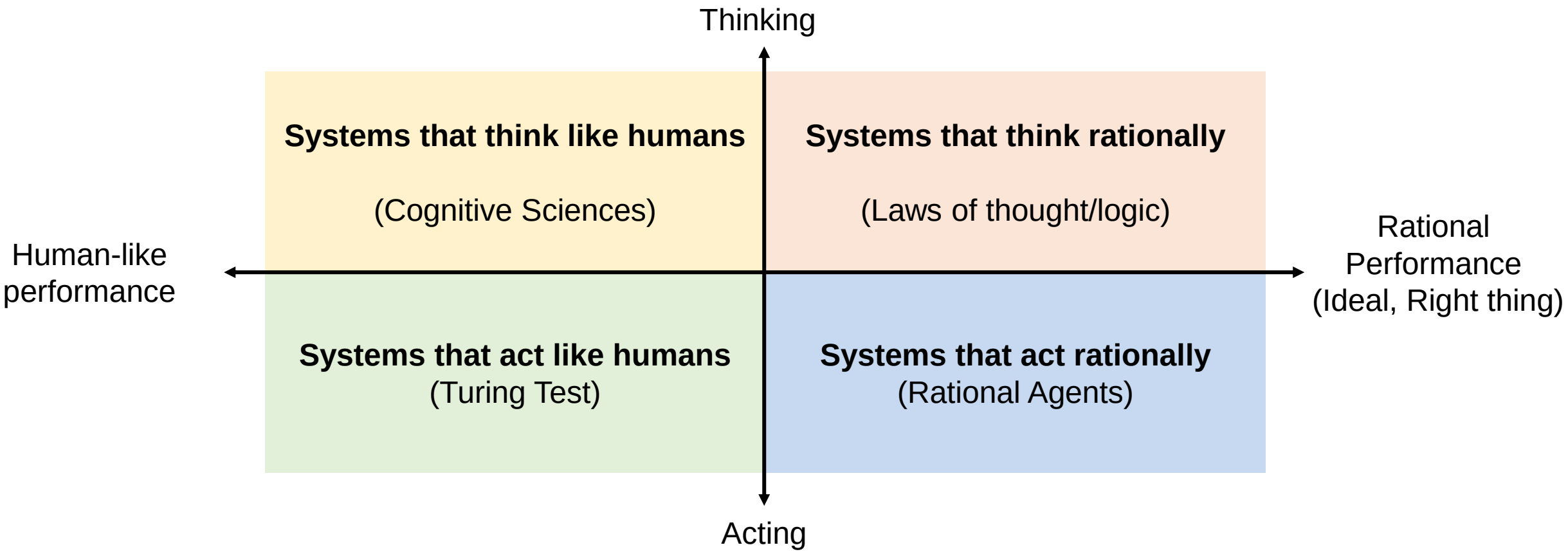
[https://www.orbitinside.com/ai-in-agriculture-new-age-of-farming/]

What is AI?

- AI is concerned with ***understanding* and *building intelligent entities*** - machines that can compute how to act effectively and safely in a wide variety of novel situations.

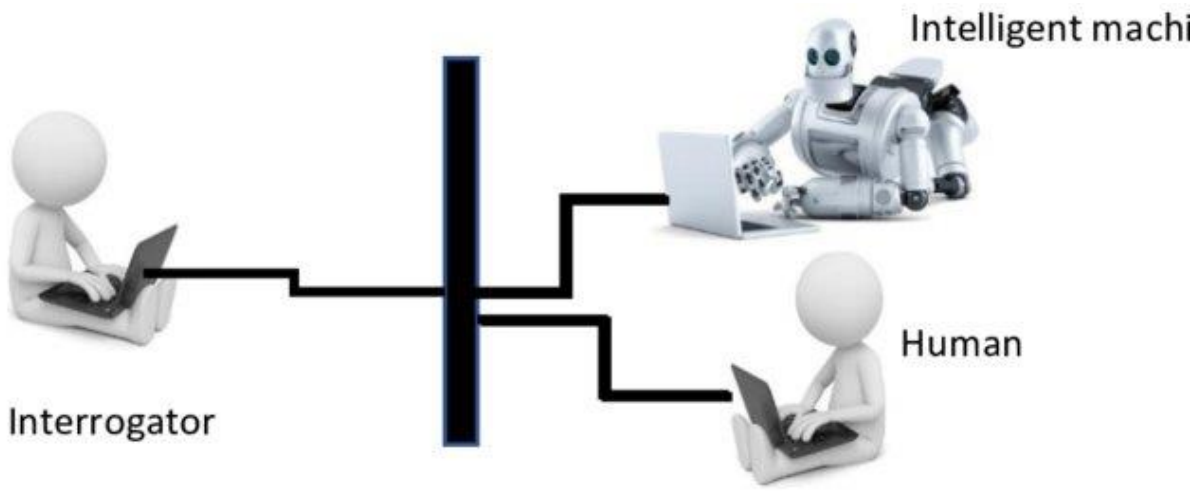
What is AI?

- Four potential goals or definitions of AI.



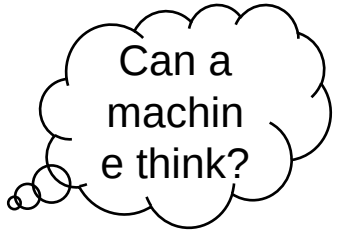
Acting humanly: The Turing Test Approach

- The Turing test
  - “Can a machine think?” → “Can a machine behave intelligently?”
  - A test of a machine's ability to exhibit intelligent behavior equivalent to that of a human.
  - The computer is said to possess “artificial intelligence” if the interrogator can not reliably distinguish the human from the computer.



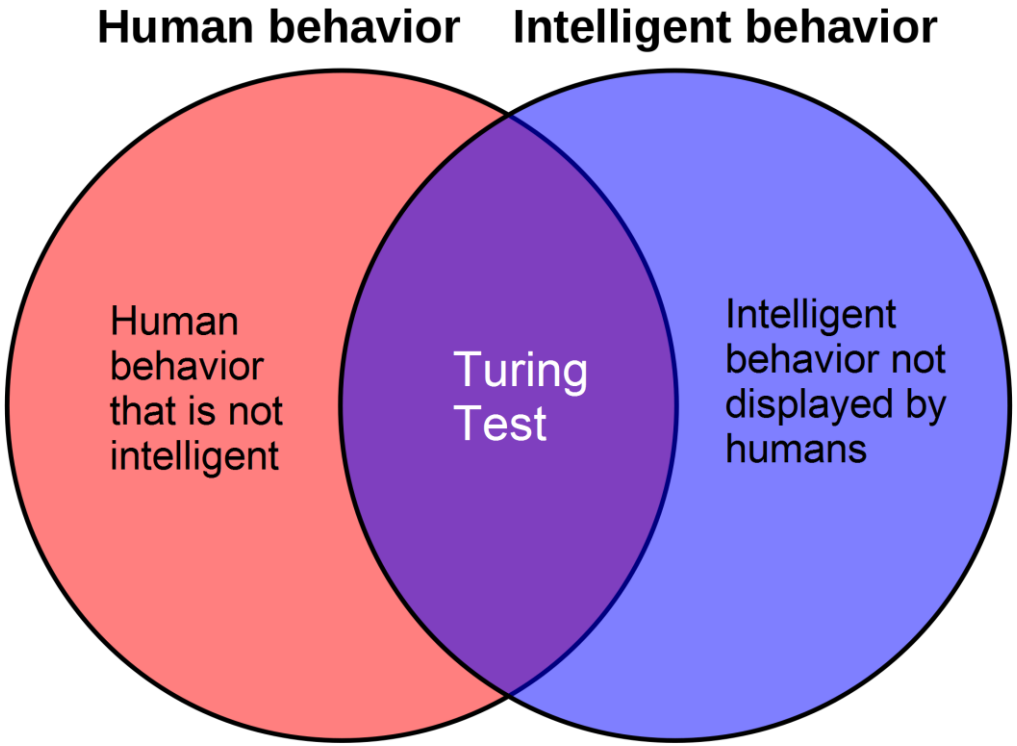
The imitation game/ The Turing test

Mimicking Human



Acting humanly: The Turing Test Approach

- Pitfalls of the Turing Test
  - Doesn’t really indicate if the machine has intelligence.
  - Mimicking human behavior does not make machines intelligent.
  - Human intelligence is not the only form of intelligence.



Acting humanly: The Turing Test Approach

- Suggested major components of AI
  - **Natural language processing** to communicate successfully in a human language;
  - **Knowledge representation** to store what it knows or hears;
  - **Automated reasoning** to answer questions and draw new conclusions;
  - **Machine learning** to adapt to new circumstances and to detect and extrapolate patterns.

  - **Computer vision** and speech recognition to perceive the world;
  - **Robotics** to manipulate objects and move about.

Thinking Humanly: The Cognitive Modeling Approach

- Machines that think like humans
- Before we can develop machines that can think like humans, we need to determine how humans think.
- Possible ways
  - **Introspection -** trying to catch our own thoughts as they go by;
  - **psychological** experiments - observing a person in action;
  - **brain imaging -** observing the brain in action.
- Once we have a sufficiently precise theory of the mind, we can try to realize that in machines.
- If the program’s input-output behavior matches corresponding human behavior, that is evidence that some of the program’s mechanisms could also be operating in humans.

Thinking Rationally: The “Laws of Thought” Approach

- Ideal or correct way of reasoning or thinking: Logic
  - Socrates is a man; all men are mortal; therefore, Socrates is mortal

- Problems with this approach,
  - Difficult to take informal knowledge and state it in formal logical terms.
  - Computationally intensive: Even a problem with a few dozen facts can exhaust any computer unless it’s guided as to which reasoning steps to try first.

Acting Rationally: The Rational Agent Approach

- **An agent** is an entity that perceives and acts.
- Computer agents are expected to
  - Operate autonomously
  - Perceive their environment
  - Persist over a prolonged time period
  - Adapt to change
  - Create and pursue goals
- **A rational agent** is one that acts so as to achieve the best outcome or when there is uncertainty, the best-expected outcome.

Acting Rationally: The Rational Agent Approach

- **Rational agents**
  - Doing the right thing
  - Thinking rationally or logical reasoning is **one** way of acting rationally. **But there are other ways**.
    - Taking your hand off a hot stove – you don’t try to reason, just do it instantly.
  - Can be different from Acting human, because humans don’t always do the right thing.
  - All the skills needed for the Turing test also allow an agent to act rationally.
- Advantages of rational agents
  - More general than the “laws of thought” approach.
  - More amenable to scientific development.

Acting Rationally: The Rational Agent Approach

- **Rational agents**
  - AI has focused on the study and construction of agents that do **the right thing**.
  - What counts as the right thing is defined by the objective that we provide to the agent.

- *This module concentrates on general principles of rational agents and on components for constructing them.*

- Limited rationality
  - The perfect rationality is not feasible in complex environments! The computational demands are just too high.

In Class Activity

The Foundations of AI

- Philosophy
  - Logic, methods of reasoning, mind as physical system foundations of learning, language, rationality
- Mathematics
  - Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability
- Economics
  - Utility, decision theory
- Neuroscience
  - Study of the nervous system, particularly, the brain

The Foundations of AI Cont.

- Psychology
  - Study how humans and animals think
- Computer engineering
  - Building fast computers
- Control theory
  - Design systems that maximize an objective function over time
- Linguistics
  - Knowledge representation, grammar

The History of AI

- The inception of artificial intelligence (1943–1956)
  - McCulloch & Pitts (1943)
    - Boolean Circuit model of brain
    - First reference of a neural network computations
  - Marvin Minsky & Dean Edmonds (1951)
    - SNARC, a neural network computer
    - 40 neurons
    - 3000 vacuum tubes
  - Alan Turing (1950)
    - “Computing Machinery and Intelligence” provided the complete vision of AI.
    - Problem solving by searching through state space, guided by heuristics.
  - Darmouth Meeting (1956)
    - The term “Artificial Intelligence” was found.

The History of AI

- Early enthusiasm, great expectations (1952–1969)
  - Alan Newell and Herbert Simon (1956)
    - Logic Theorist
    - Considered to be the first AI program
    - General Problem Solver (GPS)
  - Gelernter (1959)
    - Geometry Theorem Prover - Proves theorems that many students of mathematics would find quite tricky.
  - Samuel’s Checkers program (1952-1956)
    - Samuel’s programs learned to play at a strong amateur level.
    - The first machine learning system that received public recognition.
    - The precursor of later systems such as ALPHAGO.

The History of AI

- Early enthusiasm, great expectations (1952–1969)
  - James Slagle (1961)
    - The first symbolic integration program (SAINT)
    - Solves calculus problems at college freshman level
  - Thomas Evan (1963)
    - Program to solve IQ test type analogy problems

The History of AI

- A dose of reality (1966–1973)
- Expert systems (1969–1986)
  - Faigenbaum et al. (1969)
    - Dendral Program
    - First successful knowledge-based program for scientific reasoning
- The return of neural networks (1986–present)
  - Mid 80’s reinventing backpropagation learning algorithm

The History of AI

- Probabilistic reasoning and machine learning (1987–present)
  - Borrowing concepts from other fields
  - Hidden Markov models (HMMs)

- Big data (2001–present)
  - The creation of very large data sets.
  - The development of learning algorithms specially designed to take advantage of very large data sets.
  - ImageNet database (2009)

- Deep learning (2011–present)
  - 2012 ImageNet competition

The State of the Art of AI

- ***Based on One Hundred Year Study on AI 2018 and 2019.***
- **Publications:** AI papers increased 20-fold between 2010 and 2019 to about 20,000 a year. The most popular category was machine learning.
- **Students:** Course enrollment increased 5-fold in the U.S. and 16-fold internationally from a 2010 baseline. AI is the most popular specialization in Computer Science.
- **Conferences:** Attendance at NeurIPS increased 800% since 2012 to 13,500 attendees. Other conferences are seeing annual growth of about 30%.
- **Industry:** AI startups in the U.S. increased 20-fold to over 800.

The State of the Art of AI

- ***Based on One Hundred Year Study on AI 2018 and 2019.***
- **Internationalization**: China publishes more papers per year than the U.S. and about as many as all of Europe. However, in citation-weighted impact, U.S. authors are 50%ahead of Chinese authors.

- **Vision**: Error rates for object detection improved from 28% in 2010 to 2% in 2017, exceeding human performance. Accuracy in open-ended visual question answering 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.

The State of the Art of AI

- ***Based on One Hundred Year Study on AI 2018 and 2019.***
- **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.

The State of the Art of AI

- Robotic Vehicles
  - E.g. Waymo - https://youtu.be/hA_-MkU0Nfw

The State of the Art of AI

- Robots
  - E.g., BigDog - https://youtu.be/PQr6U3RWzVg

The State of the Art of AI

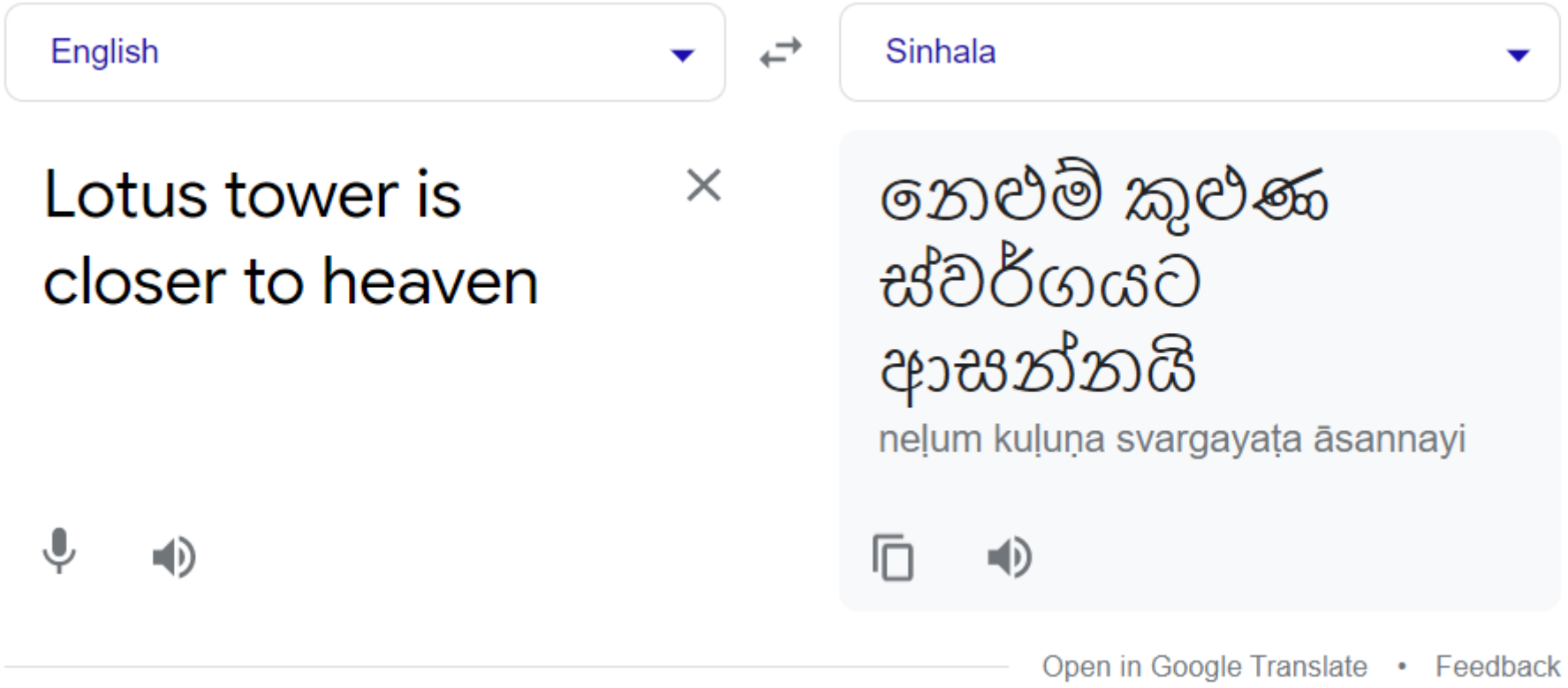
- Robots
  - E.g., Sophia - https://youtu.be/BhU9hOo5Cuc

The State of the Art of AI

- Autonomous planning and scheduling
  - E.g., NASA's Mars - https://youtu.be/5qqsMjy8Rx0

The State of the Art of AI

- Machine Translation
  - Online machine translation systems now enable the reading of documents in over 100 languages.



The State of the Art of AI

- Speech Recognition
  - Alexa, Siri, Cortana, and Google offer assistants that can answer questions and carry out tasks for the user.
  - Alexa - https://www.youtube.com/watch?v=W3DEJgnGZYc

The State of the Art of AI

- Recommendations
  - Companies such as 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.
- Medicine
  - AI algorithms now equal or exceed expert doctors at diagnosing many conditions, particularly when the diagnosis is based on images. E.g., Alzheimer’s disease, metastatic cancer, ophthalmic disease, and skin diseases.

Road of AI

Intelligence by a machine is possible.

Intelligence can be achieved by encoding expert knowledge into logic.

The probabilistic models of the world will be the main tool.

Machine Learning will induce models that might not be based on any well-understood theory at all.

Next??

Limits of AI at Present

- Today’s successful AI systems
  - Operates in well-defined domains
  - Employ narrow, specialized knowledge
- A step ahead would be
  - Systems that can work in multiple domains
  - Such a system would have to have “common sense” knowledge to function in open-ended worlds
  - Understand unconstrained natural language