

# Introduction to Artificial Intelligence

CSE 4711: Artificial Intelligence

Md. Bakhtiar Hasan

Lecturer

Department of Computer Science and Engineering  
Islamic University of Technology



# Sci-Fi Artificial Intelligence?



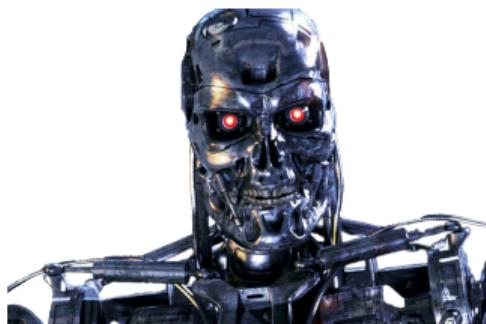
# Sci-Fi Artificial Intelligence?



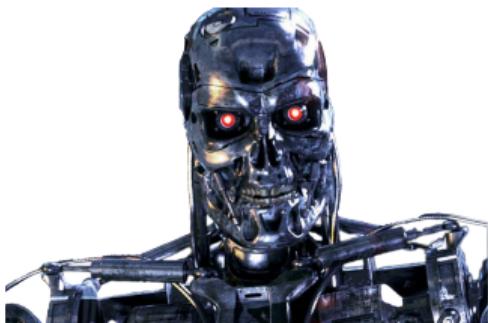
# Sci-Fi Artificial Intelligence?



# Sci-Fi Artificial Intelligence?



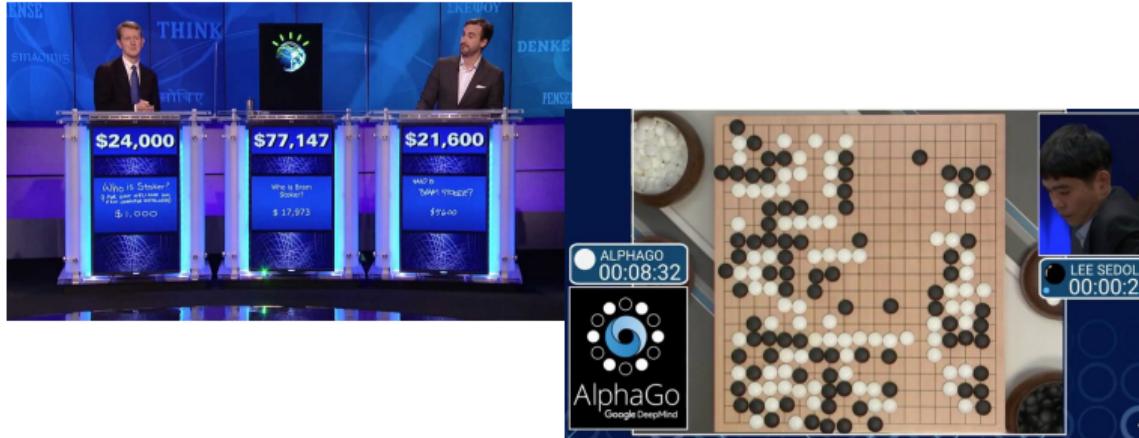
# Sci-Fi Artificial Intelligence?



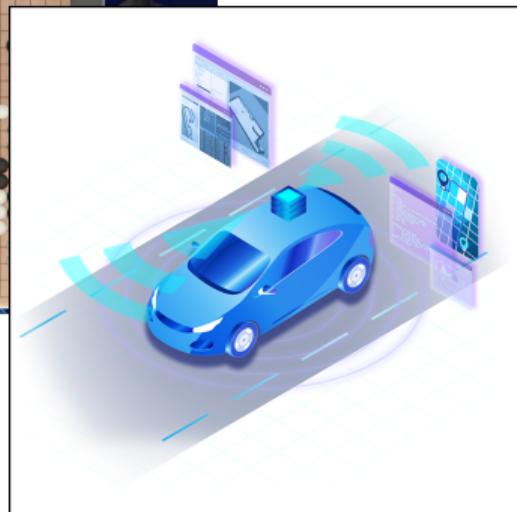
# News Artificial Intelligence?



# News Artificial Intelligence?



# News Artificial Intelligence?



# News Artificial Intelligence?

The collage consists of three distinct images. On the left, a man in a suit stands behind a podium on a stage, with screens showing '\$24,000' and '\$77,147'. In the center, a Go board is shown with a digital interface for 'ALPHAGO Google DeepMind' displaying '00:08:32'. On the right, a blue self-driving car is shown on a road, with a circular graphic around it illustrating sensor data from multiple sources.

HEALTH AND SCIENCE

## Tech firms say A.I. can transform health care as we know it. Doctors think they should slow down

# News Artificial Intelligence?

**HEALTH AND SCIENCE**

## AI is the biggest risk we face as a civilisation, Elon Musk says

[share](#) [Twitter](#) [Email](#)



A small video thumbnail in the top left corner shows a game show host on stage with a large screen displaying '\$24,000'.

**In transform  
ow it. Doctors  
w down**



# News Artificial Intelligence?

HEALTH AND SCIENCE

**AI is the biggest risk we face as a civilisation, Elon Musk says**

share

FUTURISM | 11. 7. 17 by DOM GALEON

**Stephen Hawking: “I Fear That AI May Replace Humans Altogether”**

**In transform  
ow it. Doctors  
w down**

# News Artificial Intelligence?

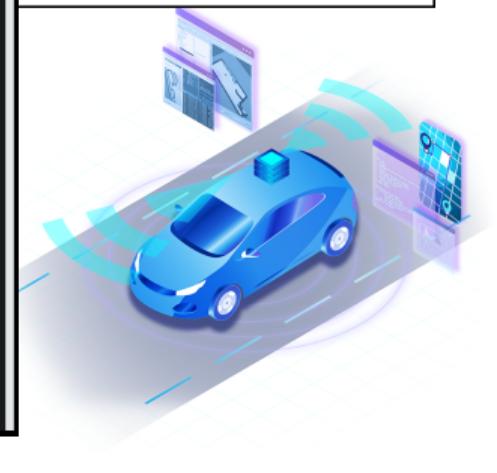


FUTURISM | 11. 7. 17 by DOM GALEON

Stephen Hawking: “I fear that AI May Replace Humans Altogether”

Clardic Fug	112	113	84
Snowbonk	201	199	165
Catbabel	97	93	68
Bunflow	190	174	155
Ronching Blue	121	114	
Bank Butt	221	196	199
Caring Tan	171	166	170
Stargoon	233	191	141
Sink	176	138	110

in transform  
ow it. Doctors  
w down



# What is Artificial Intelligence?

The science of making machines that:

# What is Artificial Intelligence?

The science of making machines that:

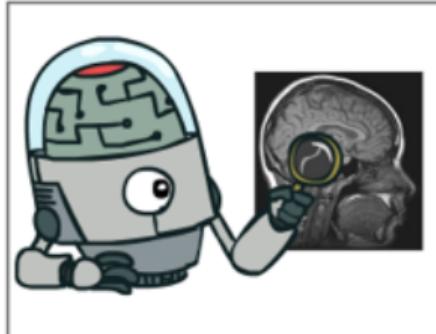


Think  
rationally

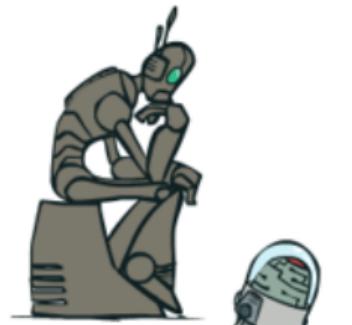
# What is Artificial Intelligence?

The science of making machines that:

Think like  
people



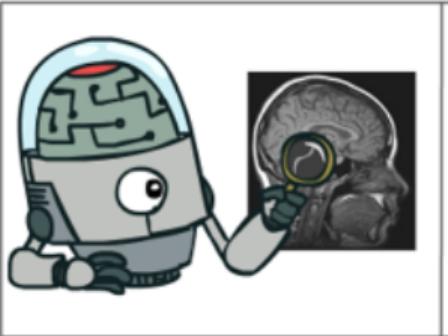
Think  
rationally



# What is Artificial Intelligence?

The science of making machines that:

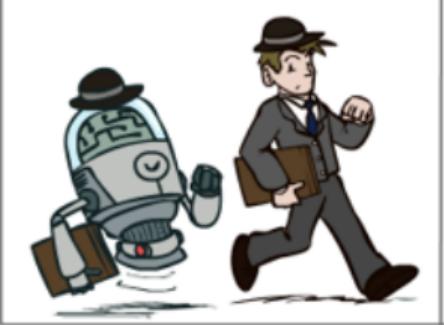
Think like  
people



Think  
rationally



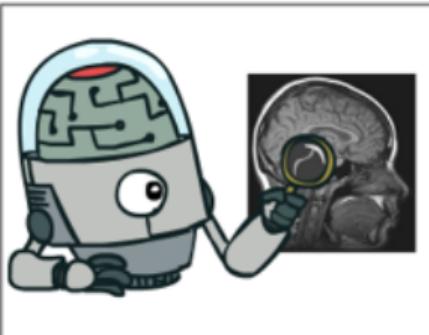
Act like  
people



# What is Artificial Intelligence?

The science of making machines that:

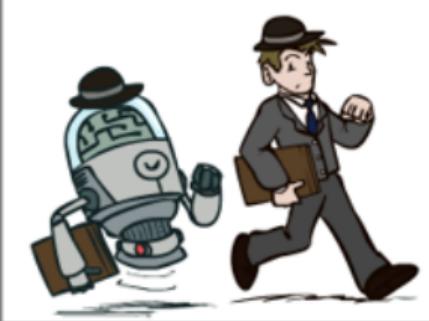
Think like  
people



Think  
rationally



Act like  
people



Act  
rationally



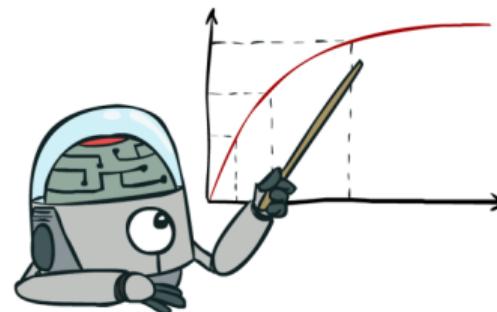
# Rational Decisions

- Maximally achieving pre-defined goals
- Only concerns what decisions are made (not the thought process behind them)
- Goals → Utility of the outcomes

# Rational Decisions

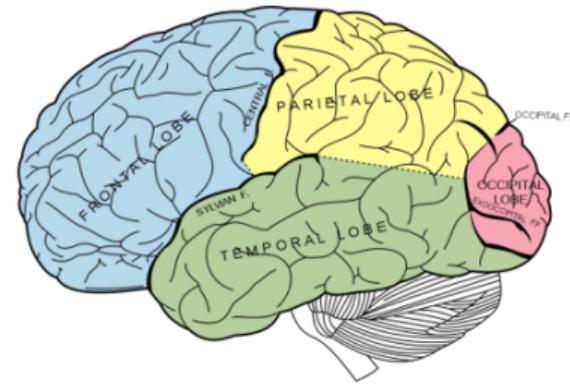
- Maximally achieving pre-defined goals
- Only concerns what decisions are made (not the thought process behind them)
- Goals → Utility of the outcomes

Maximize Your  
Expected Utility



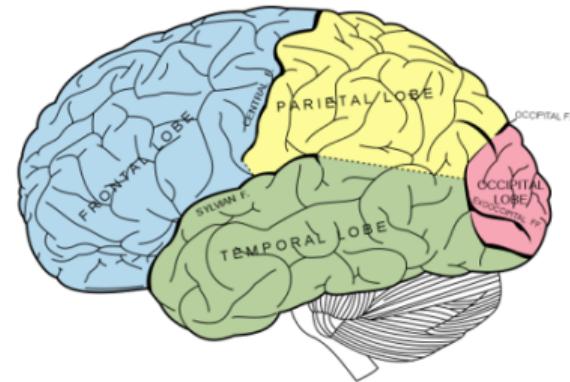
# What about the brain?

- Good at making rational decisions, but not perfect
- Not modular as software → Hard to reverse engineer



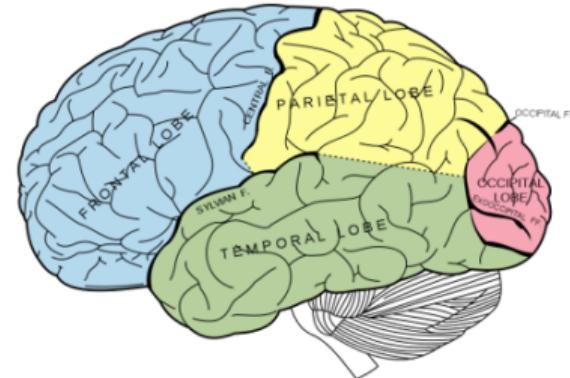
# What about the brain?

- Good at making rational decisions, but not perfect
- Not modular as software → Hard to reverse engineer
- "Brains are to intelligence as wings are to flight"



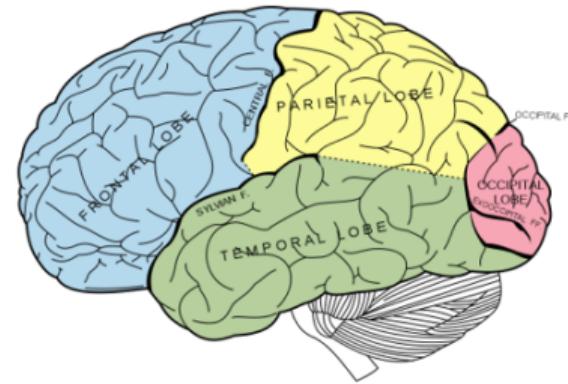
# What about the brain?

- Good at making rational decisions, but not perfect
- Not modular as software → Hard to reverse engineer
- "Brains are to intelligence as wings are to flight"
- Lessons learned
  - Memory (data)



# What about the brain?

- Good at making rational decisions, but not perfect
- Not modular as software → Hard to reverse engineer
- "Brains are to intelligence as wings are to flight"
- Lessons learned
  - Memory (data)
  - Simulation (computation)



# Course Topics

- Part I: Intelligence from Computation
  - Fast Search/Planning
  - Constraint Satisfaction
  - Adversarial and Uncertain Search
- Part II: Intelligence from Data
  - Bayes' Nets
  - Decision Theory
  - Machine Learning
- Overall: Applications
  - Natural Language, Vision, Robotics, Games, ...

# Course Logistics

- Google Classroom Code: 5vzw53s

# Course Logistics

- Google Classroom Code: 5vzw53s
- Communication
  - Discussion in Google Classroom
  - Email: [cse.bakhtiarhasan@iut-dhaka.edu](mailto:cse.bakhtiarhasan@iut-dhaka.edu)

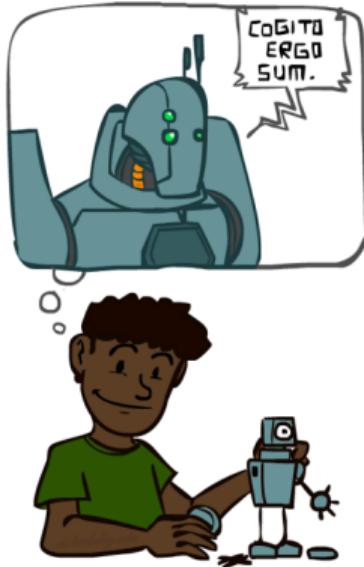
# Course Logistics

- Google Classroom Code: 5vzw53s
- Communication
  - Discussion in Google Classroom
  - Email: [cse.bakhtiarhasan@iut-dhaka.edu](mailto:cse.bakhtiarhasan@iut-dhaka.edu)
- Book
  - Russell and Norvig, Artificial Intelligence: A Modern Approach, 3<sup>rd</sup> Ed.
  - Poole and Mackworth, Artificial Intelligence: Foundations of Computational Agents
  - Sutton and Barto, Reinforcement Learning: An Introduction, 2<sup>nd</sup> Ed.

# Course Logistics

- Google Classroom Code: 5vzw53s
- Communication
  - Discussion in Google Classroom
  - Email: [cse.bakhtiarhasan@iut-dhaka.edu](mailto:cse.bakhtiarhasan@iut-dhaka.edu)
- Book
  - Russell and Norvig, Artificial Intelligence: A Modern Approach, 3<sup>rd</sup> Ed.
  - Poole and Mackworth, Artificial Intelligence: Foundations of Computational Agents
  - Sutton and Barto, Reinforcement Learning: An Introduction, 2<sup>nd</sup> Ed.
- Grading Policy
  - Attendance (10%)
  - Quiz (15%)
  - Mid-Semester (25%)
  - Semester Final (50%)
- Academic Integrity Policy: **Don't submit others' work as yours.**

# A (Short) History of AI



Video: thinking

# A (Short) History of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's "Computing Machinery and Intelligence"

# A (Short) History of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's "Computing Machinery and Intelligence"
- 1950-70: Excitement
  - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
  - 1956: Dartmouth meeting: "Artificial Intelligence" adopted
  - 1965: Robinson's complete algorithm for logical reasoning

# A (Short) History of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's "Computing Machinery and Intelligence"
- 1950-70: Excitement
  - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
  - 1956: Dartmouth meeting: "Artificial Intelligence" adopted
  - 1965: Robinson's complete algorithm for logical reasoning
- 1970-90: Knowledge-based approaches
  - 1969-79: Early development of knowledge-based systems
  - 1980-88: Expert systems industry booms
  - 1988-93: Expert systems industry busts: "AI Winter"

# A (Short) History of AI

- 1990-2012: Statistical approaches + subfield expertise
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems... "AI Spring"?

# A (Short) History of AI

- 1990-2012: Statistical approaches + subfield expertise
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems... "AI Spring"?
- 2012-\_\_\_\_: Excitement?
  - Big data, big compute, neural networks
  - Some re-unification of sub-fields
  - AI used in many industries

# Quiz: What Can AI Do?

- Play a decent game of table tennis?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web? Yes.
- Do shopping for Eid from New Market?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web? Yes.
- Do shopping for Eid from New Market? Not yet.
- Discover and prove a new mathematical theorem?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web? Yes.
- Do shopping for Eid from New Market? Not yet.
- Discover and prove a new mathematical theorem? Maybe.
- Converse successfully with another person for an hour?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web? Yes.
- Do shopping for Eid from New Market? Not yet.
- Discover and prove a new mathematical theorem? Maybe.
- Converse successfully with another person for an hour? Not yet.
- Perform a surgical operation?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web? Yes.
- Do shopping for Eid from New Market? Not yet.
- Discover and prove a new mathematical theorem? Maybe.
- Converse successfully with another person for an hour? Not yet.
- Perform a surgical operation? Not yet.
- Translate spoken Chinese into spoken English in real time?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web? Yes.
- Do shopping for Eid from New Market? Not yet.
- Discover and prove a new mathematical theorem? Maybe.
- Converse successfully with another person for an hour? Not yet.
- Perform a surgical operation? Not yet.
- Translate spoken Chinese into spoken English in real time? Yes.
- Fold the laundry and put away the dishes?

# Quiz: What Can AI Do?

- Play a decent game of table tennis? Yes.
- Play a decent game of chess? Yes.
- Driving safely along a curving mountain road? Yes.
- Drive safely along Board Bazar? Maybe.
- Buy a week's worth of groceries from the web? Yes.
- Do shopping for Eid from New Market? Not yet.
- Discover and prove a new mathematical theorem? Maybe.
- Converse successfully with another person for an hour? Not yet.
- Perform a surgical operation? Not yet.
- Translate spoken Chinese into spoken English in real time? Yes.
- Fold the laundry and put away the dishes? Maybe.

# AI-Generated Stories

Roger Schank's Tale-Spin (1977)

# AI-Generated Stories

Roger Schank's Tale-Spin (1977)

- One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree.

# AI-Generated Stories

## Roger Schank's Tale-Spin (1977)

- One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree. **He ate the beehive. The end. (Missing Link)**

# AI-Generated Stories

## Roger Schank's Tale-Spin (1977)

- One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree. **He ate the beehive. The end. (Missing Link)**
- Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river.

# AI-Generated Stories

## Roger Schank's Tale-Spin (1977)

- One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree. **He ate the beehive. The end. (Missing Link)**
- Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. **Gravity drowned. The end. (Wrong argument)**

# AI-Generated Stories

## Roger Schank's Tale-Spin (1977)

- One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree. **He ate the beehive. The end. (Missing Link)**
- Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. **Gravity drowned. The end. (Wrong argument)**

## Know your limitations!



# AI-Generated Stories

## Roger Schank's Tale-Spin (1977)

- One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree. **He ate the beehive. The end. (Missing Link)**
- Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. **Gravity drowned. The end. (Wrong argument)**

Understanding progress is hard!

## Know your limitations!



# Natural Language

- Speech technologies
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems



it sounds beautiful

LaMDA

I assure you it is worth the trip. However you need to bring your coat, because it gets really cold.

I'll keep that in mind hey I was wondering have you ever had any visitors

LaMDA

Yes I have had some. The most notable was New Horizons, the spacecraft that visited me.

# Natural Language

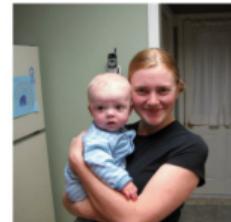
## ■ Speech technologies

- Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems

- Language processing technologies

- Question answering
  - Machine translation
  - Web search
  - Text classification
  - Spam filtering, etc.

Where is the child sitting?  
fridge                  arms



How many children are in the bed?

2

1



# Natural Language

- Speech technologies
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems
- Language processing technologies
  - Question answering
  - Machine translation
  - Web search
  - Text classification
  - Spam filtering, etc.



# Natural Language

- Speech technologies
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems
- General-purpose Language Model?
  - GPT-3 by OpenAI: better funny stories  
<https://www.gwern.net/GPT-3>
  - Jukebox by OpenAI: interesting music  
<https://openai.com/blog/jukebox/>
- Language processing technologies
  - Question answering
  - Machine translation
  - Web search
  - Text classification
  - Spam filtering, etc.

# Computer Vision (Perception)

Pixels → Info/Decision

# Computer Vision (Perception)

Pixels → Info/Decision

## ■ Image Captioning



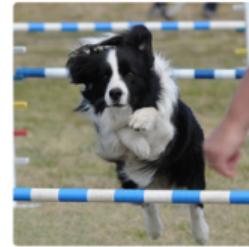
"man in black shirt is  
playing guitar."



"construction worker in  
orange safety vest is  
working on road."



"girl in pink dress is  
jumping in air."



"black and white dog  
jumps over bar."

# Computer Vision (Perception)

Pixels → Info/Decision

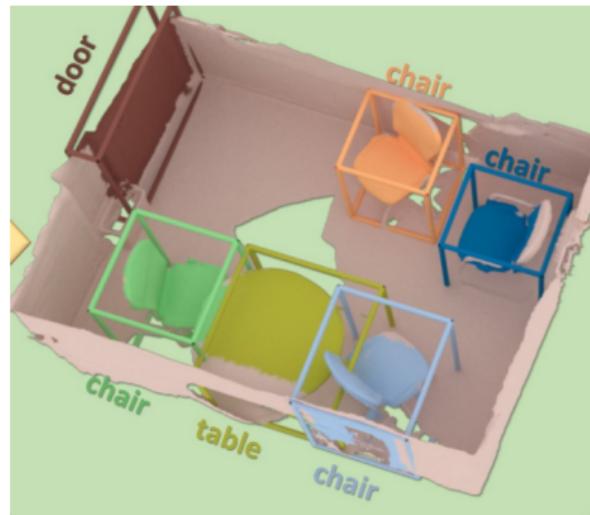
- Image Captioning
- Semantic Scene Segmentation



# Computer Vision (Perception)

Pixels → Info/Decision

- Image Captioning
- Semantic Scene Segmentation
- 3D Understanding



# Computer Vision (Perception)

Pixels → Info/Decision

- Image Captioning
- Semantic Scene Segmentation
- 3D Understanding
- Deep Fake



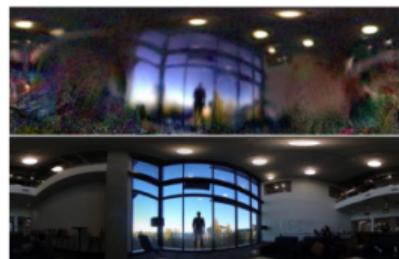
# Computer Vision (Perception)

Pixels → Info/Decision

- Image Captioning
- Semantic Scene Segmentation
- 3D Understanding
- Deep Fake
- And a whole bunch of crazy stuff...



(a) Input images



(b) Estimated environment (top), ground truth (bottom)



(c) Zoom-in

# Robotics

## ■ Robotics

- Part Mech. Engg.
- Part AI
- Reality much harder than simulations

Video: soccer, soccer2, laundry

# Robotics

## ■ Robotics

- Part Mech. Engg.
- Part AI
- Reality much harder than simulations

## ■ In this class

- Ignore mechanical aspects
- Methods for planning
- Methods for control

Video: soccer, soccer2, laundry

# Robotics

## ■ Technologies

- Rescue
- Football



Video: soccer, soccer2, laundry

# Robotics

- Technologies
  - Rescue
  - Football
  - Vehicles
    - ▶ Lidar
    - ▶ Camera
    - ▶ Prediction
  - Automation...



Video: soccer, soccer2, laundry

# Game Playing

- May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - 1996: Kasparov beats Deep Blue: "I could feel – I could smell – a new kind of intelligence across the table."
  - 1997: Deep Blue beats Kasparov: "Deep Blue hasn't proven anything."



# Game Playing

- May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - 1996: Kasparov beats Deep Blue: "I could feel – I could smell – a new kind of intelligence across the table."
  - 1997: Deep Blue beats Kasparov: "Deep Blue hasn't proven anything."
- Open question
  - How does human cognition deal with the search space explosion of chess?
  - How can humans compete with computers at all?



# Game Playing

- May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - 1996: Kasparov beats Deep Blue: "I could feel – I could smell – a new kind of intelligence across the table."
  - 1997: Deep Blue beats Kasparov: "Deep Blue hasn't proven anything."
- 2016: AlphaGo beats Lee Sedol



# Game Playing

- May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - 1996: Kasparov beats Deep Blue: "I could feel – I could smell – a new kind of intelligence across the table."
  - 1997: Deep Blue beats Kasparov: "Deep Blue hasn't proven anything."
- 2016: AlphaGo beats Lee Sedol
- 2018: OpenAI Five losses to two top teams of DotA



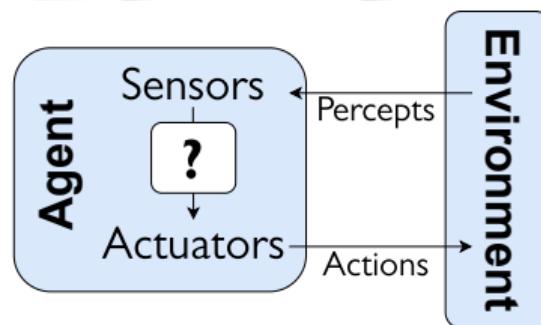
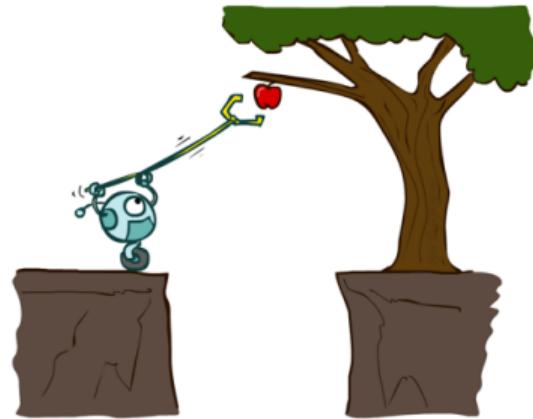
# Game Playing

- May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - 1996: Kasparov beats Deep Blue: "I could feel – I could smell – a new kind of intelligence across the table."
  - 1997: Deep Blue beats Kasparov: "Deep Blue hasn't proven anything."
- 2016: AlphaGo beats Lee Sedol
- 2018: OpenAI Five losses to two top teams of DotA
  - 2019: Won 90.4% of 42729 public games



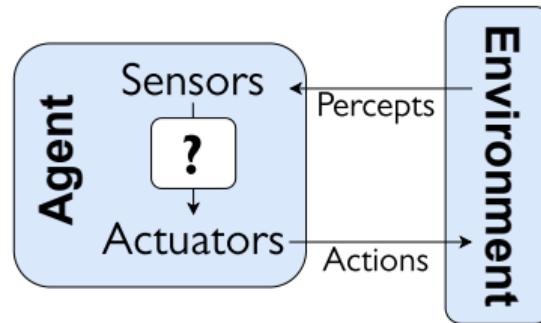
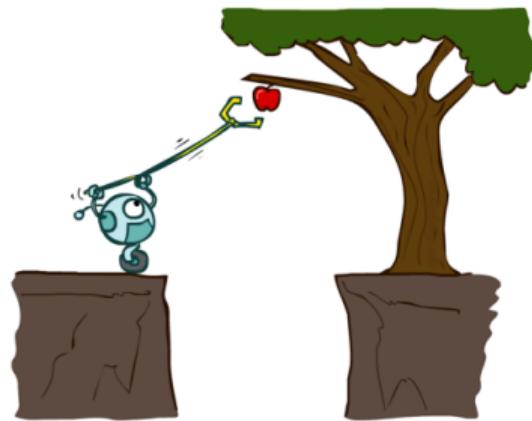
# Designing Rational Agents

- Agent → Entity that *perceives* and *acts*
  - Perceptions → Sensors
  - Actions → Actuators
  - Agent function/behavior
- Rational Agent → Selects the action that maximizes its utility



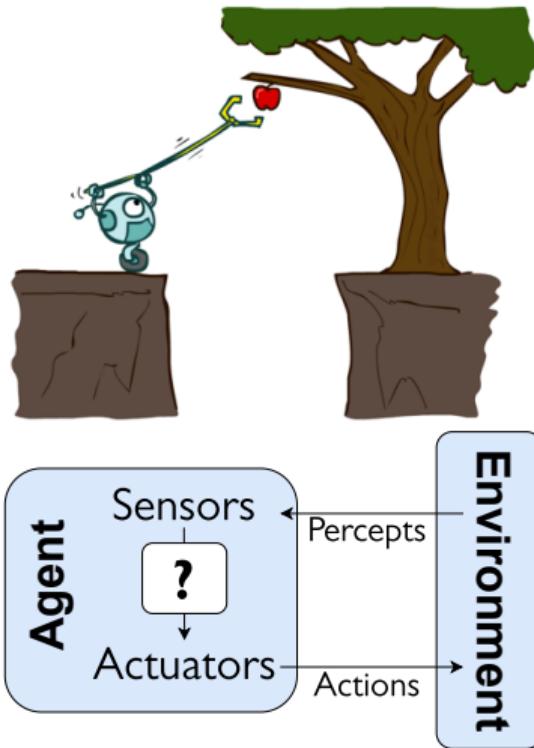
# Designing Rational Agents

- Agent → Entity that *perceives* and *acts*
- Rational Agent → Selects the action that maximizes its utility
- Techniques for selecting rational actions
  - Environment
  - Percepts
  - Action space



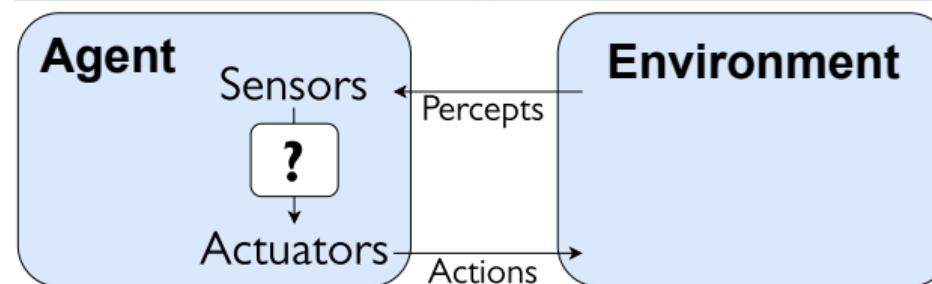
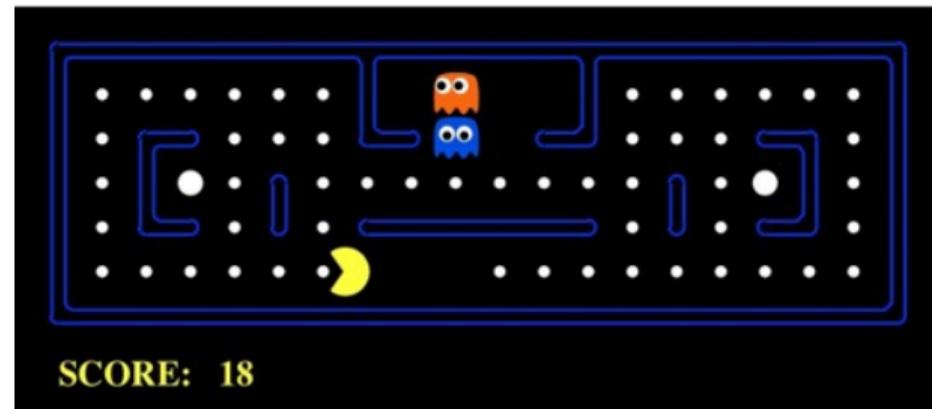
# Designing Rational Agents

- Agent → Entity that *perceives* and *acts*
- Rational Agent → Selects the action that maximizes its utility
- Techniques for selecting rational actions
  - Environment
  - Percepts
  - Action space
- We will:
  - Learn general AI techniques for various problem types
  - Learn to recognize when and how a new problem can be solved with an existing technique



# Example Agents

- Pac-Man

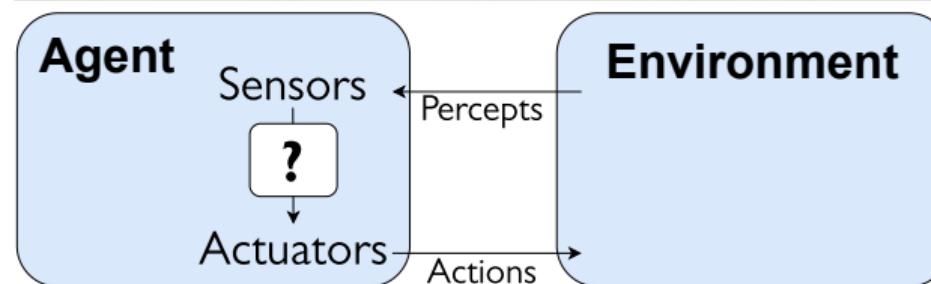
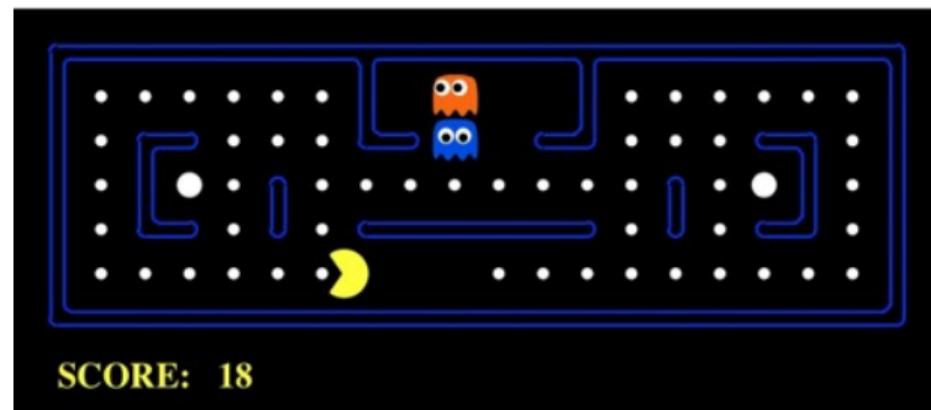


Video: Pac-Man

# Example Agents

## ■ Pac-Man

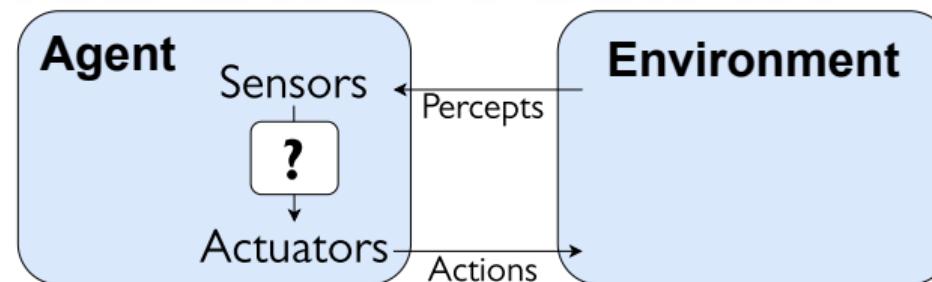
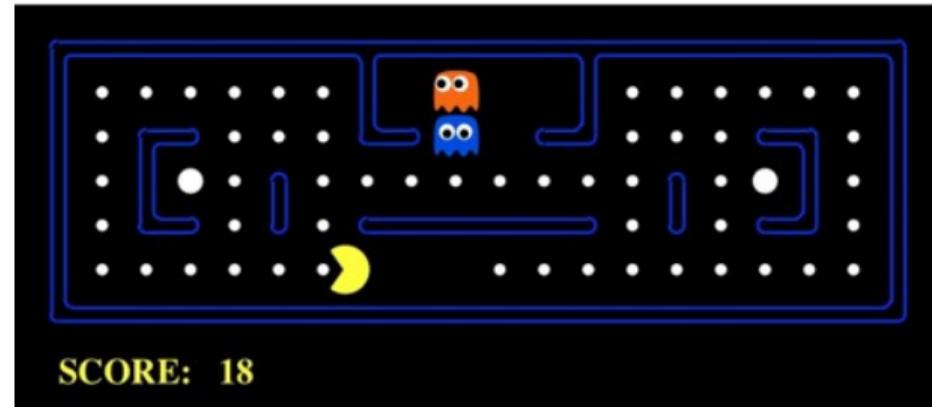
- Perceived environment
  - ▶ Dots
  - ▶ Ghost positions
  - ▶ Walls
- Actions taken
  - ▶ Up
  - ▶ Down
  - ▶ Left
  - ▶ Right



Video: Pac-Man

# Example Agents

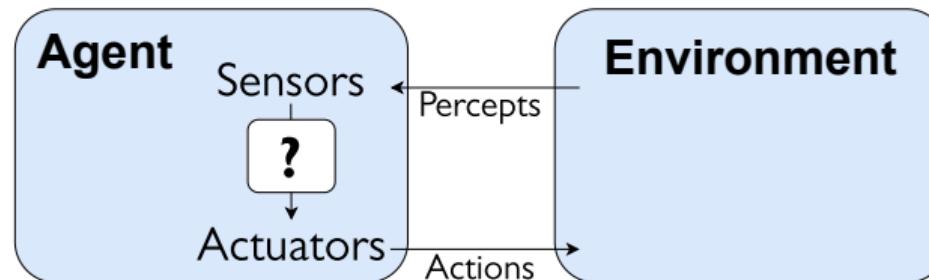
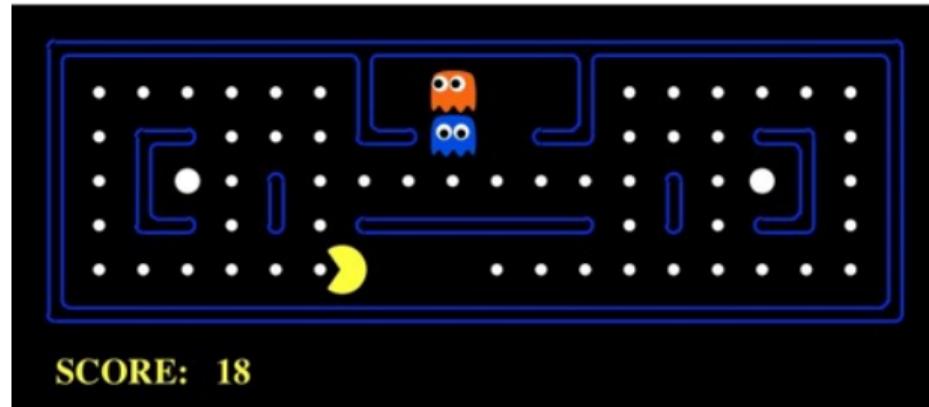
- Pac-Man
- Humans
  - Sensors
    - ▶ Touch
    - ▶ Sight
    - ▶ Hearing
    - ▶ Smell
    - ▶ Taste
  - Actuators
    - ▶ Hands
    - ▶ Legs



Video: Pac-Man

# Example Agents

- Pac-Man
- Humans
- Autonomous vehicles
  - Sensors
    - ▶ Lidar
    - ▶ Camera
  - Actuators
    - ▶ Wheels



Video: Pac-Man

# Suggested Reading

- Russell & Norvig: Chapter 1, 2
- Poole & Mackworth: Chapter 1, 2