KENTECH
Korea Institute of Energy Technology

Visionary Course – Energy AI
Week 04

Mar. 25, 2022

Seokju Lee

KENTECH
Korea Institute of Energy Technology

Week 04a – Introduction to Autonomous Driving

Before Starting the Lecture…

Notice : team member and weekly role of AI kit management

- Students in the group should take the duty (kit distribution & collection) in the given week.

▪ Team information

Team	Member	Distribution /collection week (temporary)
1	강민우, 김지호	4
2	박세종, 이강호	5
3	노경민, 정민우	6
4	전민규, 홍리경	7
5	손동현, 최동제	8
6	송민석, 위송서	9
7	배유리, 양지우	11
8	김찬혁, 최태준	12
9	김기현, 박수빈	13
10	구형준, 김성준	14
11	전재현, 정희성	15

▪ Role

1. Kit distribution
   - ➢ Move kits (from 2F교수연구실2 cabinet to classroom) and distribute kits to each group
2. Kit collection/check
   - ➢ After class, collect the kit per group and check all kits and return kits (from classroom to 2F교수연구실2 cabinet)
3. Check classroom
   - ➢ Check if there are any leftover equipment parts in the classroom.

Before Starting the Lecture…

Software preparation for the Jetson Nano (B01)

1. Go to the JetRacer page, and download the Ubuntu image file.

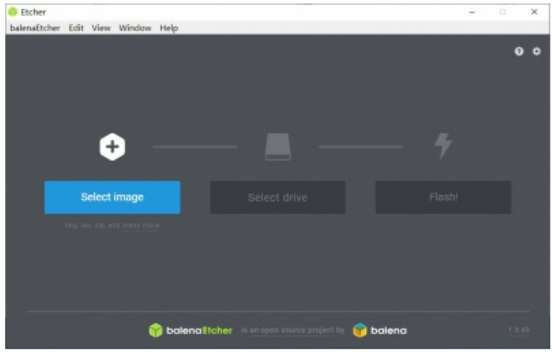
   → JetRacer Pro AI Kit - Waveshare Wiki (Google search)

- `jetracer_pro_ws.img`
- Balena Etcher (link)
- MobaXterm (link)
- Sublime Text (link)

2. Install OS image on the SD card.

Step 1. Write JetRacer image to SD card

- You need to prepare an SD card which should be at least 64G
- Download JetRacer image which is provided by NVIDIA and unzip it. Click here to download it
  - If you use Jetson Nano developer Kit (B01), You can use the Pre-built image below. With the Pre-built image, you just need to connect the wifi and run the examples without other settings
  - Pre-Built image based on Jetpack4.5
- Connect the SD card to PC via a card reader
- User Etcher software to write the image (unzip above) to SD card.Click here to download Etcher software



- After writing, eject the SD card

After installation, (link)

1. Hardware setup
   - Mount WiFi card.
   - Connect expansion board, cooling fan, camera, and antenna.
2. Display, WiFi, SSH setting

Course Syllabus

lecture/presentation, project, competition

Week #01	Introduction to machine learning and AI	Week #09	Making JetRacer run
Week #02	Python programming (1)	Week #10	Field trip (depending on COVID-19 situation)
Week #03	Python programming (2)	Week #11	Making JetRacer self-driving
Week #04	Introduction to autonomous driving	Week #12	Making JetRacer faster and more stable
Week #05	Jetson Nano AI applications (1)	Week #13	Making JetRacer more efficient
Week #06	Jetson Nano AI applications (2)	Week #14	Team mission & racing competition
Week #07	Jetson Nano projects (team mission)	Week #15	Team mission & racing competition
Week #08	Jetson Nano projects (team mission)	Week #16	Team mission & racing competition

What You Will Learn through the 4th ~ 6th Weeks

1. Overview of autonomous driving

- Key components for self-driving
- AI and human intelligence
- Limitations

2. Overview of deep learning

- Convolutional neural networks
- Basics of computer vision

3. Play with Edge AI device

- Getting used to Linux system
- AI programming on NVIDIA Jetson Nano
- Designing creative AI applications

About Me

- **Seoul Joongdong high school (Feb 2010)**
- **B.S. in Electrical and Computer Engineering @ UNIST (Aug 2013)**
  → Wireless and Mobile Networking Lab (WMNL), advisor: Prof. Hyoil Kim
- **M.S. in Robotics Program @ KAIST (Aug 2015)**
  → Unmanned System Research Group (USRG), advisor: Prof. David Hyunchul Shim
  → Keywords: robotic platforms (UAV/UGV), sensor fusion, autonomous driving (system-oriented)
- **Ph.D. in Robotics Program @ KAIST (Aug 2021)**
  → Robotics and Computer Vision (RCV) Lab, advisor: Prof. In So Kweon
  → Keywords: deep learning, computer vision, autonomous driving (AI-oriented)
- **Assistant Professor @ KENTECH (Jan 2022 ~)**
  → Energy AI Track, PI of VIEW Lab

(*collaboration with*)

What is Autonomous Driving?

Driving without human intervention

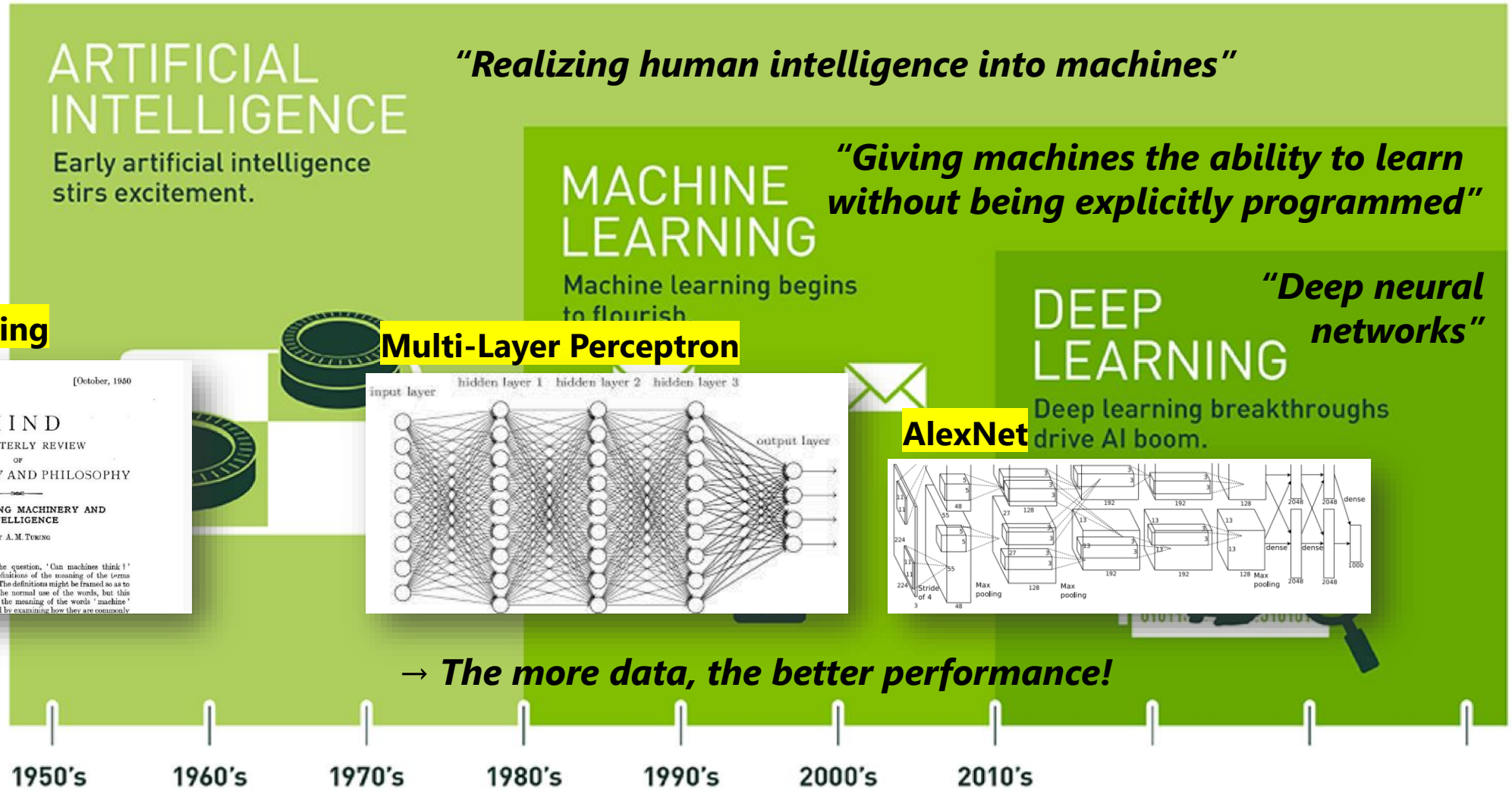
Requirement: human intelligence

How to make it possible?

Can artificial intelligence (AI) achieve this?

What is AI? **Should it be similar to human intelligence..?**

AI ⊃ Machine Learning ⊃ Deep Learning



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

Machine Learning = Interpreting High Dimensional Data

Modeling issues:
- Curse of dimensionality
- Too complex or redundant design

…

Data issues:
- Data hungry issue
- Overfitting & underfitting
- Class imbalance problem

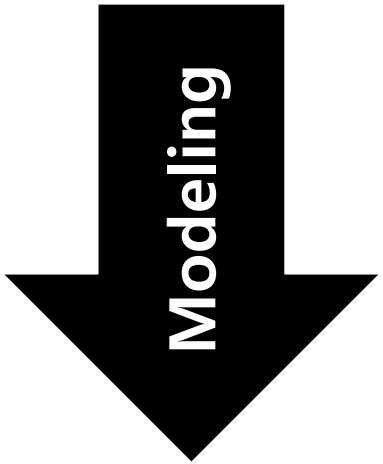
…

→ Computational & memory efficiency ↓
→ **Energy consumption ↑**

"What is the most **efficient** solution?"

In real world,

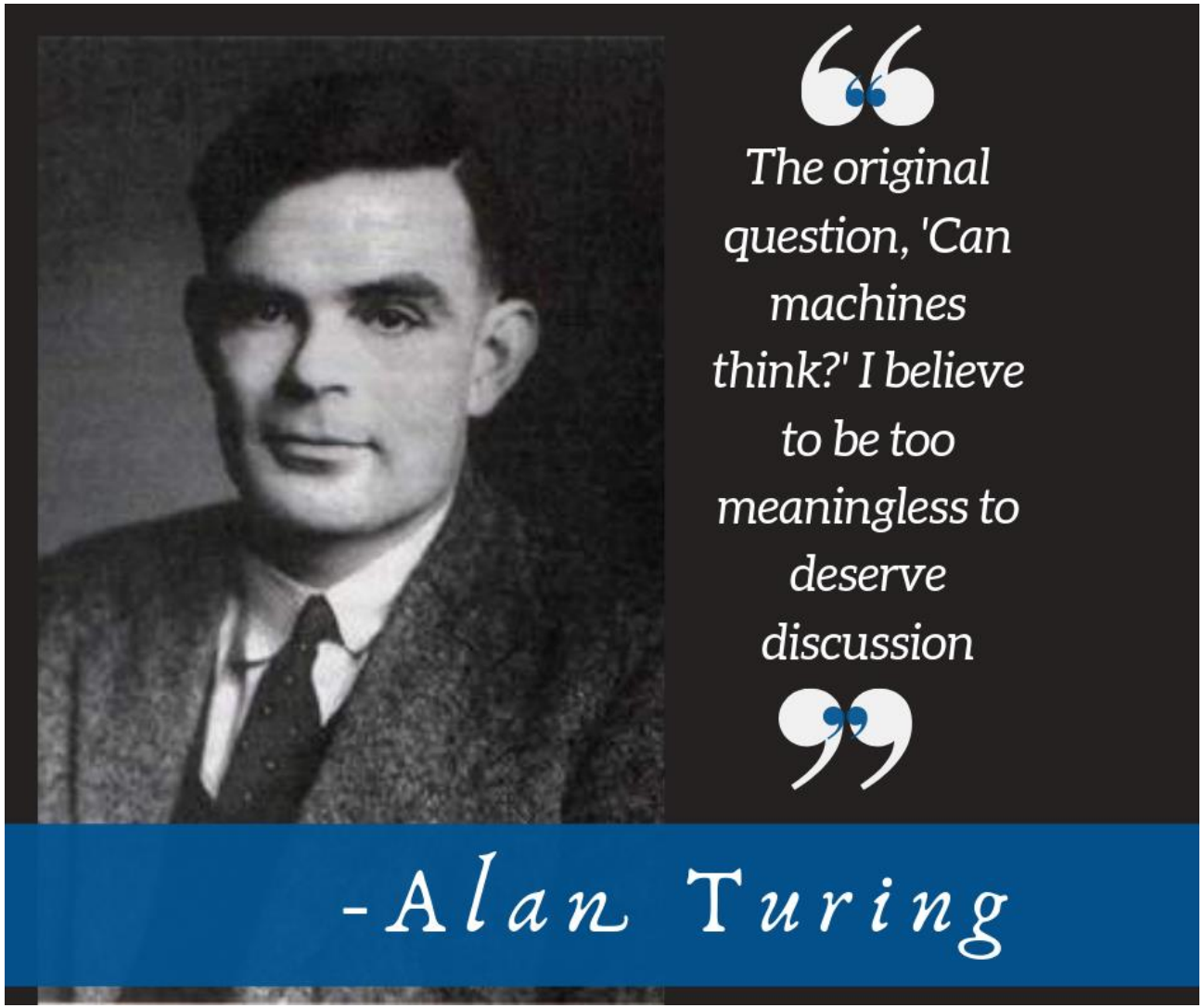
Super high dimensional data



For prediction,

Difficulty in data representation
Requires domain specific knowledge

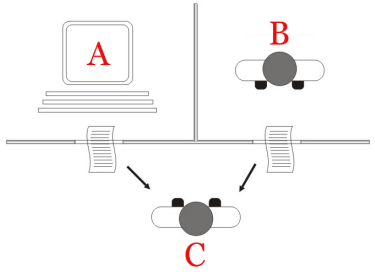
Defining AI



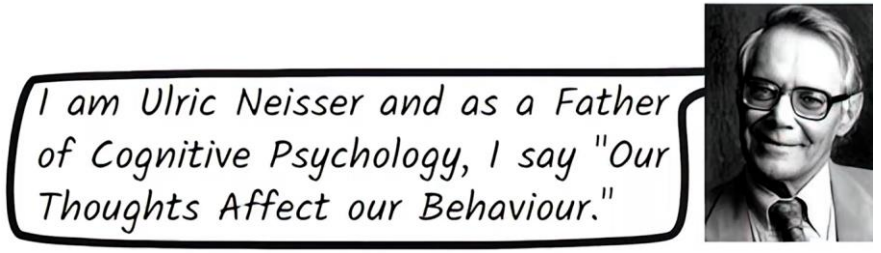
"Can machines think?"

→ We don't know what thinking actually is.

→ **"Turing test" [1]**



"Thinking" ≈ "Cognition" [2]



[1] Alan Turing, "Computing Machinery and Intelligence", 1950.
[2] Ulric Neisser, "Cognitive psychology", 1966.

“Thoughts Affect our Behavior”

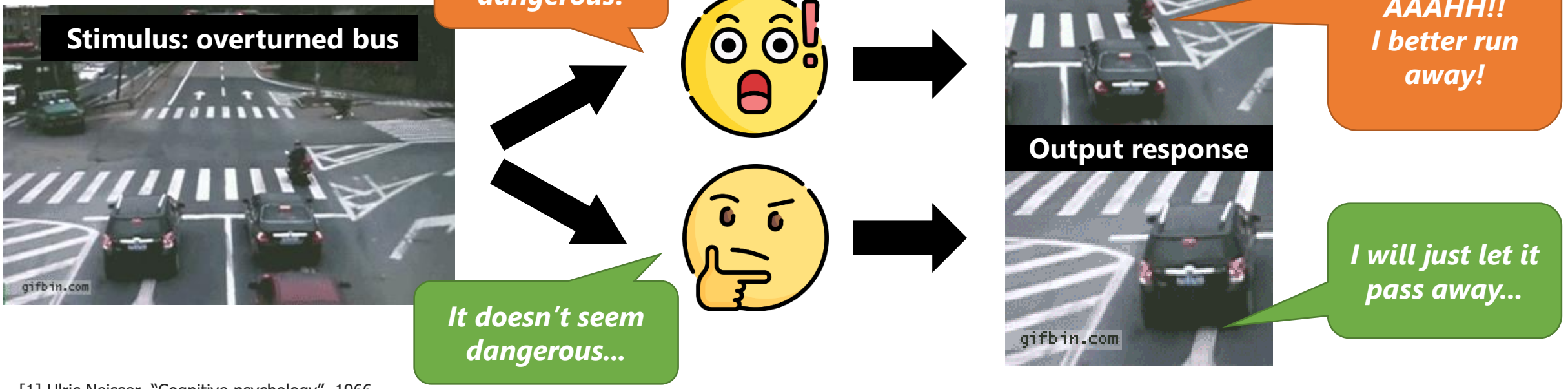
↔ *Behavioral perspective*

Cognitive perspective [1]

Stimulus (Input)

Cognition **(Hidden/non-observable mediational process)** *e.g.*, memory, perception, attention

Response (Output)



[1] Ulric Neisser, “Cognitive psychology”, 1966.

“Thoughts Affect our Behavior”

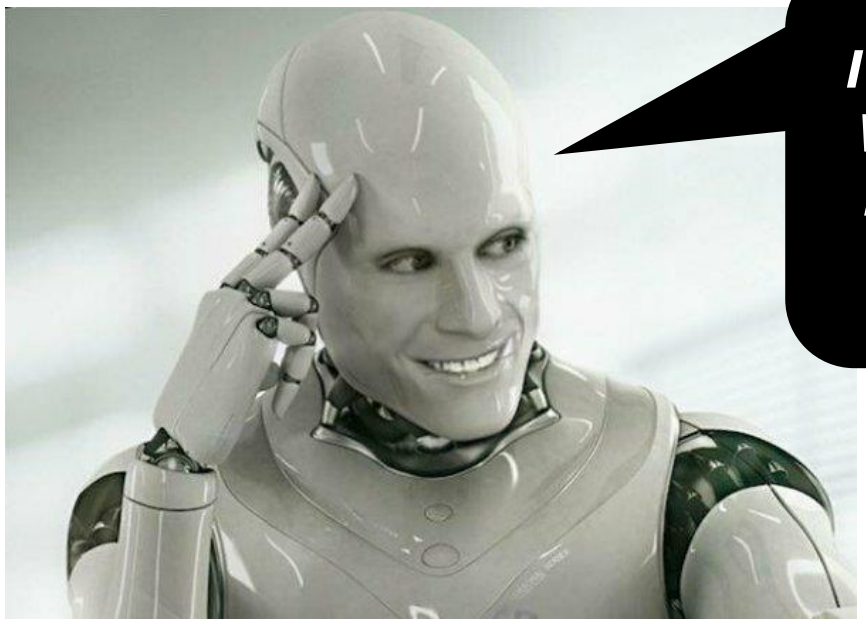
Cognitive perspective [1]

Stimulus (Input)

Cognition (Mediational process) *e.g.*, memory, perception, attention

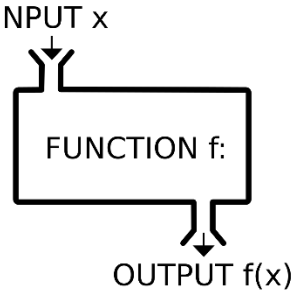
Response (Output)

It’s all how we think!



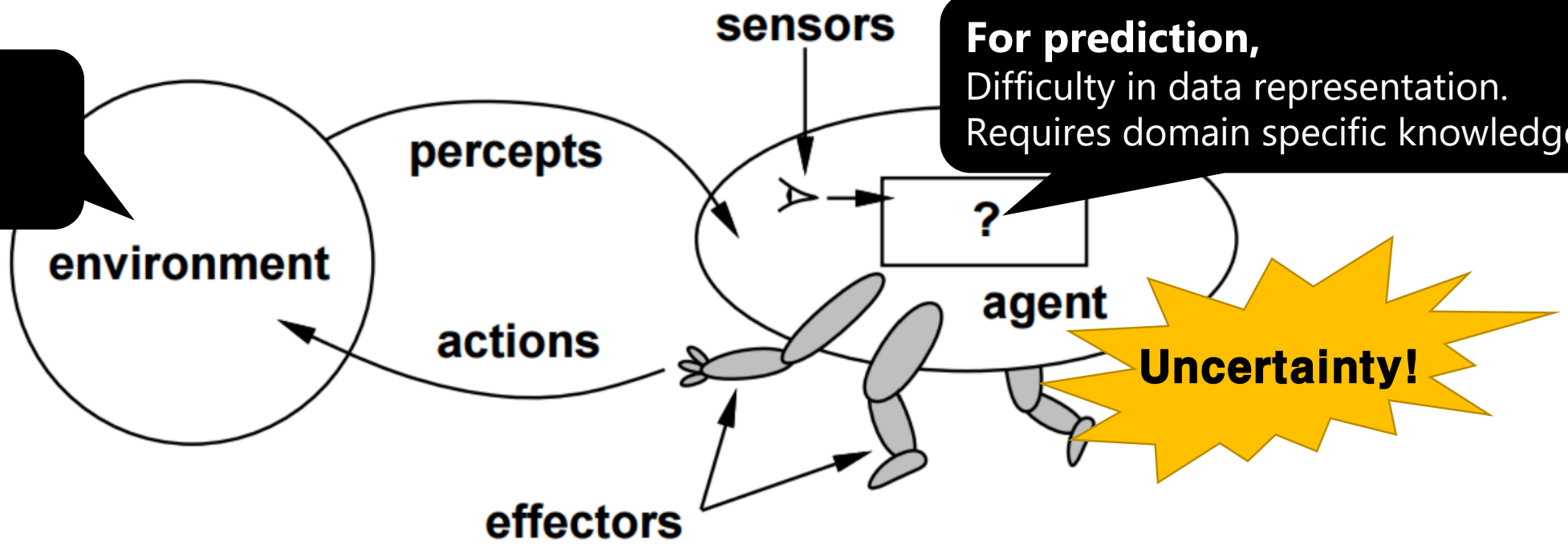
I am like you, human. We both take INPUT, PROCESS it and give OUTPUT.

cf.)



[1] Ulric Neisser, “Cognitive psychology”, 1966.

AI as a System



In real world,
Super high dimensional data!

For prediction,
Difficulty in data representation.
Requires domain specific knowledge.

Special-purpose AI:
Can it achieve a well-defined finite set of goals?

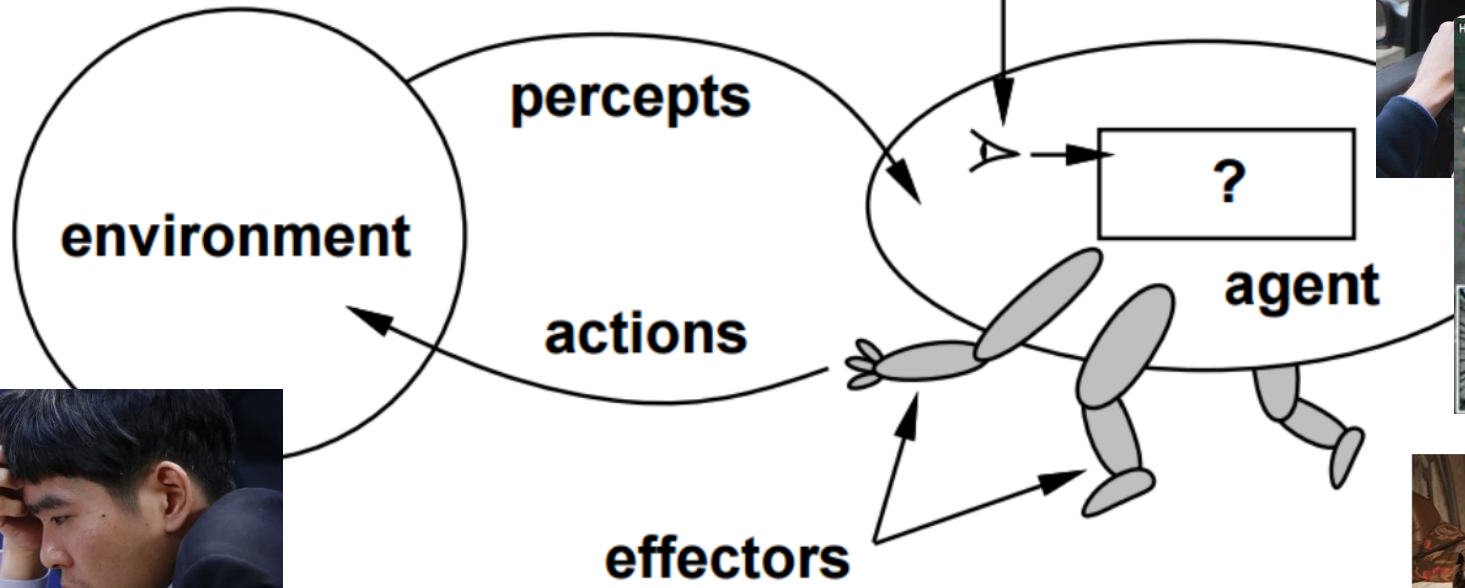
Uncertainty ↓

General-purpose AI:
Can it achieve poorly-defined unconstrained set of goals?

More uncertainty ↑

Q. Will we get closer to the general-purpose AI through bunches of special purposes?

AI as a System



Formal tasks:
Playing board games, solving puzzles, mathematical problems

Expert tasks:
Medical diagnosis, engineering, teaching, programming

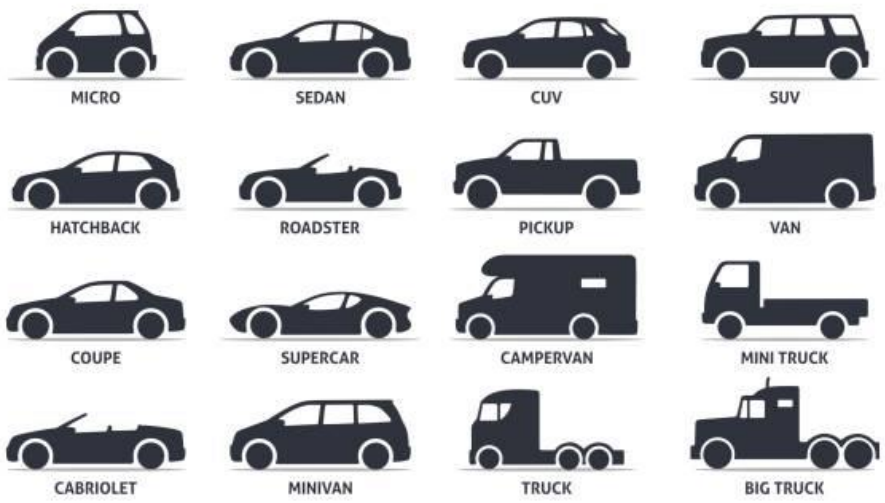
Mundane tasks:
Everyday conversation, walking, perception, dreaming in a sleep

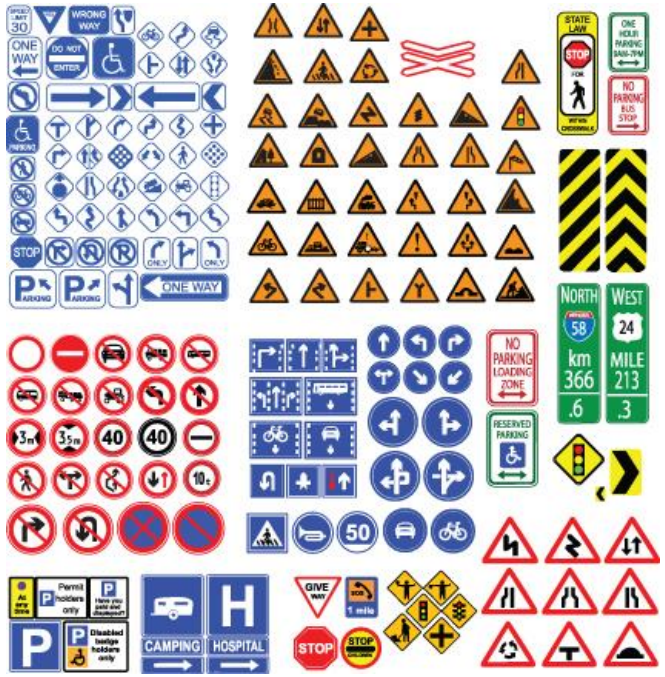
How Difficult is Driving?

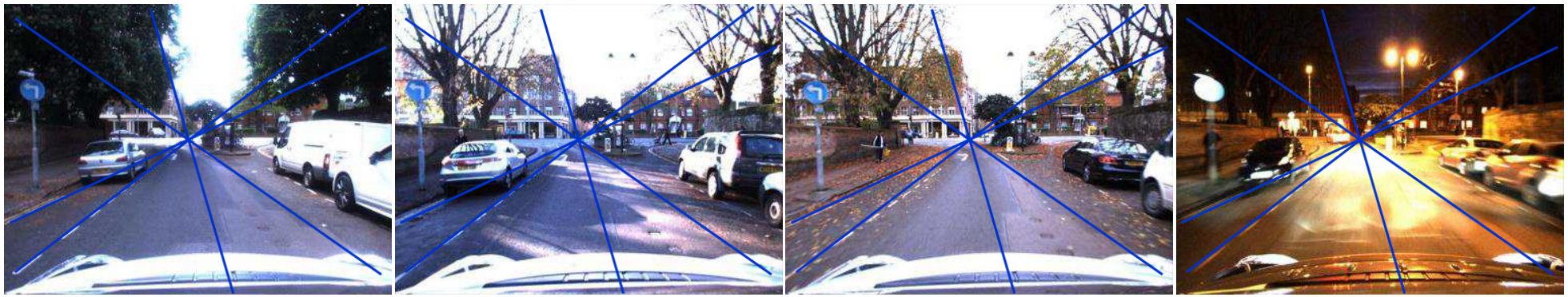
Is driving closer to **chess** or **everyday conversation**?

How Difficult is Driving?

Different types of objects



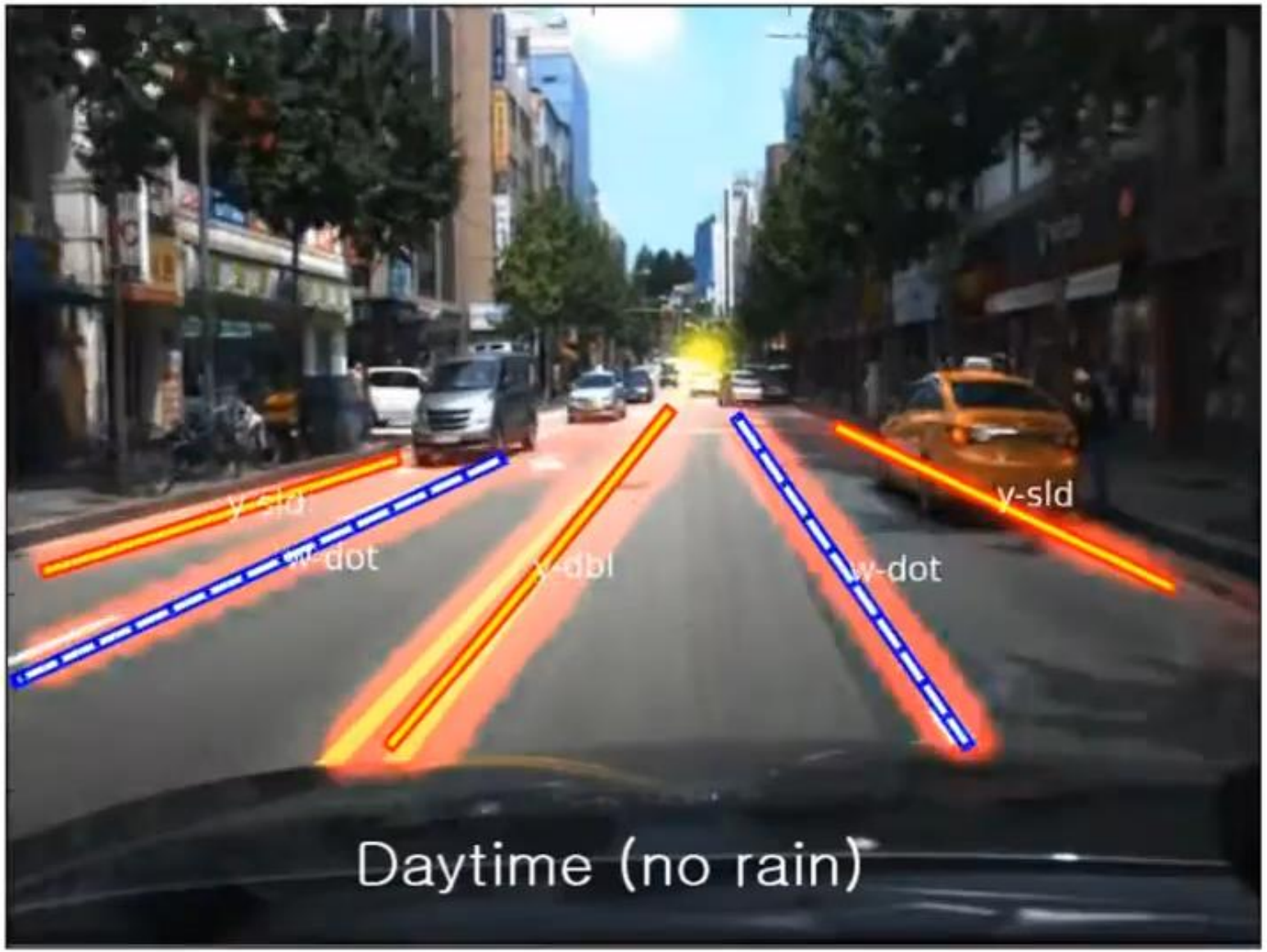




Same place, but
different weathers
(from RobotCar dataset [1])

[1] Maddern, Will, et al. "1 year, 1000 km: The Oxford RobotCar dataset." The International Journal of Robotics Research, 2017.

How Difficult is Driving?



VPGNet (ICCV'17)

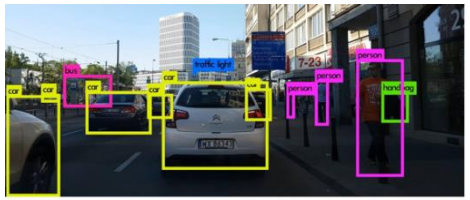
- Vanishing area
- Solid / Double white
- Dashed white
- Solid / Double yellow
- Dashed yellow
- Crosswalk
- Safety zone
- Lane heat map
- Arrow or Stop line

Three Pillars of Autonomous Driving

Sensing

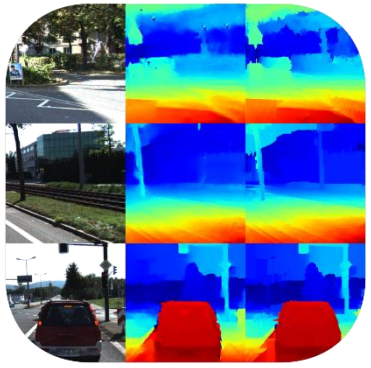
Camera, RADAR, LiDAR, GPS, ultrasonic, stereo cam, surround-view, …

Perceiving

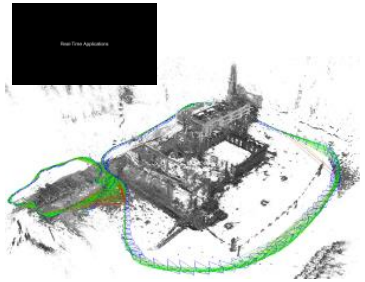


Object detection & recognition

Segmentation



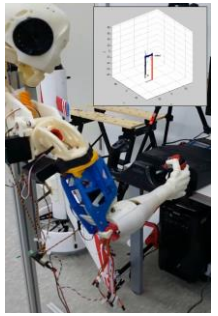
Depth



Localization and mapping

Control

Motion/path planning, reinforcement learning, adaptive control, …



DARPA Grand Challenge II (2006)

Stanford wins

DARPA Urban Challenge (2007)

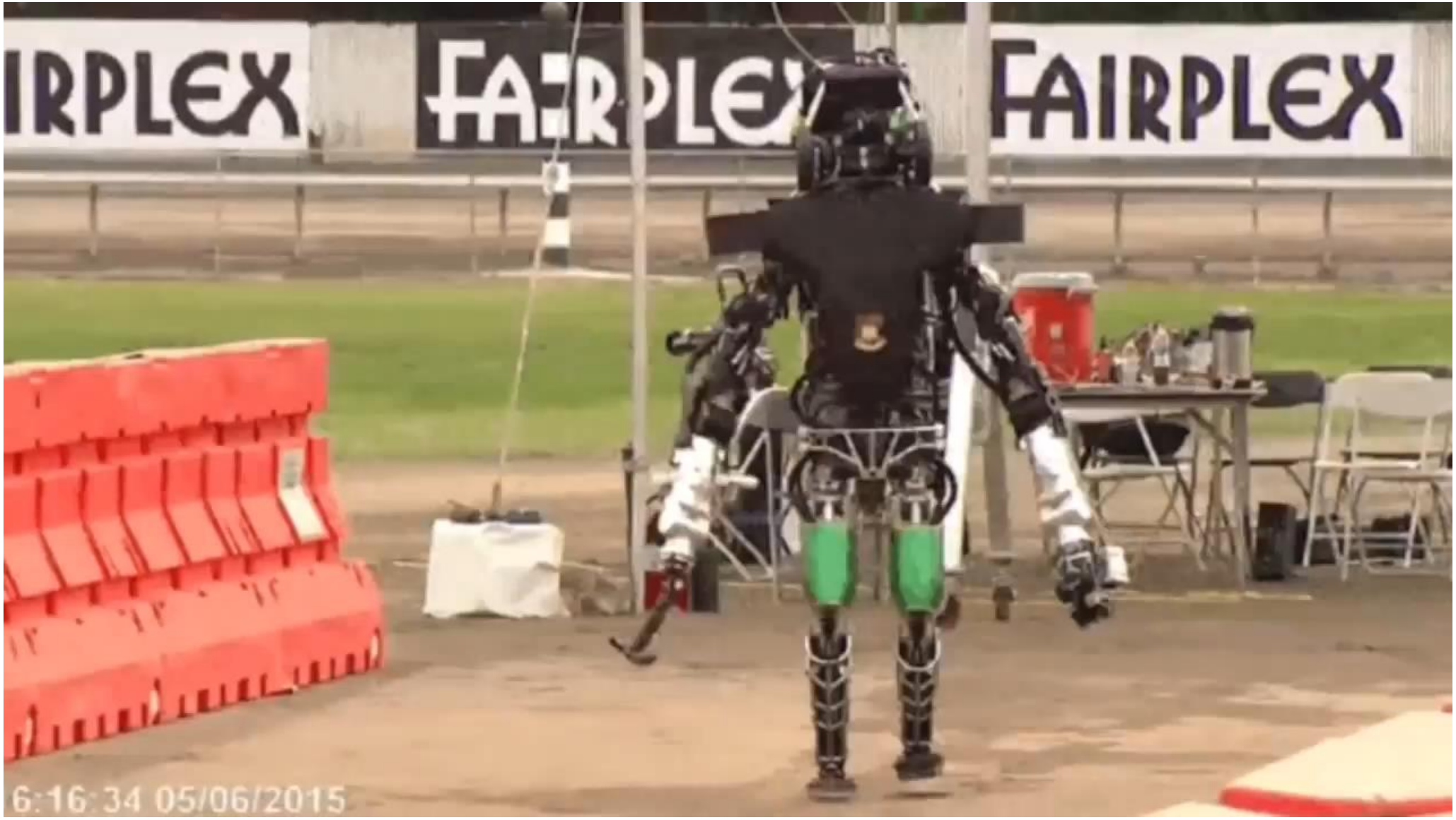
CMU wins

DARPA Robotics Challenge (2015)

KAIST wins

DARPA Robotics Challenge (2015)

Fails compilation

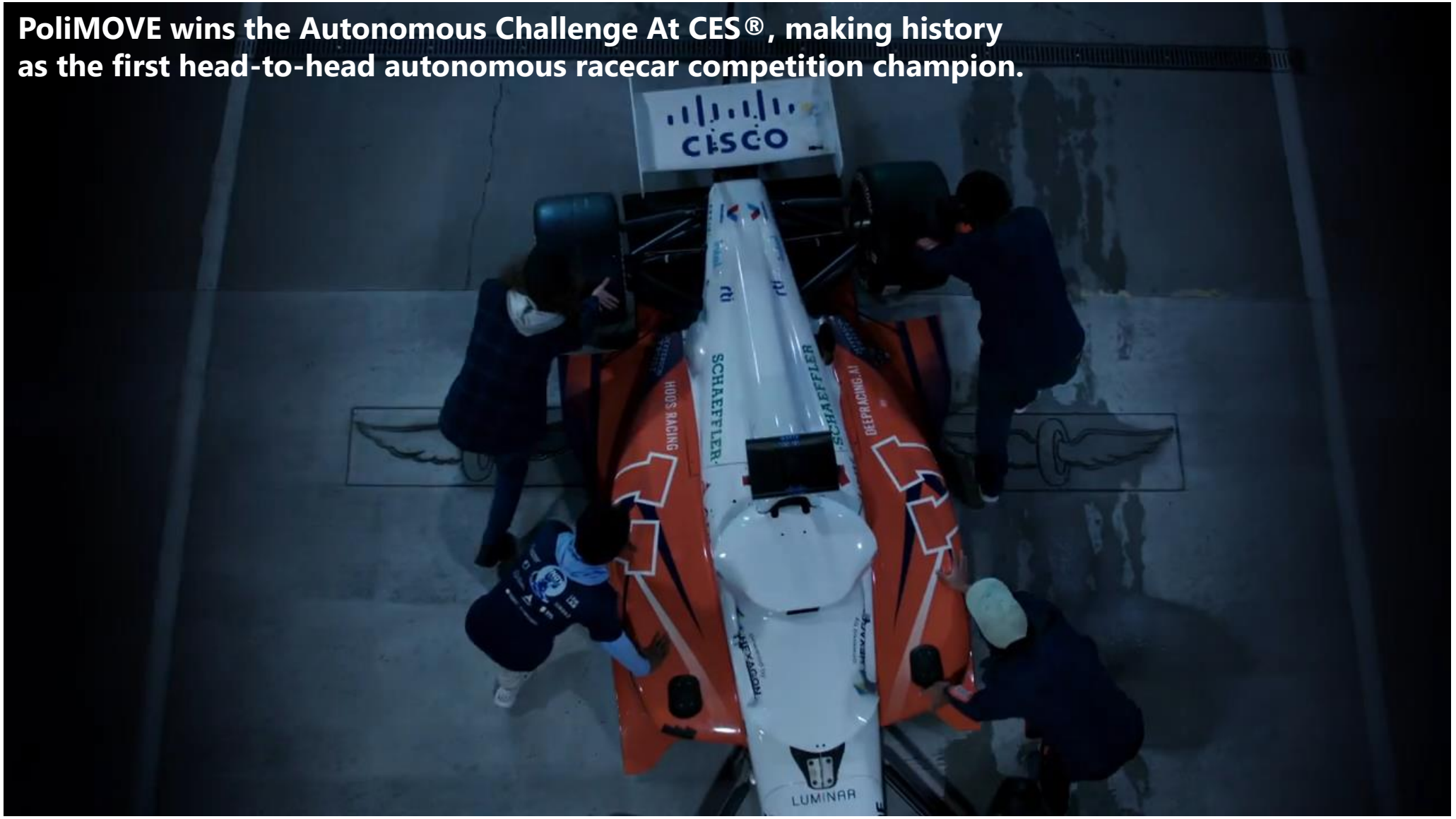


NASA Sample Return Robot Challenge (2016)

WVU wins

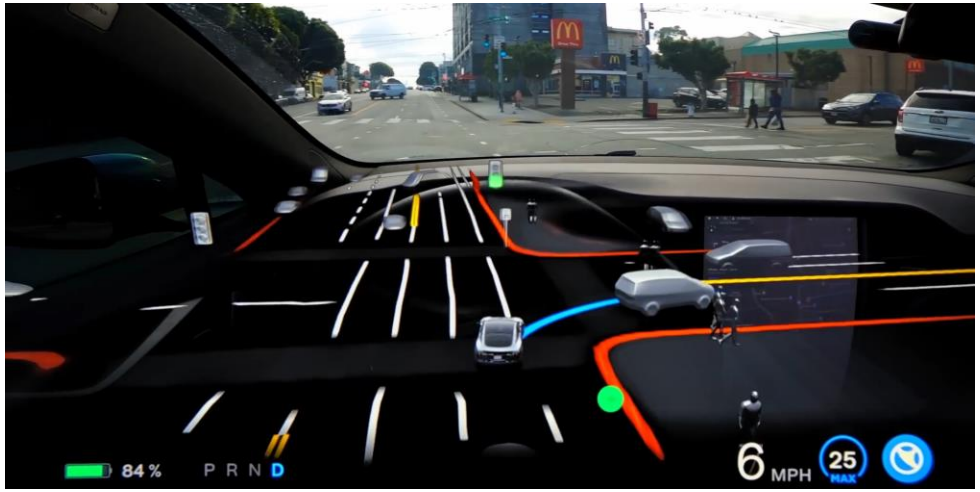
Indy Autonomous Challenge @ CES (2022)

Link



Industry Takes on the Challenge

Waymo's self-driving taxis
(Dec. 2021)



Tesla's full self-driving beta
(Jan. 2022)

"Accelerated by the recent breakthroughs in **deep learning**"