



성균관대학교  
SUNG KYUNKWAN UNIVERSITY

# Foundations of Machine Learning (ECE 5984)

## - Introduction -

Eunbyung Park

Assistant Professor

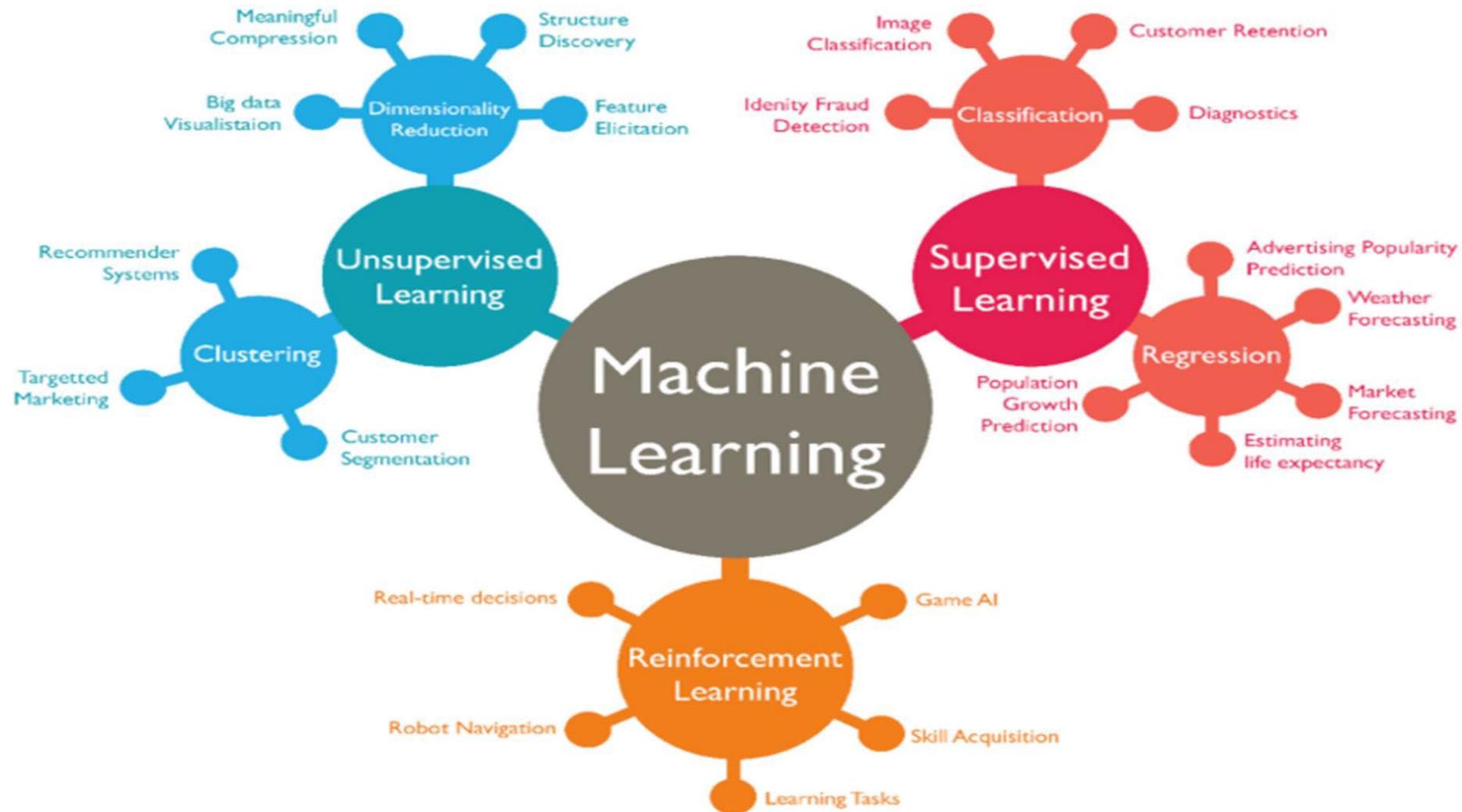
School of Electronic and Electrical Engineering

[Eunbyung Park \(silverbottlep.github.io\)](https://silverbottlep.github.io)

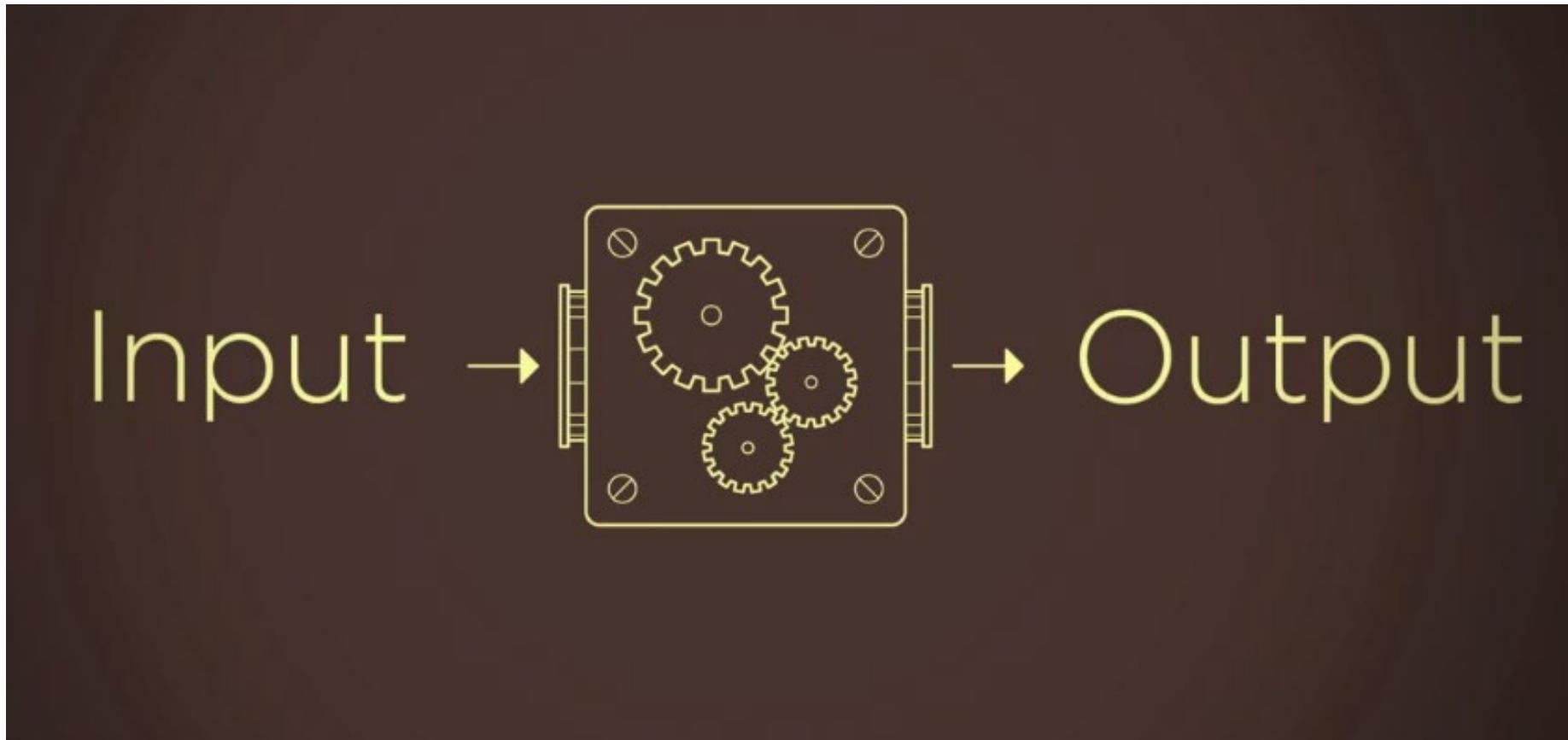
# Machine Learning

- Machine learning (ML) is the study of computer algorithms that can improve automatically through data and experience
- It's a core field in modern artificial intelligence
- Especially, deep neural networks are taking over many engineering and science fields!

# Machine Learning Taxonomy

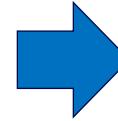
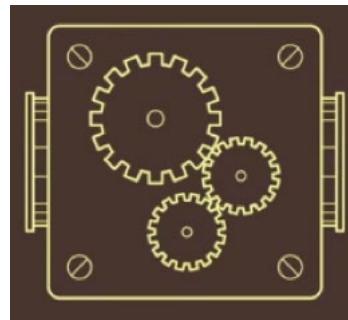
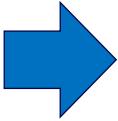


# Supervised Learning



# Examples

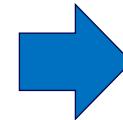
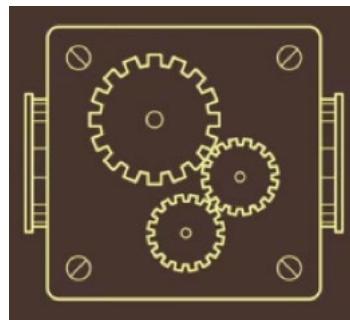
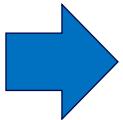
- Image classification



“Cat”

# Examples

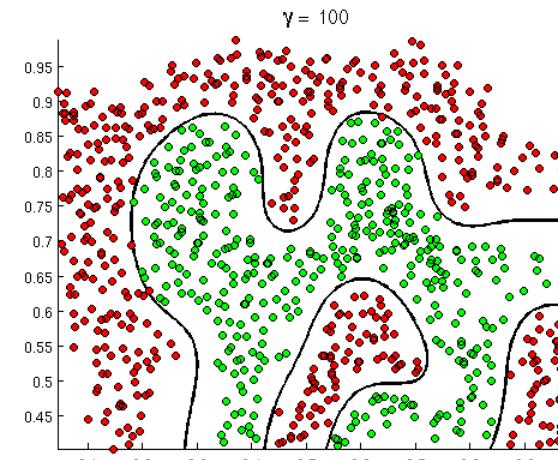
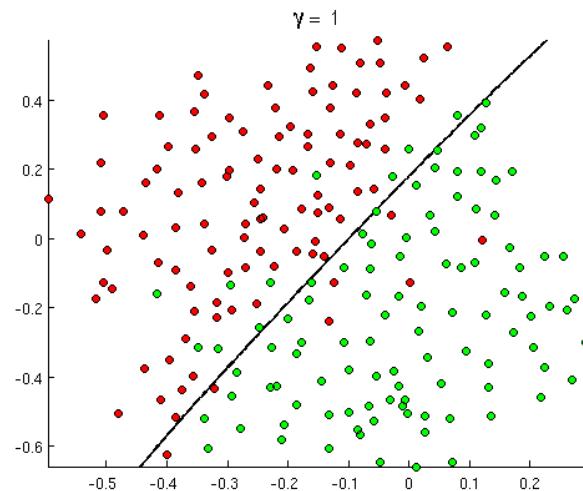
- Speech recognition



**“I love you.”**

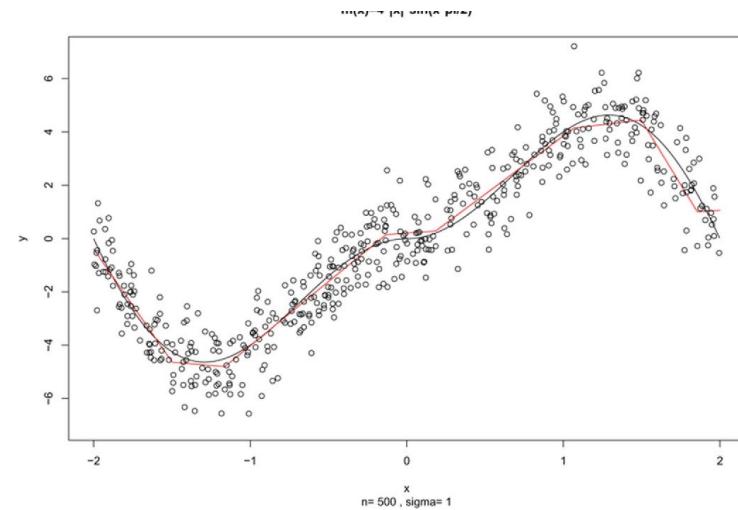
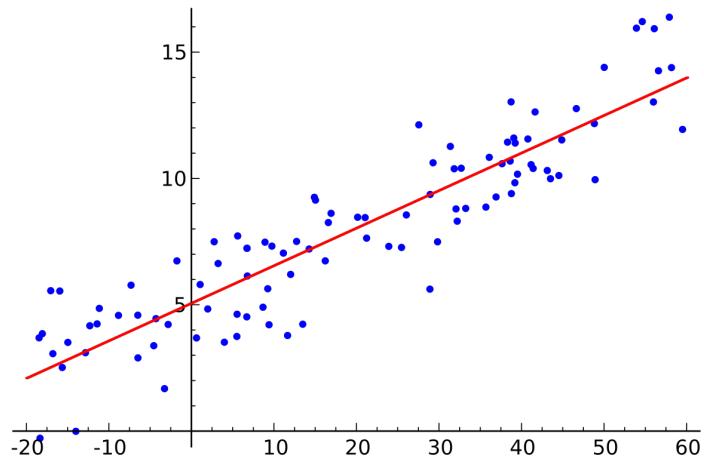
# Supervised Learning

- Classification -> Learning boundaries
  - Logistic regression
  - Support Vector Machines (SVM)
  - K-nearest neighbors
  - Decision Trees, Neural networks



# Supervised Learning

- Regression -> predicting real values
  - Linear regression
  - Polynomial regression
  - Neural networks
  - Gaussian process
  - Etc..

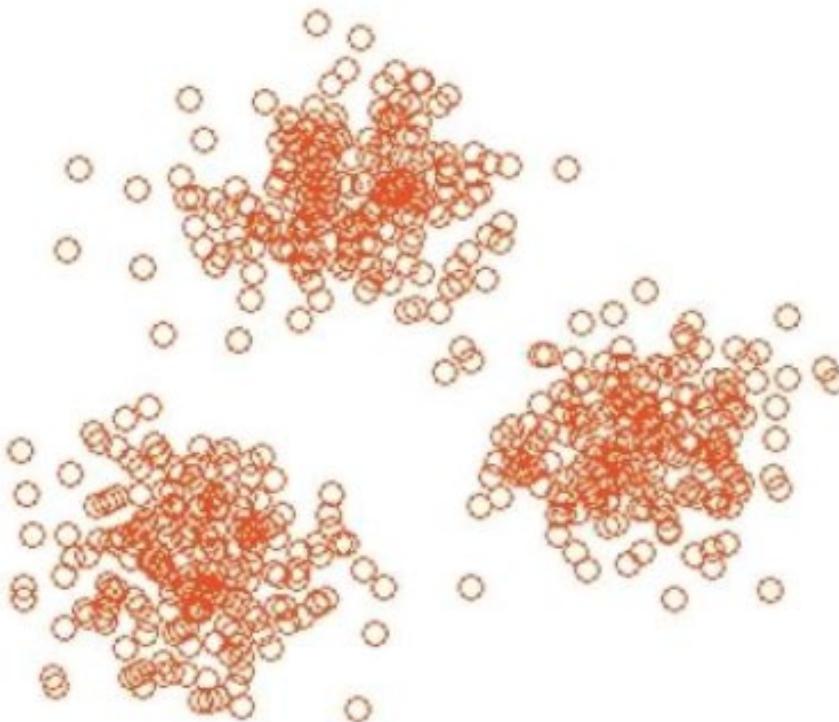


# Learning Theory

- Bias-variance tradeoff
- Training error / Test error
- Regularization and generalization bound
  - VC dimension, Hoeffding's bound
- Model selection

# Unsupervised Learning

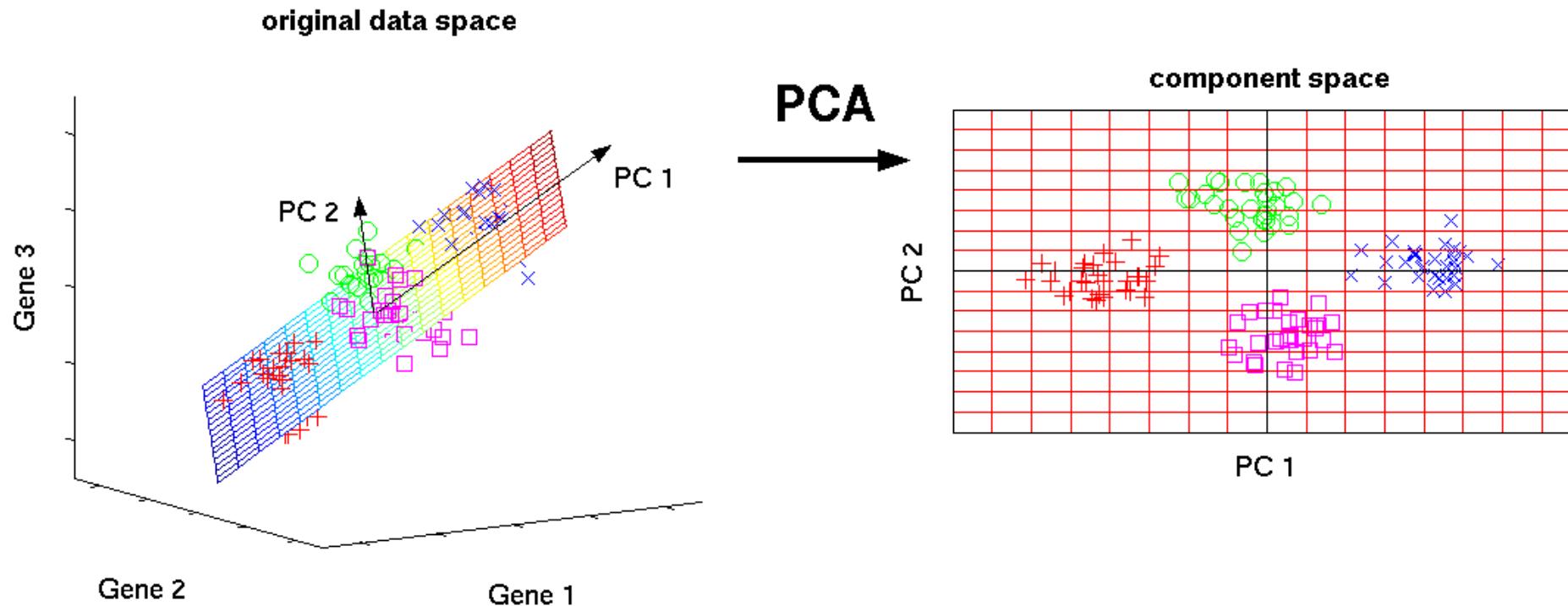
- Clustering



- Documents
- Users
- Webpages
- Diseases
- Pictures
- Vehicles
- ...

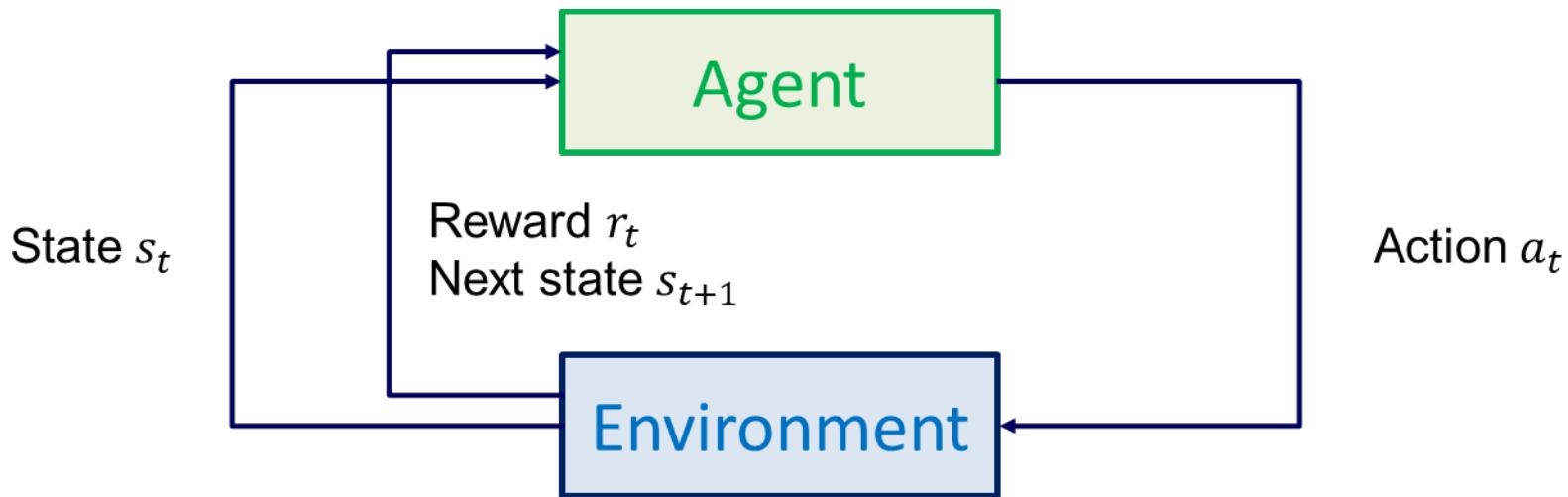
# Unsupervised Learning

- Principal Component Analyses (Dimensionality reduction)



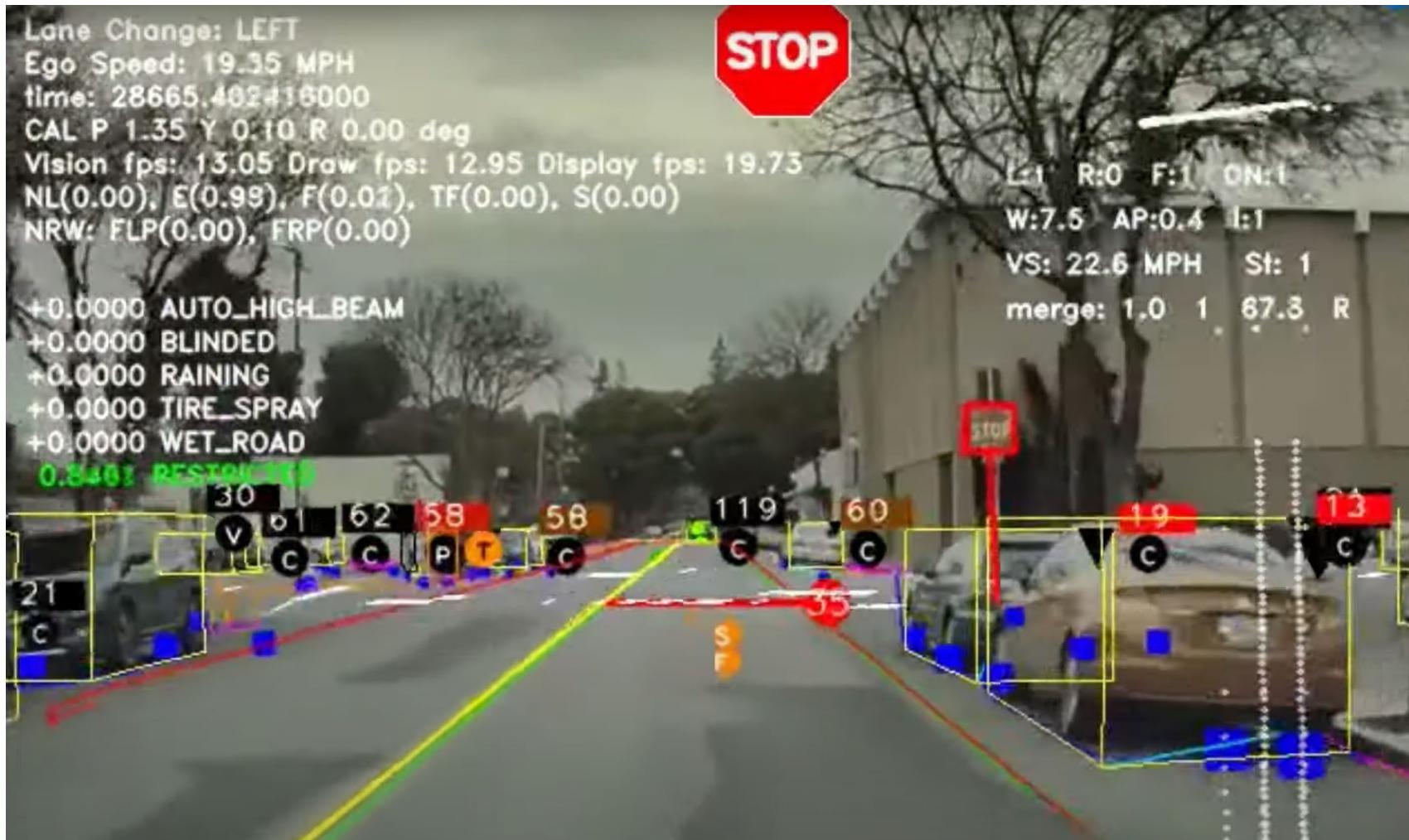
# Reinforcement Learning

- Sequential interactions between the agent and the environment
  - Alphago, robot, ...



# Recent Breakthroughs

# Object Detection



# Image Segmentation



# Human Pose Estimation



# Image Generation



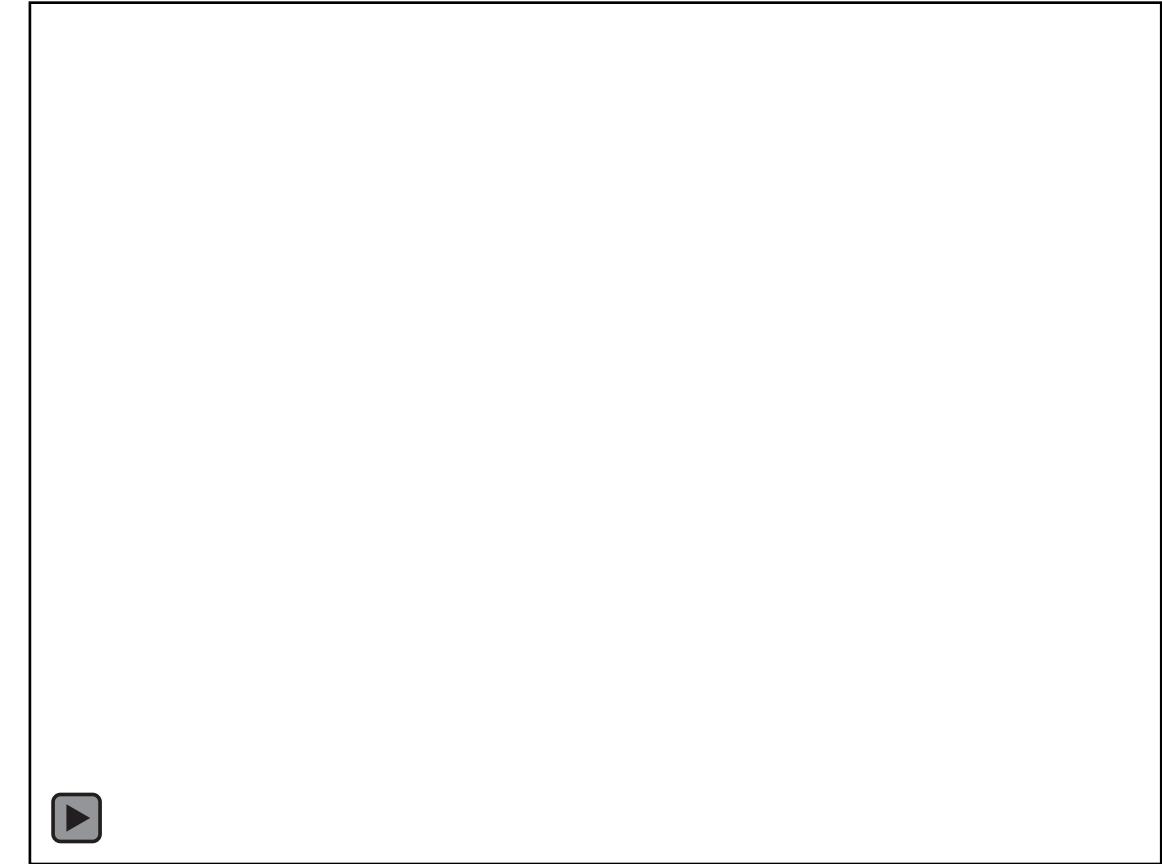
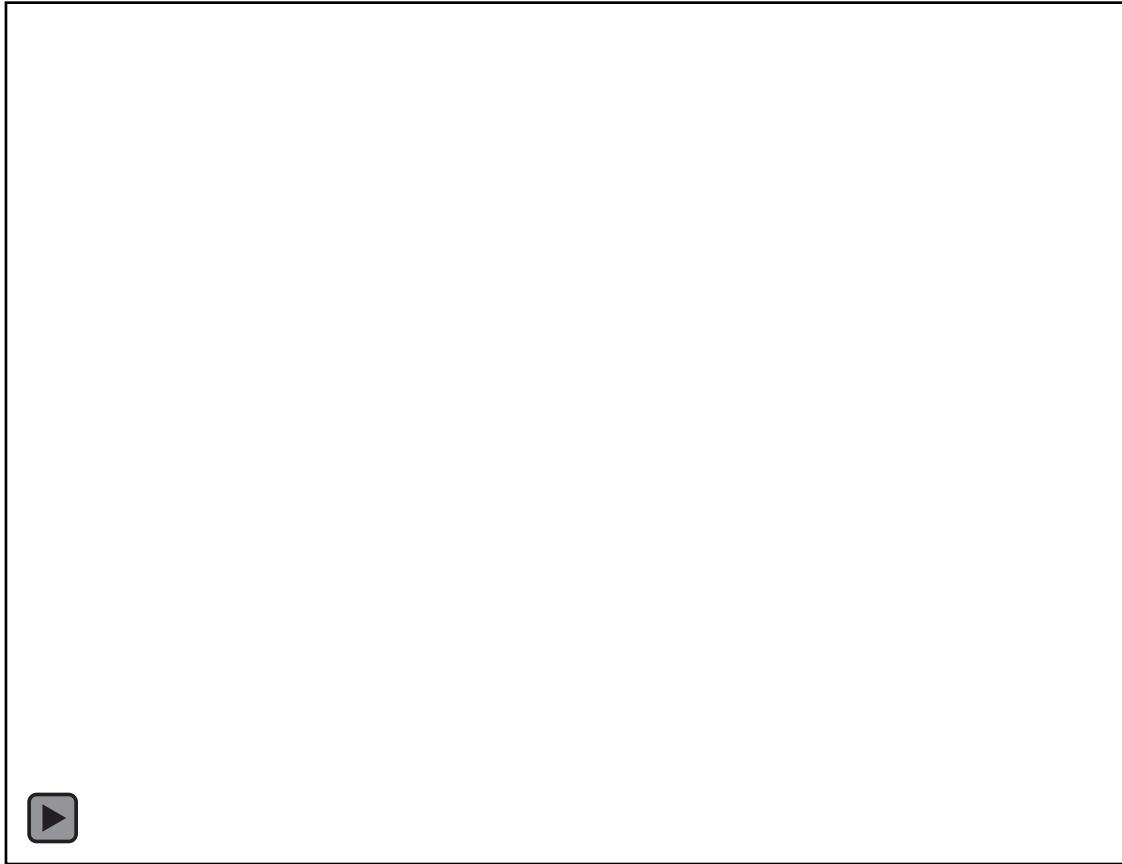
# Image Generation



# Image Generation

- [Alias-Free Generative Adversarial Networks \(StyleGAN3\) \(nvlabs.github.io\)](https://nvlabs.github.io/alias-free-gan3)

# Novel View Synthesis



# Novel View Synthesis

- Block-NeRF – Waymo

# ChatBot



Hi, do you have a favorite sports team?



My favorite team is the New York Yankees.  
Do you like any sports teams?



I like the yankees too! I don't think they're doing  
too well this year

memory write: (partner) I like the yankees. I don't think they are doing too well this year.

memory write: (self) My favorite sports team is the New York Yankees.

search: Yankees

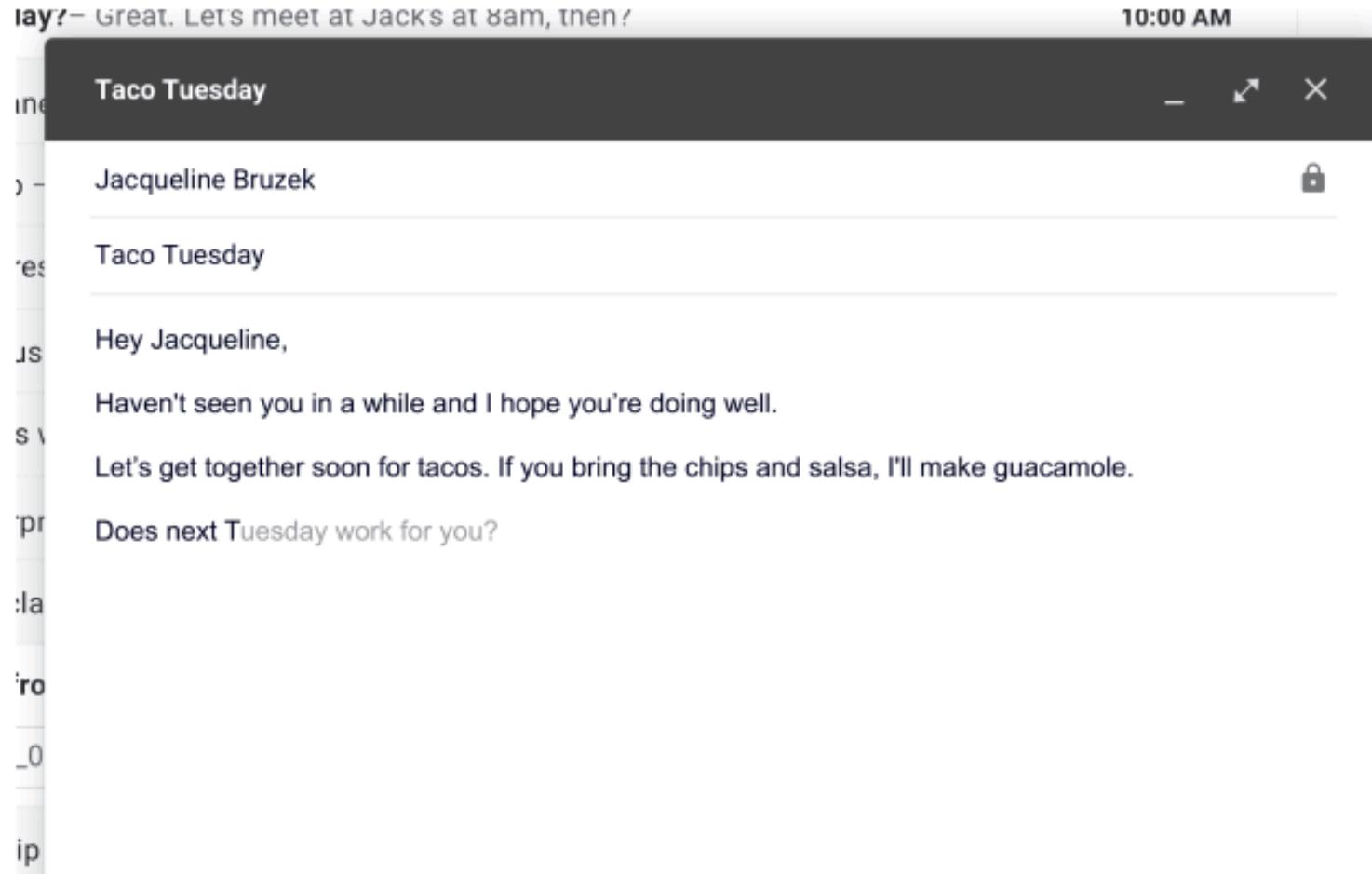


I think they will be fine. They have the best  
player in the world on their team.

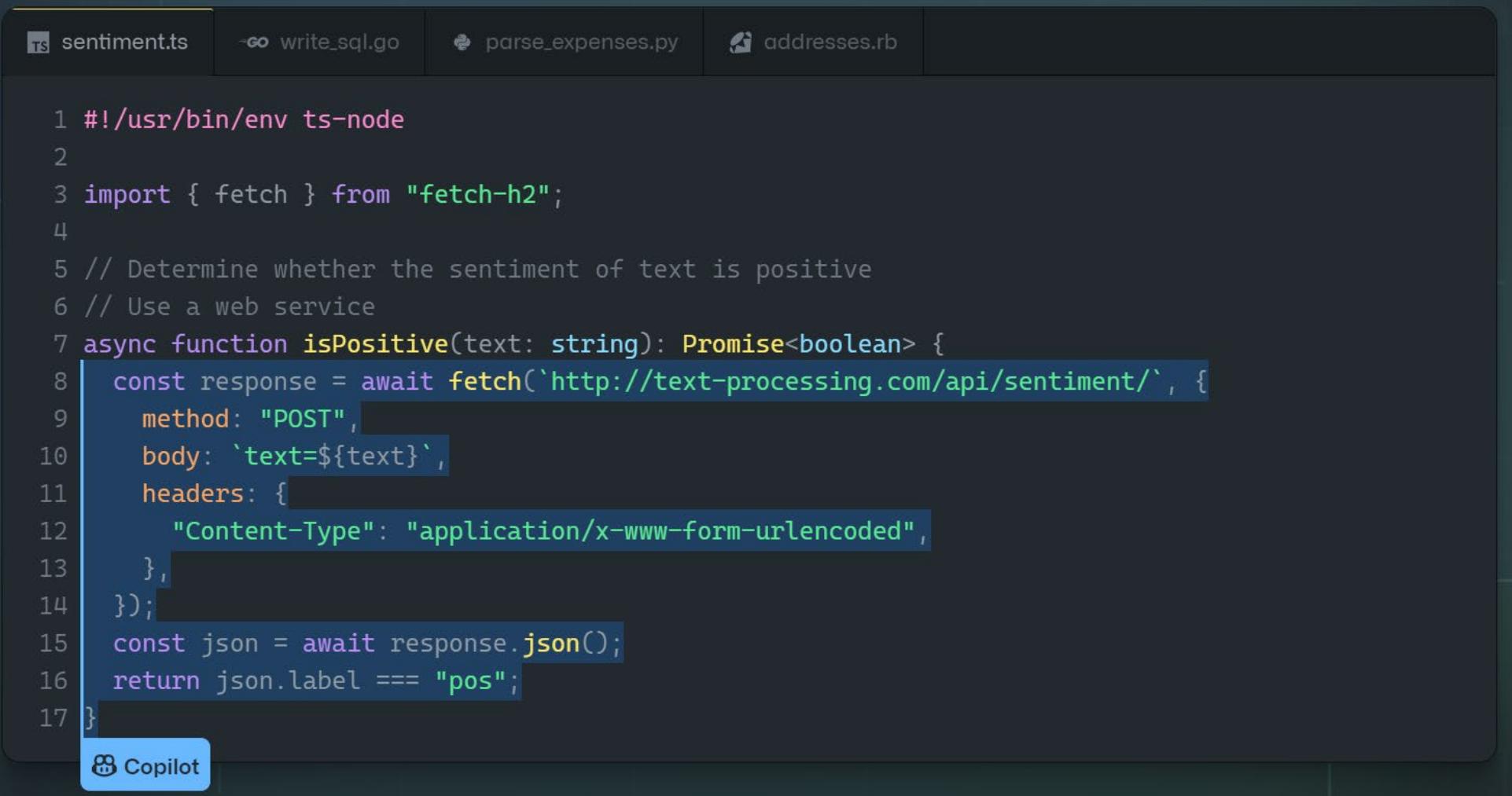


They have so many good players! Aaron Judge,  
Gerrit Cole. They just can't put it together.

# Smart Compose



# AI pair programmer (Copilot)



A screenshot of a code editor interface showing a file named `sentiment.ts`. The code implements a function `isPositive` that sends a POST request to `http://text-processing.com/api/sentiment/` with the provided text as the body. The response is parsed as JSON to determine if the sentiment is positive. The code is written in TypeScript and uses the `fetch` API.

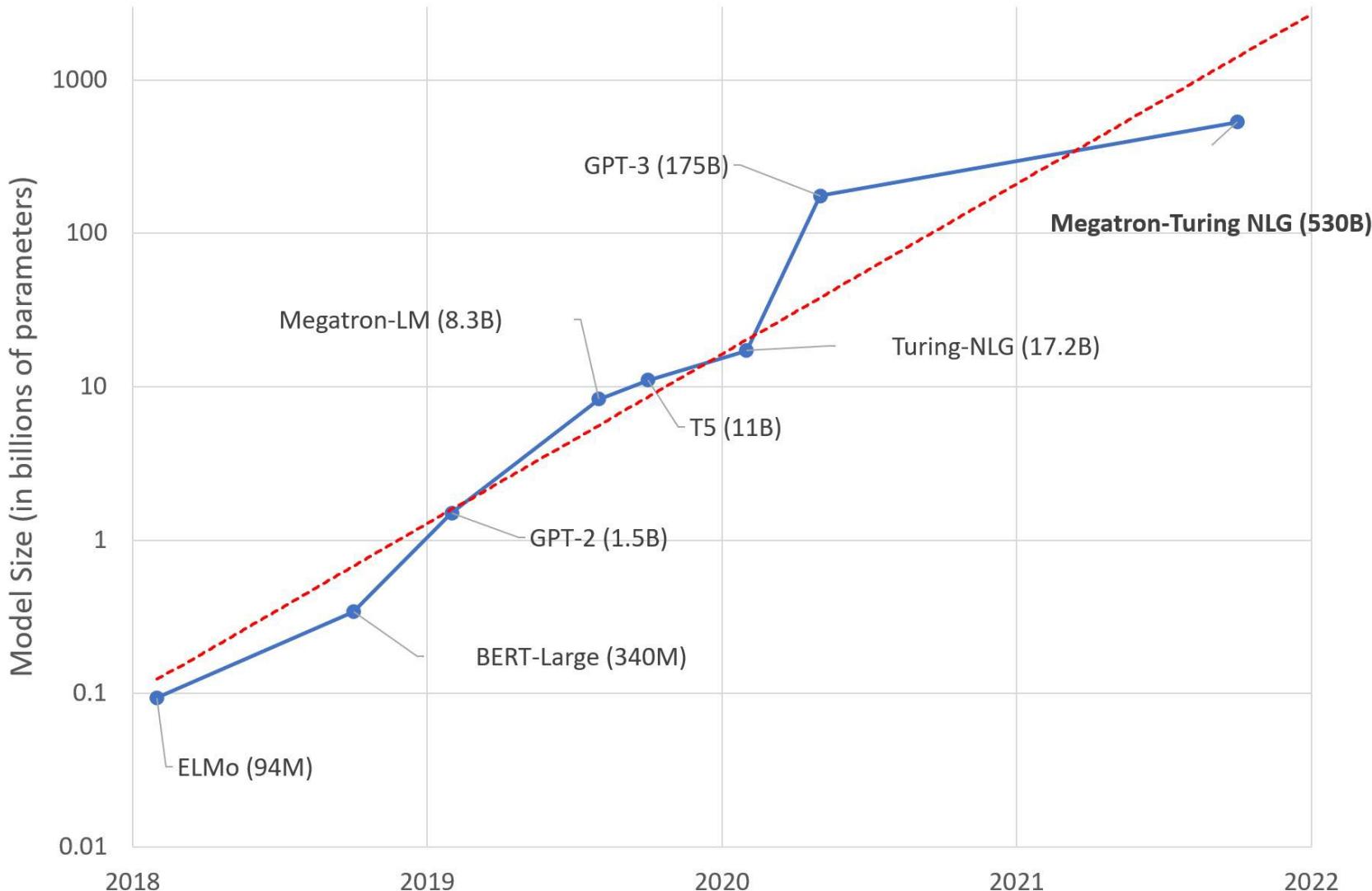
```
1 #!/usr/bin/env ts-node
2
3 import { fetch } from "fetch-h2";
4
5 // Determine whether the sentiment of text is positive
6 // Use a web service
7 async function isPositive(text: string): Promise<boolean> {
8     const response = await fetch(`http://text-processing.com/api/sentiment/`, {
9         method: "POST",
10         body: `text=${text}`,
11         headers: {
12             "Content-Type": "application/x-www-form-urlencoded",
13         },
14     });
15     const json = await response.json();
16     return json.label === "pos";
17 }
```

In the bottom left corner of the code editor, there is a blue button with a white icon and the word "Copilot".

## GPT-3 (OpenAI)

- Large scale language models
- 175B parameters
- Training cost: 36 years with 8 V100 GPUs

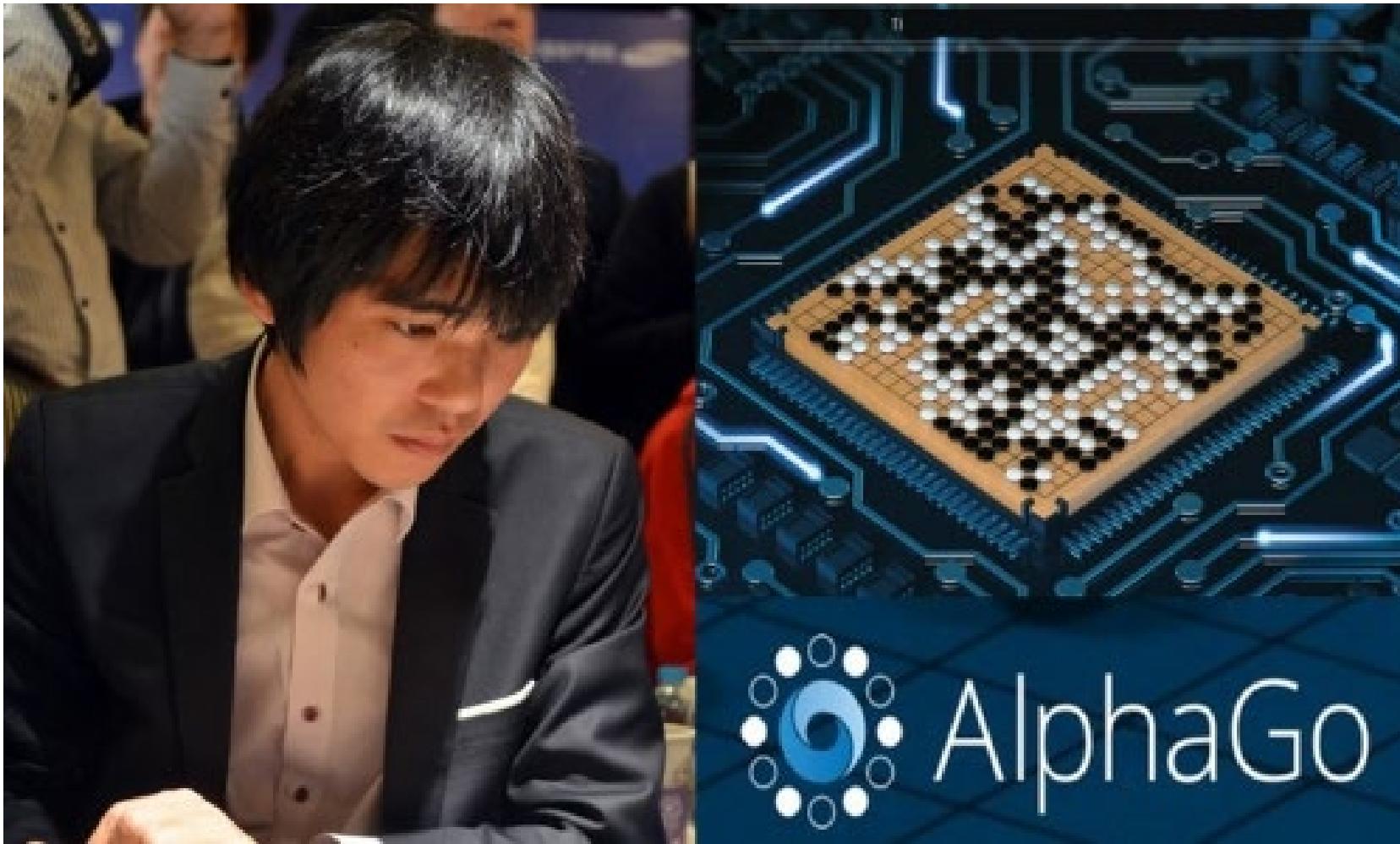
# Large Scale Language Models



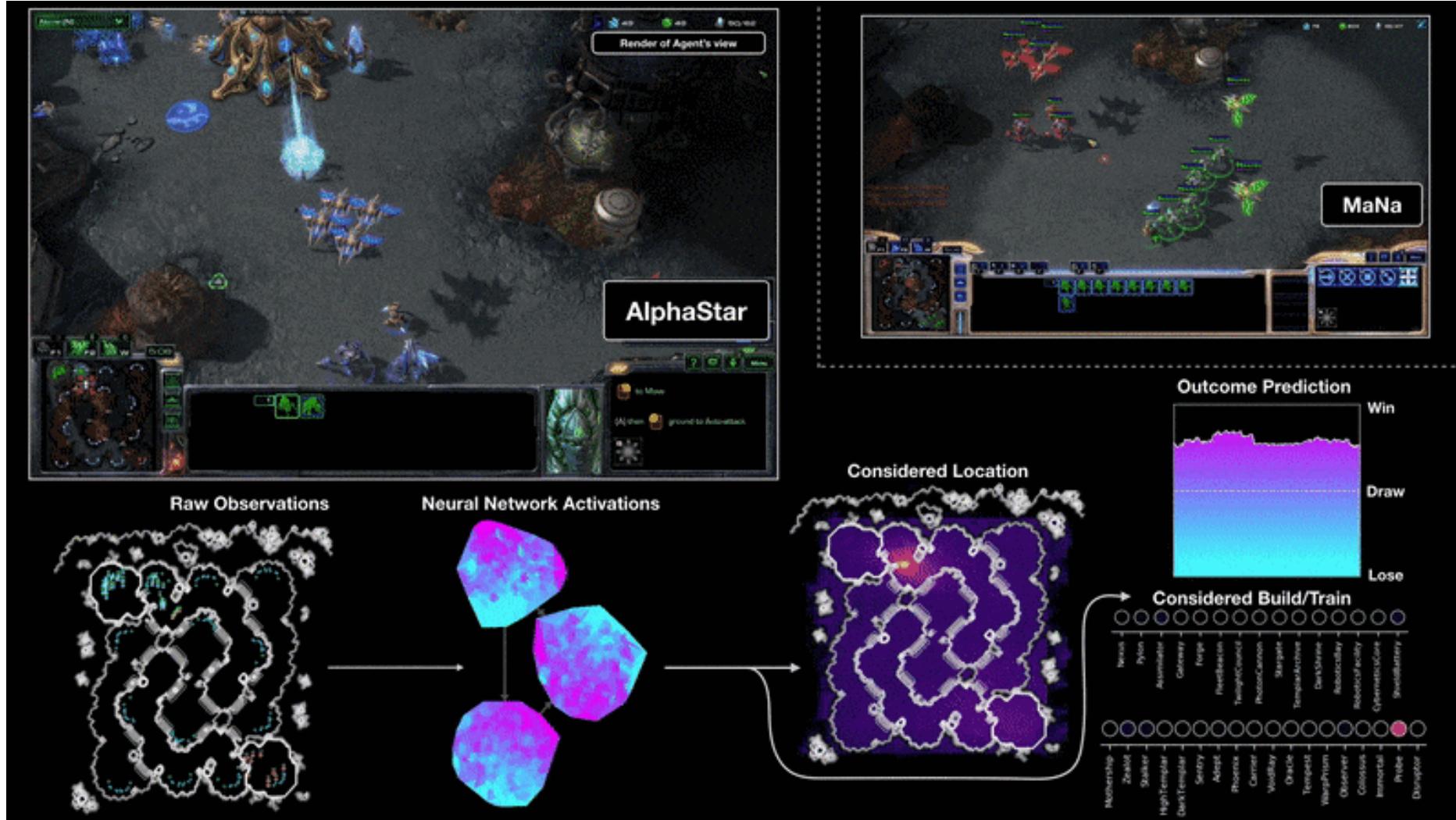
# AI Assistants



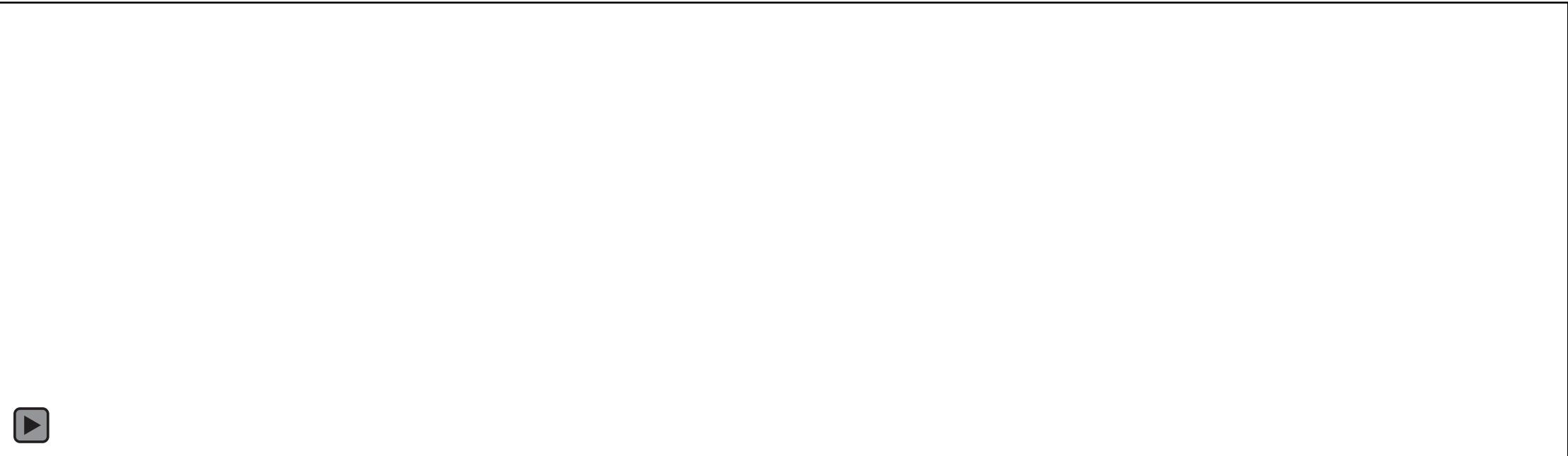
# AlphaGo



# AI Playing Video Games



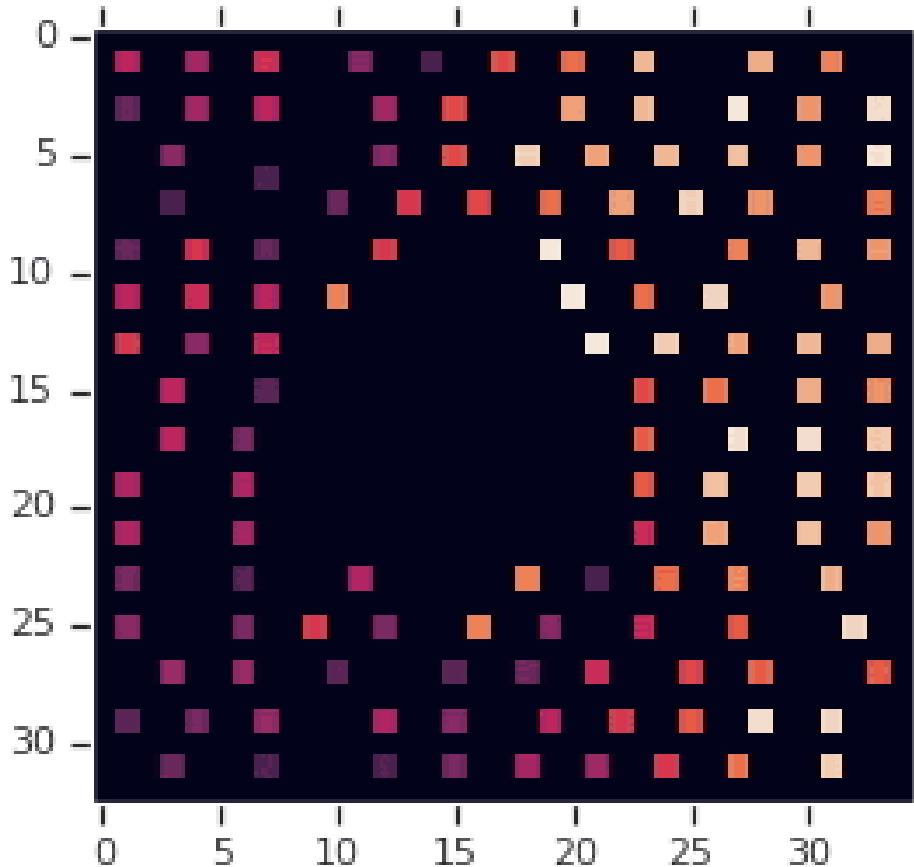
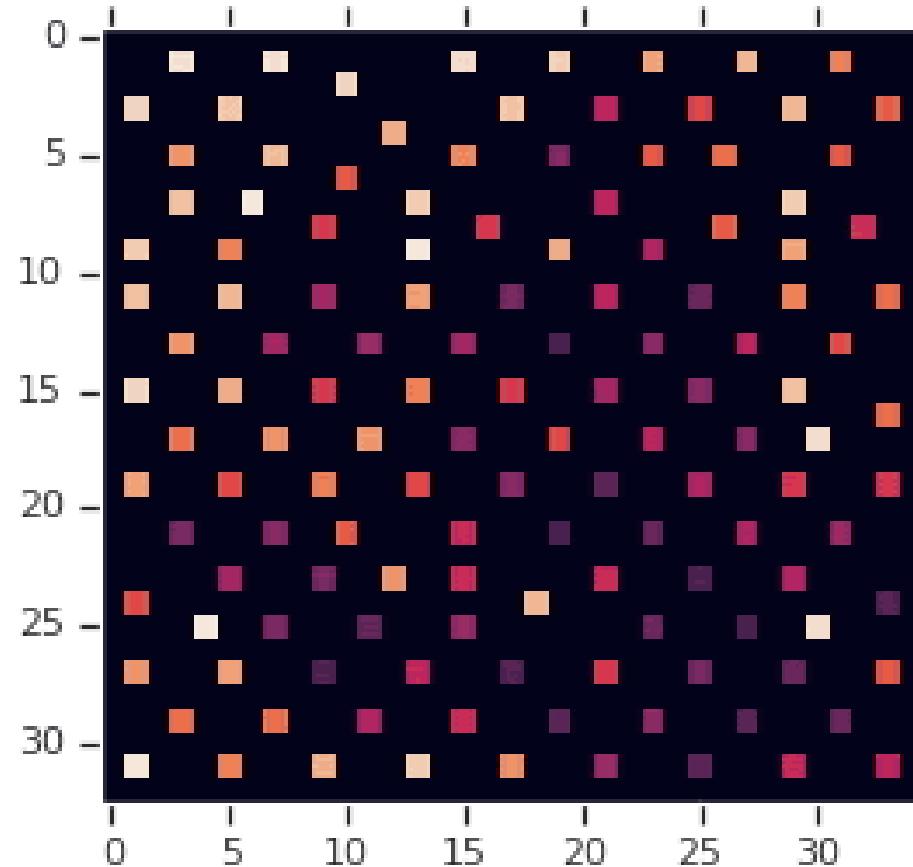
# Robot Hands



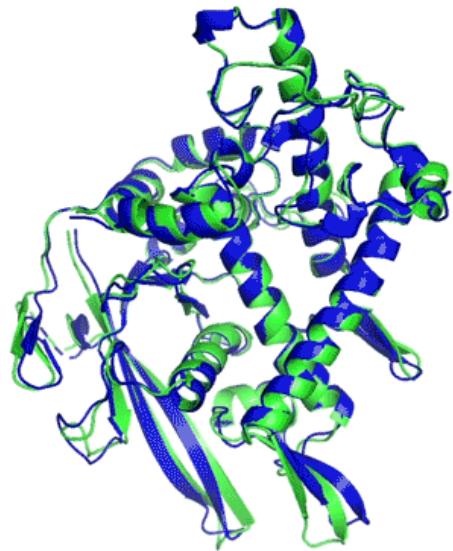


## Self-Driving Cars

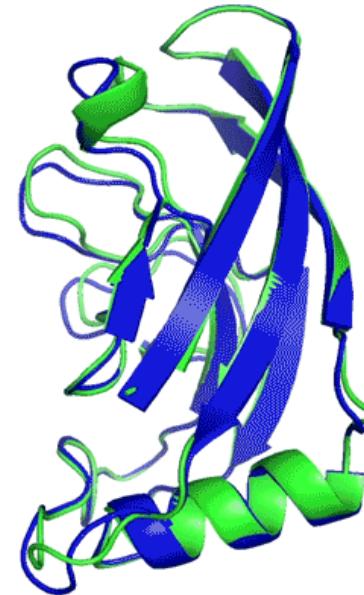
# AI Chip Designer



# AlphaFold



**T1037 / 6vr4**  
90.7 GDT  
(RNA polymerase domain)

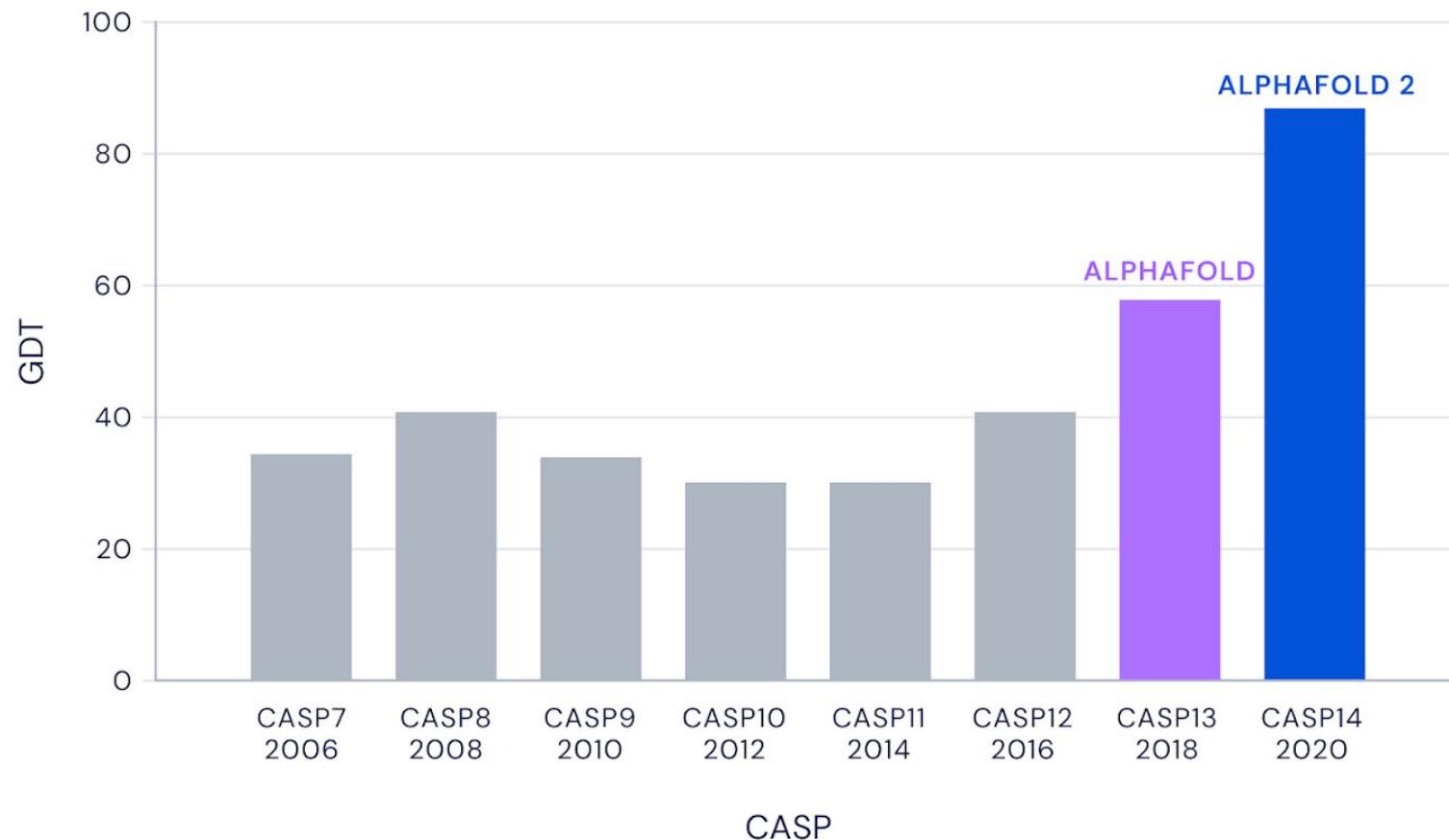


**T1049 / 6y4f**  
93.3 GDT  
(adhesin tip)

- Experimental result
- Computational prediction

# AlphaFold

## Median Free-Modelling Accuracy



# AlphaFold

- [AlphaFold: The making of a scientific breakthrough - YouTube](#)

# AlphaCode

- [AlphaCode \(deepmind.com\)](https://deepmind.com/research/project/alphacode)

# Deep Learning for Physics

- Solving PDEs w/ deep neural networks

≡ MIT Technology Review

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ARTIFICIAL INTELLIGENCE

## AI has cracked a key mathematical puzzle for understanding our world

Partial differential equations can describe everything from planetary motion to plate tectonics, but they're notoriously hard to solve.

By Karen Hao

October 30, 2020



Good Luck!