NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

CE/CZ 7454: Deep Learning for Data Science

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Liu Ziwei

School of Computer Science and Engineering

AY2021-2022, Semester 1

Instructors

- A/Prof Liu Ziwei
  - Course coordinator
  - Weeks 8-13

- A/Prof Li Boyang, Albert
  - Weeks 1-7

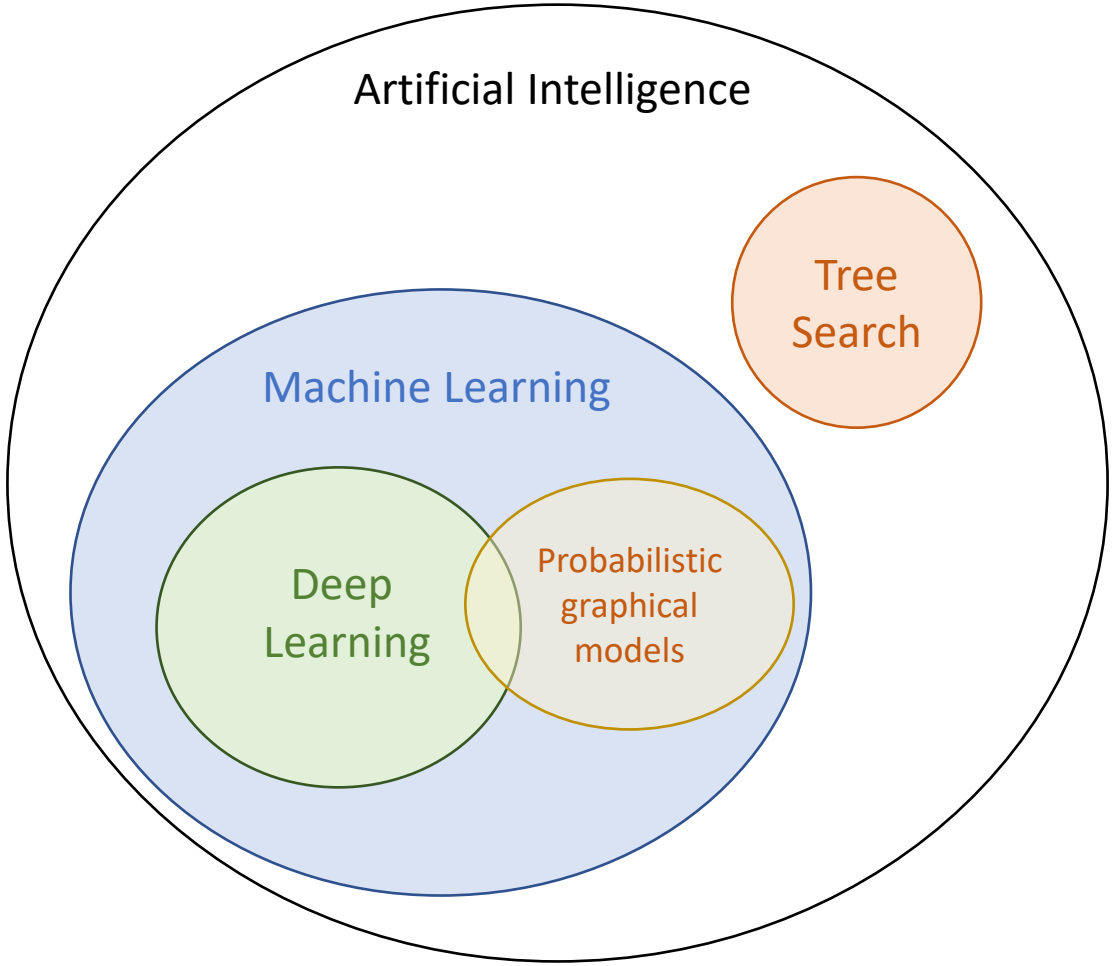
Li Boyang, Albert

- Nanyang Associate Professor
- Recipient of the NRF Fellowship
- Research: Multimodal learning, machine learning, computational narrative intelligence

- Ph.D. from Georgia Institute of Technology
- Group Leader at Disney Research Pittsburgh (2015-2017)
- Senior Research Scientist at Baidu Research USA (2018-2019)

What is Deep Learning?

- AI is the pursuit to replicate human's intelligent behaviors using computational means.
- Machine learning aims to design machines that can learn intelligent behaviors from data.
- Deep learning is machine learning using deep neural networks.



We already have intelligence. Just give some to the machines.

Recognize a chair?

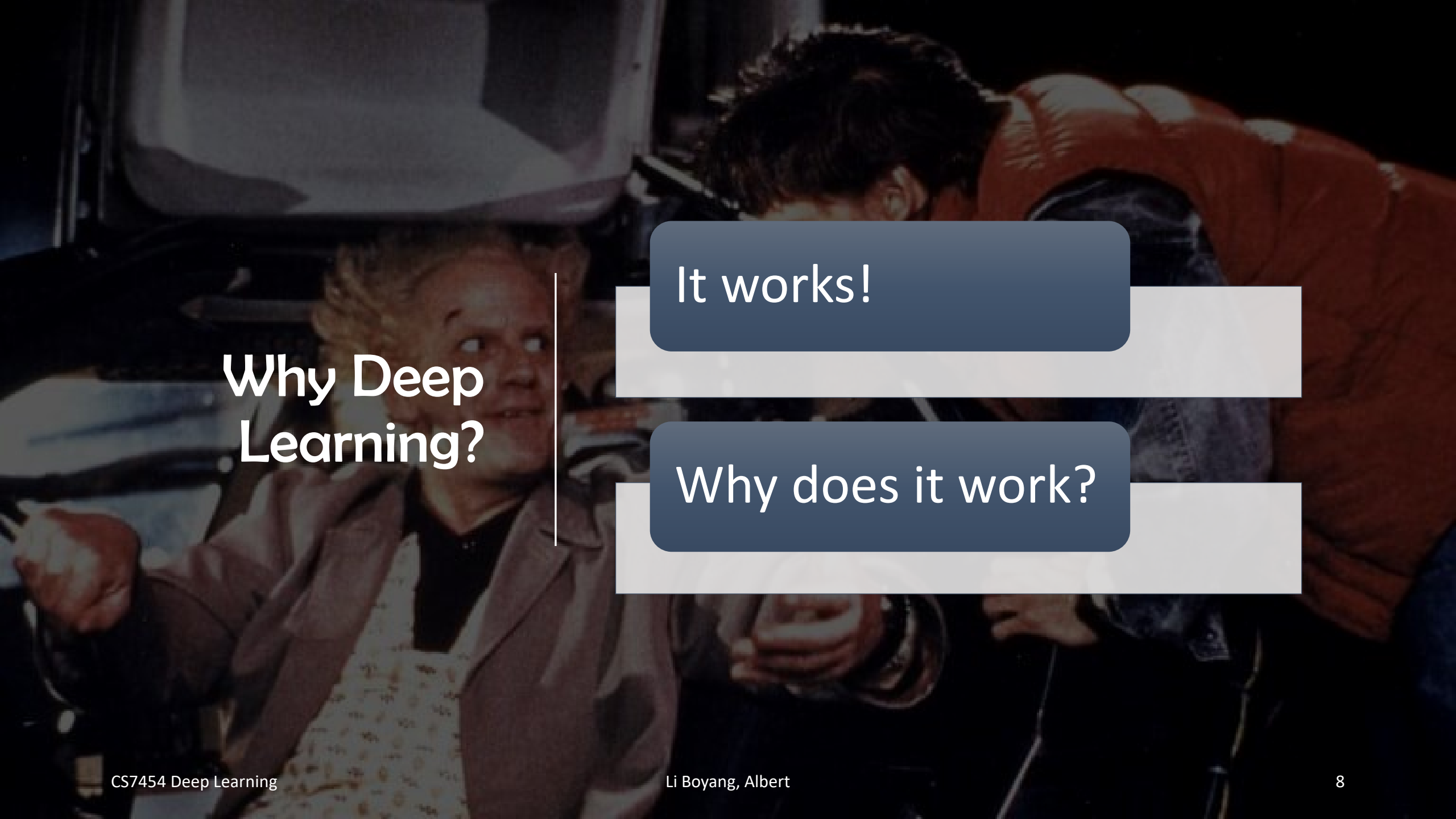






Giving our intelligence to machines directly is hard.

We have to find a way for machines to learn.



Why Deep Learning?

It works!

Why does it work?

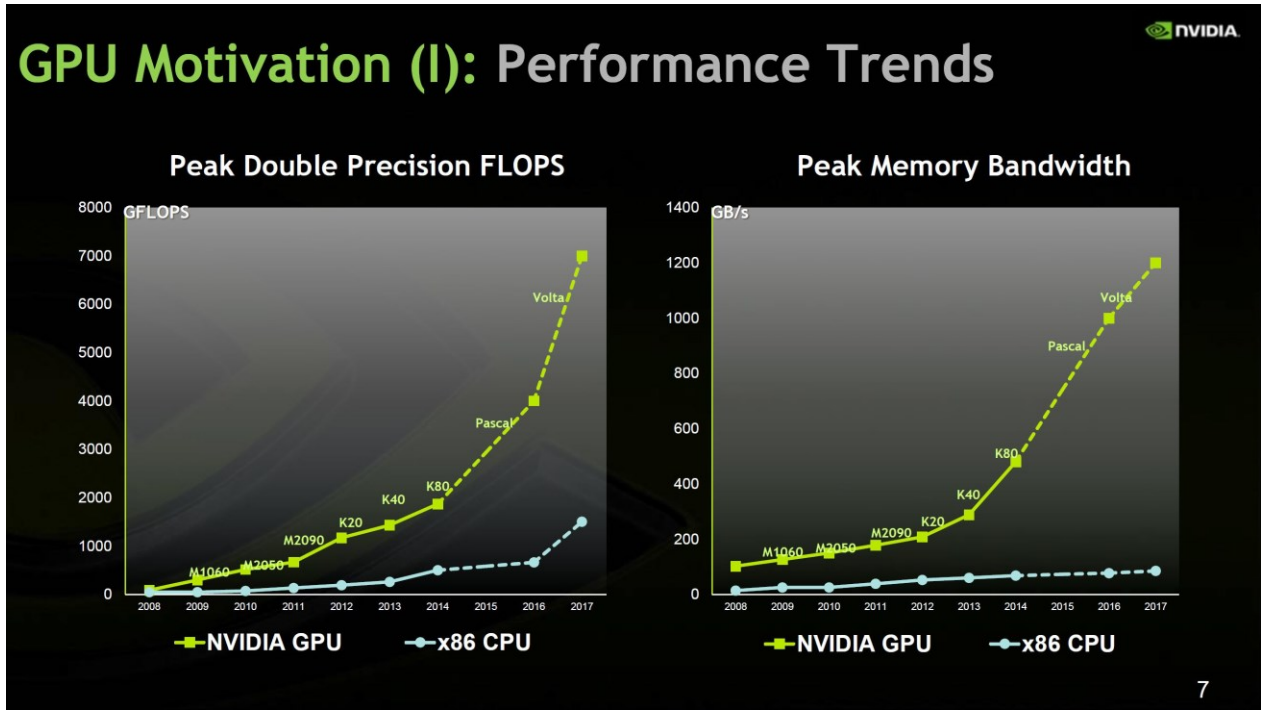
Why Deep Learning?

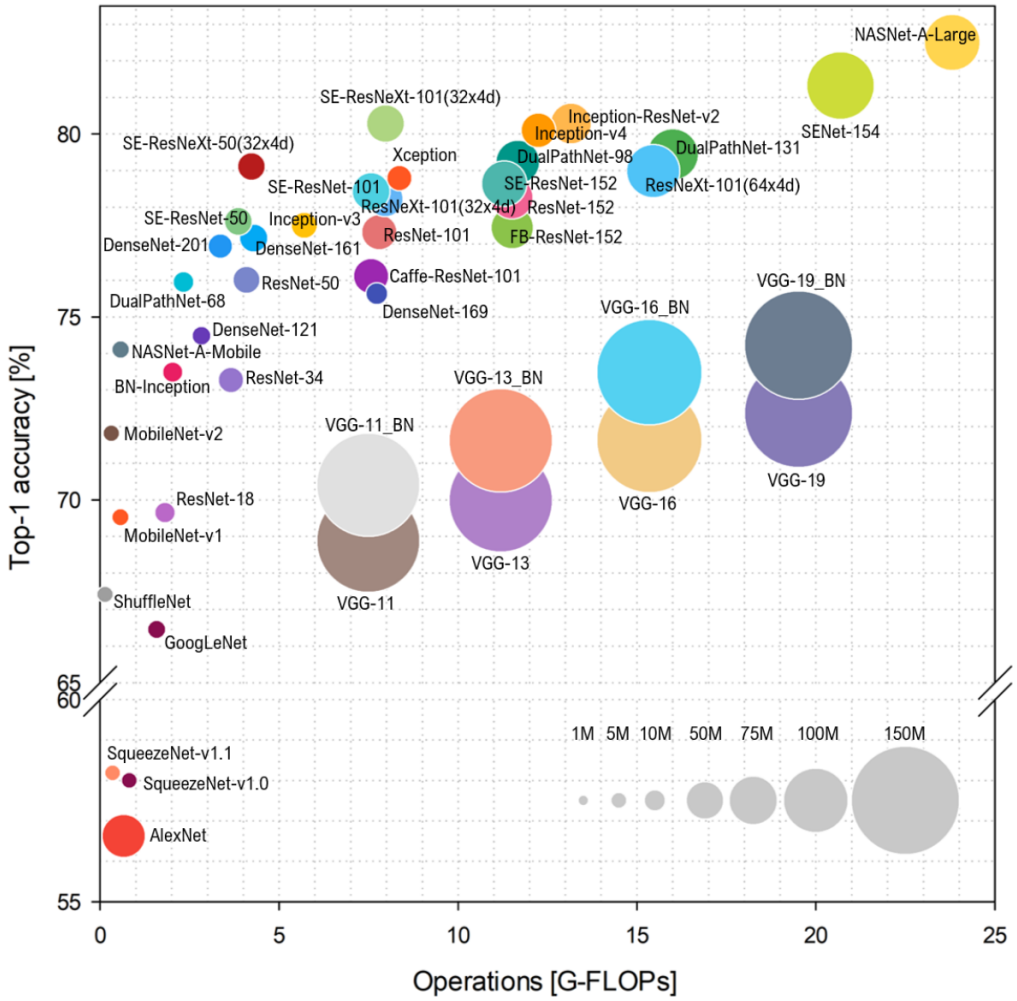
It works!

Why does it work?

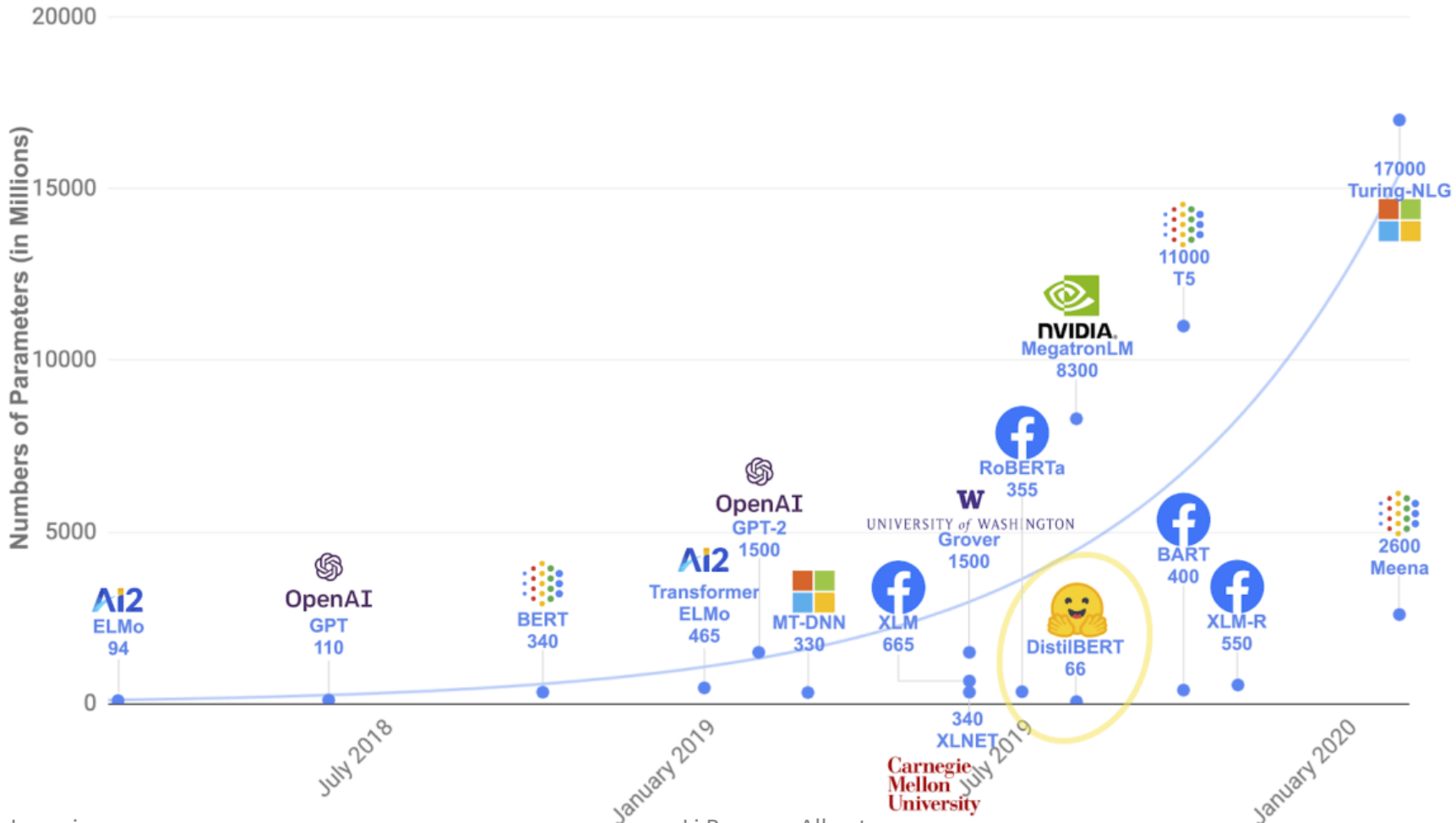
- Social reasons
- Technical reasons

Convergence of Technological Trends

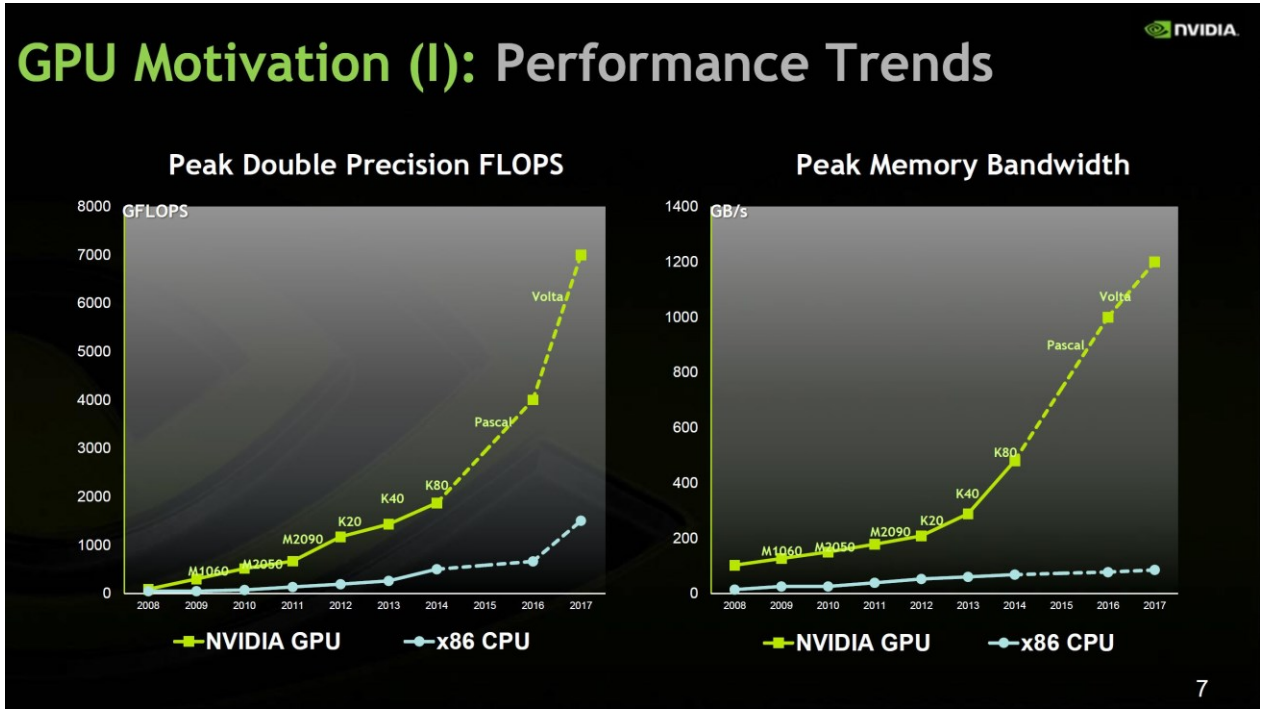


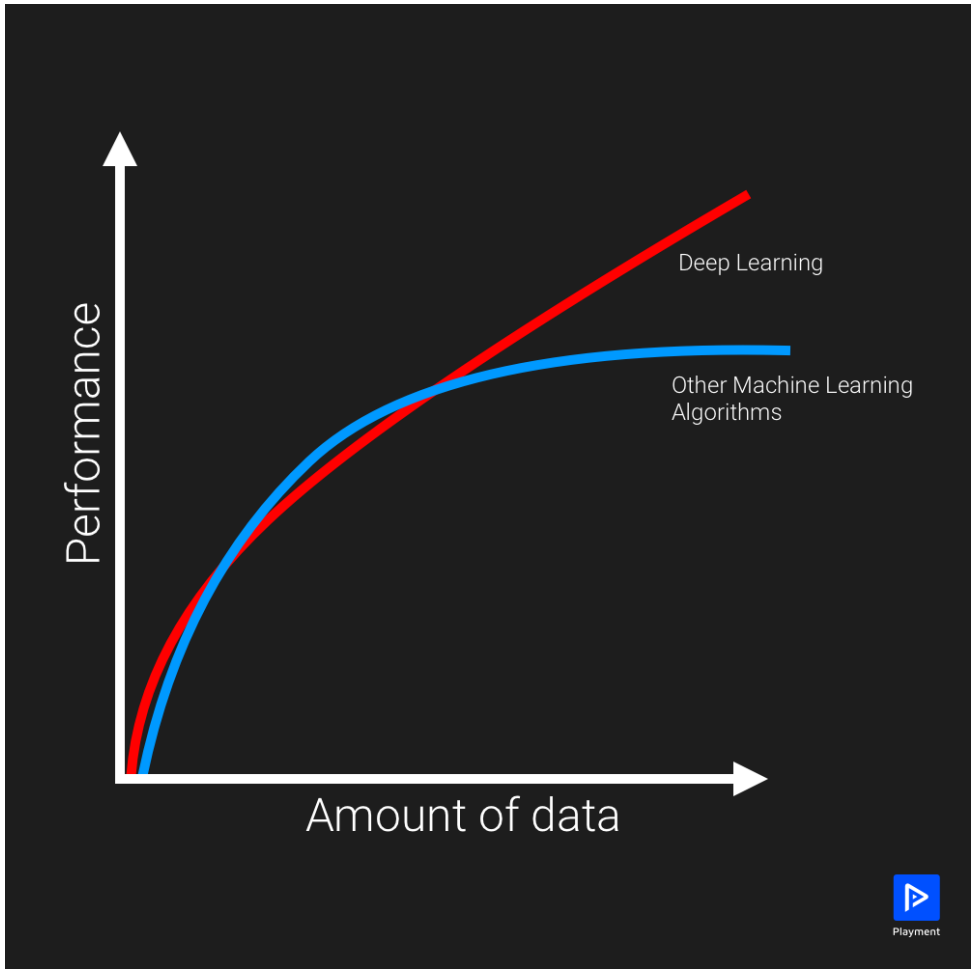


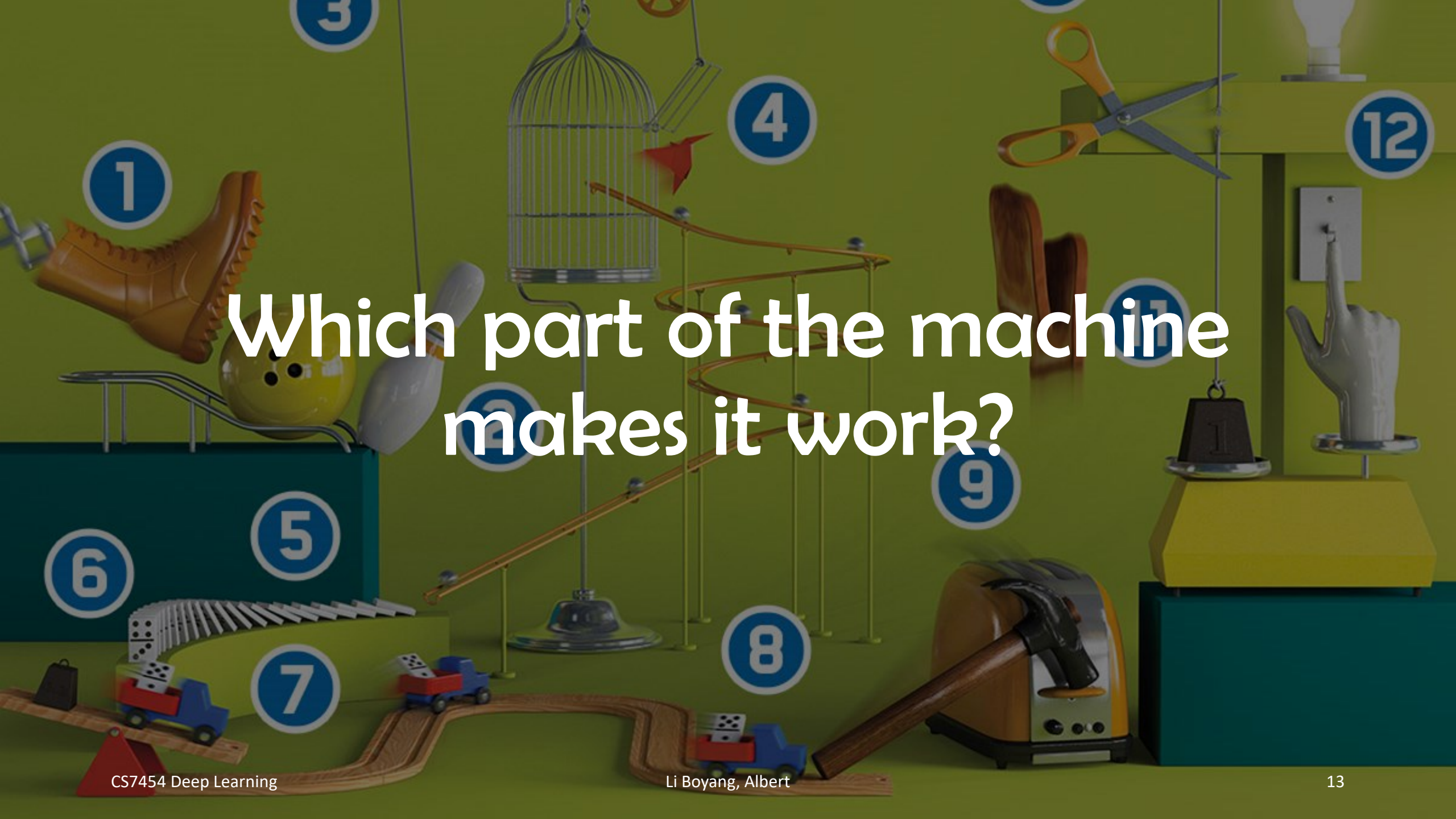
Convergence of Technological Trends



Convergence of Technological Trends

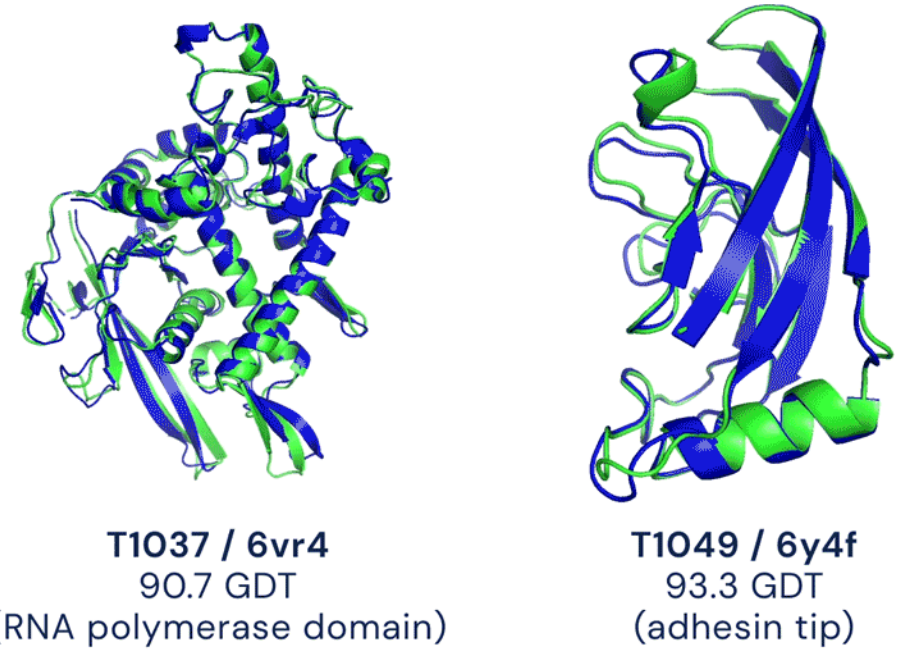





Which part of the machine makes it work?


ALPHAGO
00:05:30
Google DeepMind
Challenge Match
LEE SEDOL
00:28:28

AlphaFold



Proteins consist of chains of amino acids which spontaneously fold, in a process called protein folding, to form the three dimensional (3-D) structures of the proteins. The 3-D structure is crucial to the biological function of the protein. However, understanding how the amino acid sequence can determine the 3-D structure is highly challenging, and this is called the "protein folding problem".

In July 2021, Deepmind released predicted structures of nearly the full UniProt proteome of humans and 20 model organisms, amounting to over 365,000 proteins.

Autonomous Supermarket

- https://www.youtube.com/watch?v=ssZ_8cqfBlE


amazon go
GOOD FOOD FAST
PRODUCE
DELI
DESSERTS
YOGURT
BREAKFAST
MEAL KITS
NUTS
COOKIES
CANDY
COFFEE - TEA
FROZEN MEALS
ICE CREAM
CHOCOLATE
CANDY
DESSERT
HEAT & EAT
CHEESE

Generative Models

- VQGAN (2020) + CLIP (2021)
- From the text query “A small treehouse on top of a hill, next to the side of a field. | realistic renderings of fantastic scenes”

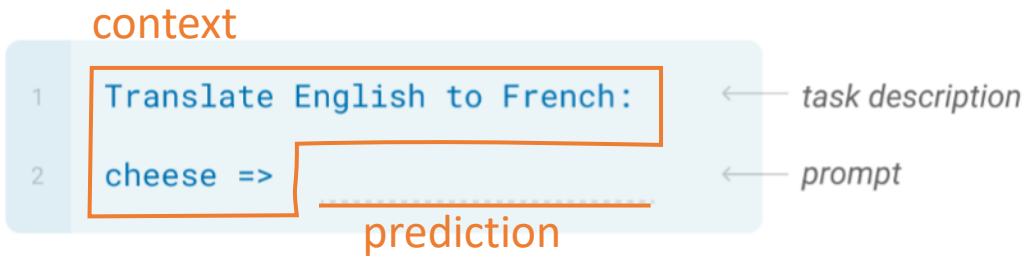
- StyleGAN2. Karras et al. Dec 2019
- https://www.thispersondoesnotexist.com/

GPT-3 (2020)

Answer: modeling

Zero-shot

The model predicts the answer given only a natural language description of the task. No gradient updates are performed.



Note: This is another form of blank filling!

The three settings we explore for in-context learning

Zero-shot

The model predicts the answer given only a natural language description of the task. No gradient updates are performed.

```
1 Translate English to French:        ← task description
2 cheese =>                           ← prompt
```

One-shot

In addition to the task description, the model sees a single example of the task. No gradient updates are performed.

```
1 Translate English to French:        ← task description
2 sea otter => loutre de mer          ← example
3 cheese =>                           ← prompt
```

Few-shot

In addition to the task description, the model sees a few examples of the task. No gradient updates are performed.

```
1 Translate English to French:        ← task description
2 sea otter => loutre de mer          ← examples
3 peppermint => menthe poivrée        ←
4 plush giraffe => girafe peluche     ←
5 cheese =>                           ← prompt
```

Traditional fine-tuning (not used for GPT-3)

Fine-tuning

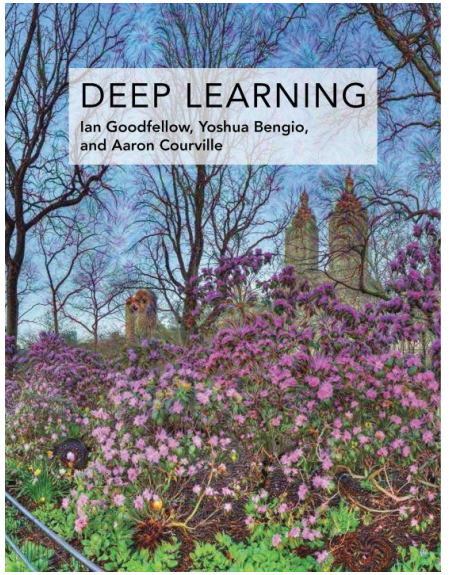
The model is trained via repeated gradient updates using a large corpus of example tasks.

```
1 sea otter => loutre de mer          ← example #1
        ↓
   gradient update
        ↓
1 peppermint => menthe poivrée        ← example #2
        ↓
   gradient update
        ↓
        ...
        ↓
1 plush giraffe => girafe peluche     ← example #N
        ↓
   gradient update
        ↓
1 cheese =>                           ← prompt
```

Course Structure

- Lecture 1 - Introduction to Deep Learning / Linear Algebra
- Lecture 2 - Probability and Information Theory
- Lecture 3 - Vanilla Neural Networks - Loss and Optimization
- Lecture 4 - Multi-Layer Perceptron - Inference and Learning
- Lecture 5 - Convolutional Neural Networks - Inference and Learning
- Lecture 6 - Convolutional Neural Networks - Regularization
- Lecture 7 - Visualizing Convolutional Neural Networks
- [Recess week] [Quiz]
- Lecture 8 - Recurrent Neural Networks
- Lecture 9 - Attention and Transformers [Assignment 1 due]
- Lecture 10 - Deep Structured Prediction
- Lecture 11 - Autoencoders
- Lecture 12 - Deep Generative Models
- Lecture 13 - Unsupervised Representation Learning

- Textbook
  - Deep Learning, by Ian Goodfellow and Yoshua Bengio and Aaron Courville. https://www.deeplearningbook.org/



Assignment

- Quiz (20%): deep learning basics - 30min (recess week)
- Project 1 (30%): fashion attributes - 4-page report in CVPR format, individual (start: Sep. 6, 2021, due: Oct. 18, 2021)
- Project 2 (40%): topic of your choice - 4-page report in CVPR format, group of 3-5 (due: Nov 22, 2021)
- Oral Presentations (10%): 5-min recorded videos (due: Nov 22, 2021)

Grading Rubric for Project 1

- Project 1 (30% of the final grade): fashion attributes - 4-page report in CVPR format, individual (start: Sep. 6, 2021, due: Oct. 18, 2021)
  - Predictive accuracy (30% of the project)
  - Optimization and regularization (20%)
  - Experimental analysis (30%)
  - Clarity of report (20%)

Grading Rubric for Project 2

- Report (40% of the final grade)
  - Project novelty and difficulty (25%)
  - Technical soundness (25%)
  - Experimental analysis (25%)
  - Clarity of report (25%)
- Presentation (10% of the final grade)
  - Clarity (20%)
  - Visualization (20%)
  - Logic Flow (20%)
  - Overall Quality (40%)

Office Hours

- Teaching assistant:
  - Mr. Lan Yushi
  - https://yushi.netlify.app/
  - Email: yushi001@e.ntu.edu.sg
- Location: online
- Time: 4-5pm on Fridays

Academic Integrity

https://www.ntu.edu.sg/docs/default-source/tlpd-documents/academic-integrity-handbook_july-2017.pdf?sfvrsn=fc5a5b24_2

I, matriculated student of NTU, pledge that I will abide by the Honour Code of the University.

I pledge that I will conduct myself at all times in a manner that is worthy of the good name of the University;

- promote, and help others to adhere to the values of truth, justice and trust
- enshrined in the Honour Code
- be honest in my academic work
- respect the University's rules and regulations, the rule of law, and the rights of others.

Avoidance of Plagiarism

A university essay (or project, or assignment) should normally have:

1. Most of the words written by you (certainly more than half, and as a general rule, around 85% of a research essay should be your own words)

2. Quotes and paraphrases from articles, books and other sources to back up your conclusions (generally no more than 15% of the total words should be quotes or paraphrases)

3. Proper citation of each quote and paraphrase (this means indicating in the body of the essay the name of the person who wrote the quote, the date and perhaps the page number)

4. A Reference List at the end of the essay giving full details of the original articles (or books or other sources)

Questions?