AI504: Programming for Artificial Intelligence

Week 1: Introduction

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What is AI?
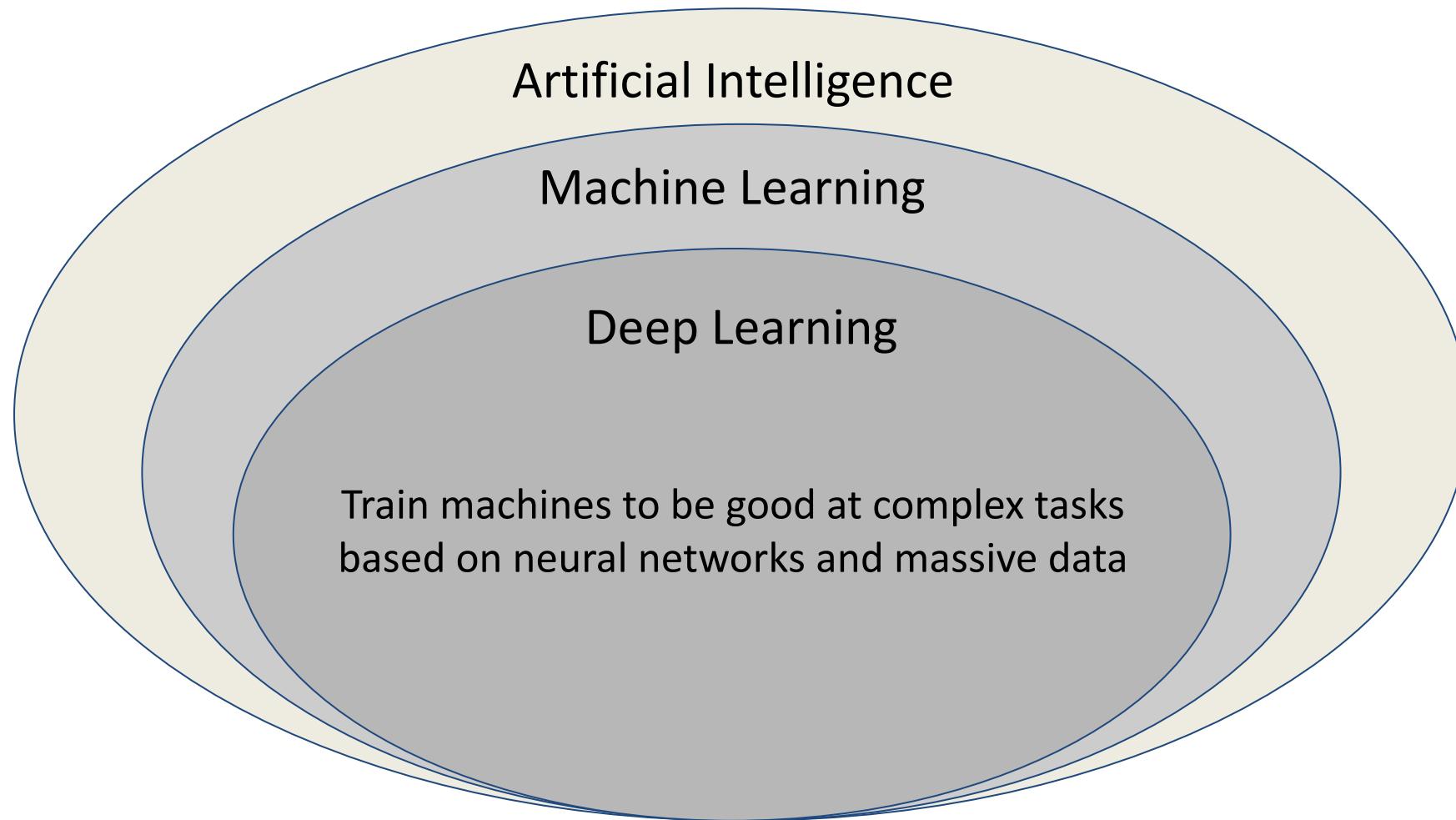
Artificial Intelligence

Make machines/computers mimic human intelligence
Concept as old as the computer (Chess program by Alan Turing)

What is Machine Learning?

Artificial Intelligence

Machine Learning

Use statistical methods to teach machines to learn from data to be good at a specific task (Spam filtering)

What is Deep Learning?

Artificial Intelligence

Machine Learning

Deep Learning

Train machines to be good at complex tasks
based on neural networks and massive data
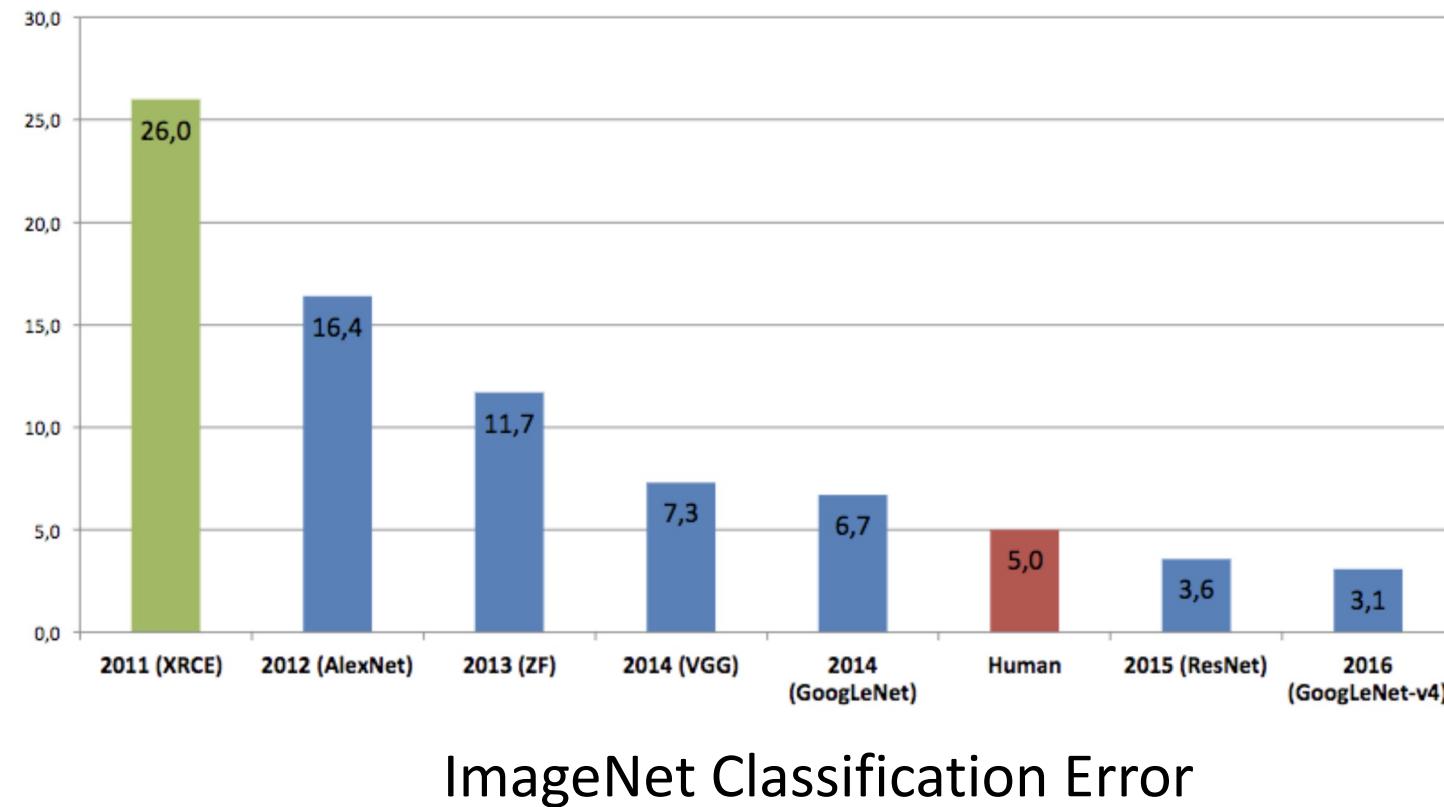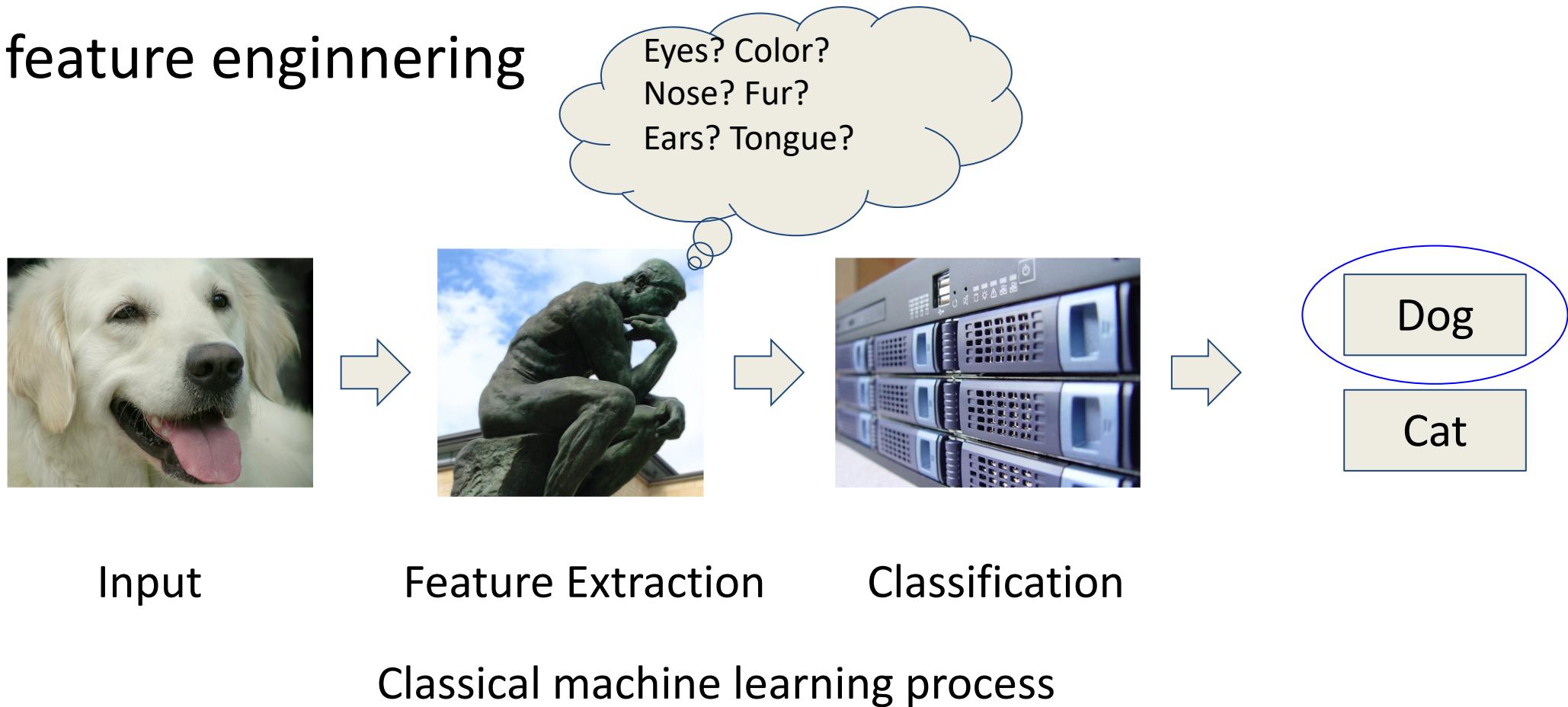
Why Deep Learning?

State-of-the-art performance

ImageNet Classification Error

Survey of neural networks in autonomous driving, Gustav von Zitzewitz,
Advanced Seminar SS 2017: Survey of Neural Networks in Autonomous Driving

Why Deep Learning?

Less feature enginnering

Eyes? Color?
Nose? Fur?
Ears? Tongue?

Input   Feature Extraction   Classification   Dog

                                                                             Cat

Classical machine learning process
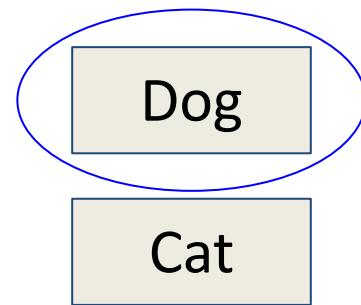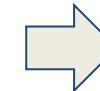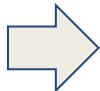
Why Deep Learning?

Less feature engineering

Input   Feature Extraction + Classification

Deep learning process

How is this Possible?
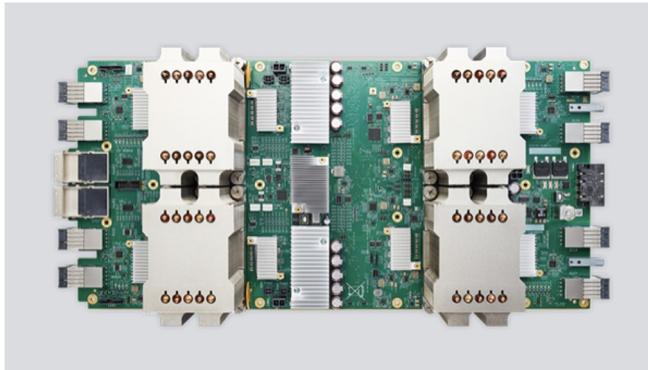
Large data

- Social network services
  - Youtube, Instagram, Twitter
- Collective intelligence
  - Wikipedia
- Mass media
 - News articls

ImageNet

How is this Possible?
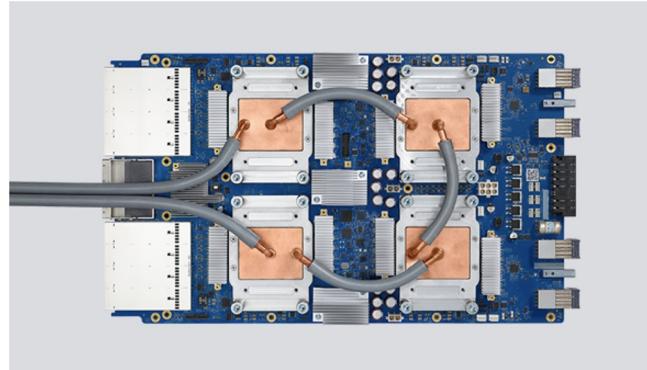
Large data + Powerful machines

Cloud TPU v2

180 teraflops
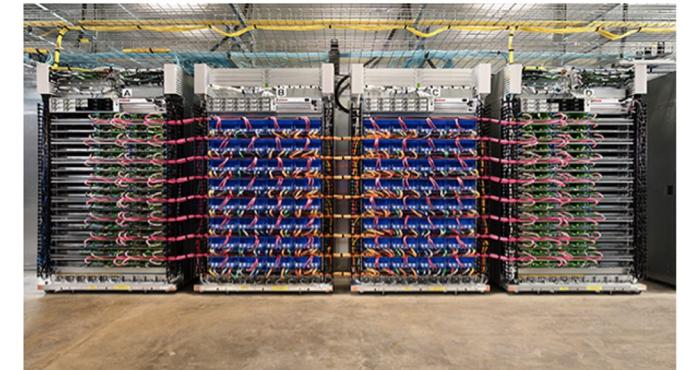
64 GB High Bandwidth Memory (HBM)

Cloud TPU v3

420 teraflops

128 GB HBM

Cloud TPU v2 Pod (alpha)

11.5 petaflops

4 TB HBM
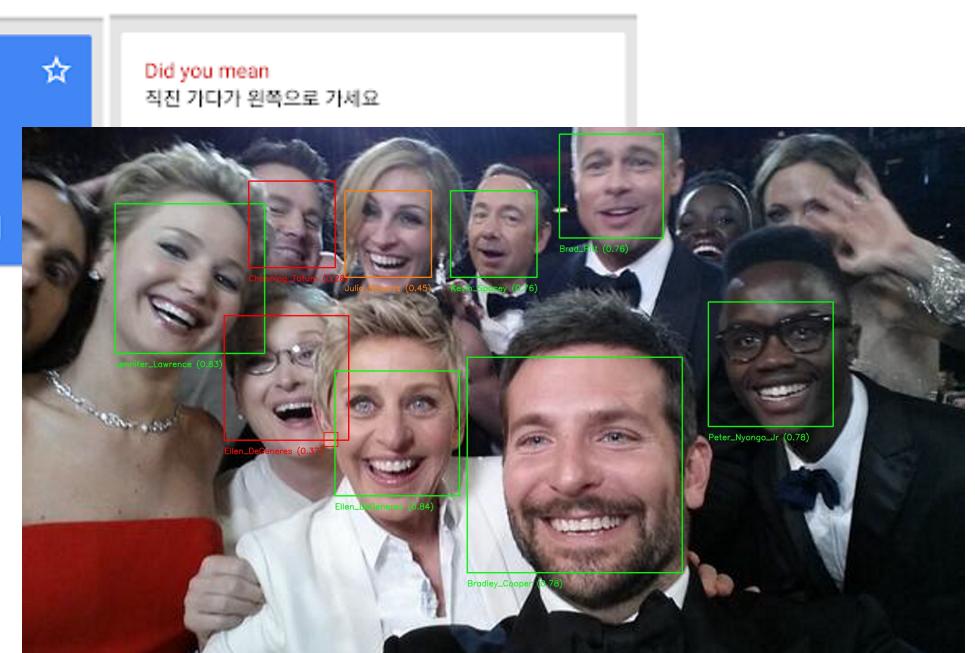
2-D toroidal mesh network

Modern AI

(Almost) Infinite Compute + (Almost) Infinite Data

Probably >1000 V100's

570GB Text (400 Billion Tokens)

175B Parameters
$4~5 Million for Training

GPT3

- Open AI's unsupervised generative language model
  - Using 96 layers of Transformer
  - BERT uses 24 layers

Title: United Methodists Agree to Historic Split
Subtitle: Those who oppose gay marriage will form their own denomination
Article: **After two days of intense debate, the United Methodist Church has agreed to a historic split - one that is expected to end in the creation of a new denomination, one that will be "theologically and socially conservative," according to The Washington Post. The majority of delegates attending the church's annual General Conference in May voted to strengthen a ban on the ordination of LGBTQ clergy and to write new rules that will "discipline" clergy who officiate at same-sex weddings. But those who opposed these measures have a new plan: They say they will form a separate denomination by 2020, calling their church the Christian Methodist denomination.**
The Post notes that the denomination, which claims 12.5 million members, was in the early 20th century the "largest Protestant denomination in the U.S.," but that it has been shrinking in recent decades. The new split will be the second in the church's history. The first occurred in 1968, when roughly 10 percent of the denomination left to form the Evangelical United Brethren Church. The Post notes that the proposed split "comes at a critical time for the church, which has been losing members for years," which has been "pushed toward the brink of a schism over the role of LGBTQ people in the church." Gay marriage is not the only issue that has divided the church. In 2016, the denomination was split over ordination of transgender clergy, with the North Pacific regional conference voting to ban them from serving as clergy, and the South Pacific regional conference voting to allow them.

A "whatpu" is a small, furry animal native to Tanzania. An example of a sentence that uses the word whatpu is:
We were traveling in Africa and we saw these very cute whatpus.

To do a "farduddle" means to jump up and down really fast. An example of a sentence that uses the word farduddle is:
One day when I was playing tag with my little sister, she got really excited and she started doing these crazy farduddles.
A "yalubalu" is a type of vegetable that looks like a big pumpkin. An example of a sentence that uses the word yalubalu is:
I was on a trip to Africa and I tried this yalubalu vegetable that was grown in a garden there. It was delicious.

A "Burringo" is a car with very fast acceleration. An example of a sentence that uses the word Burringo is:
In our garage we have a Burringo that my father drives to work every day.

A "Gigamuru" is a type of Japanese musical instrument. An example of a sentence that uses the word Gigamuru is:
I have a Gigamuru that my uncle gave me as a gift. I love to play it at home.
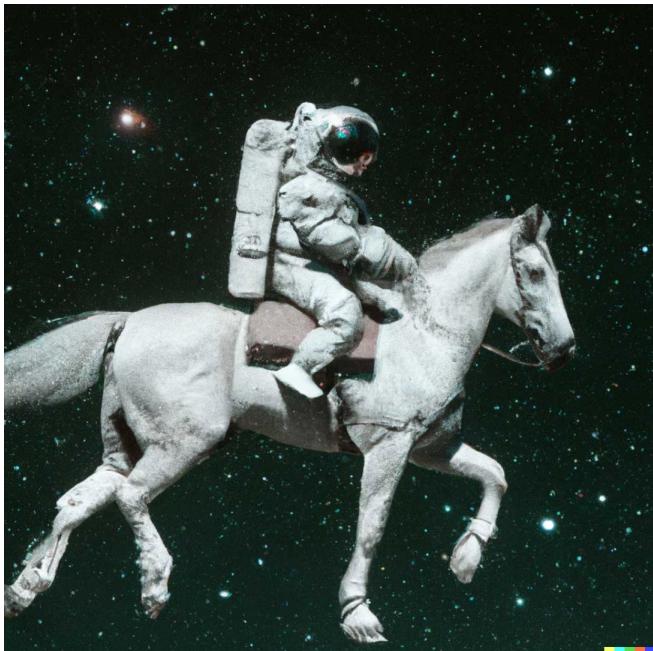
To "screeg" something is to swing a sword at it. An example of a sentence that uses the word screeg is:
We screeghed at each other for several minutes and then we went outside and ate ice cream.

DALL-E 2, Imagen, Parti

- ## Open AI & Google's conditional text-to-image generator
  - Transformer or Diffusion

An astronaut riding a horse in a photorealistic style

A chrome-plated duck with a golden beak arguing with a golden turtle in a forest
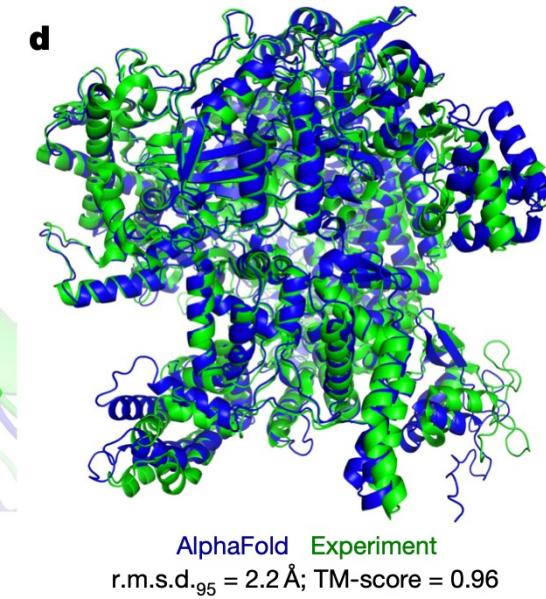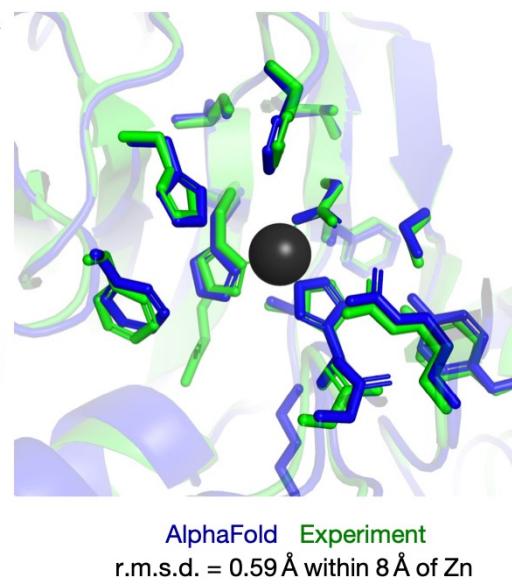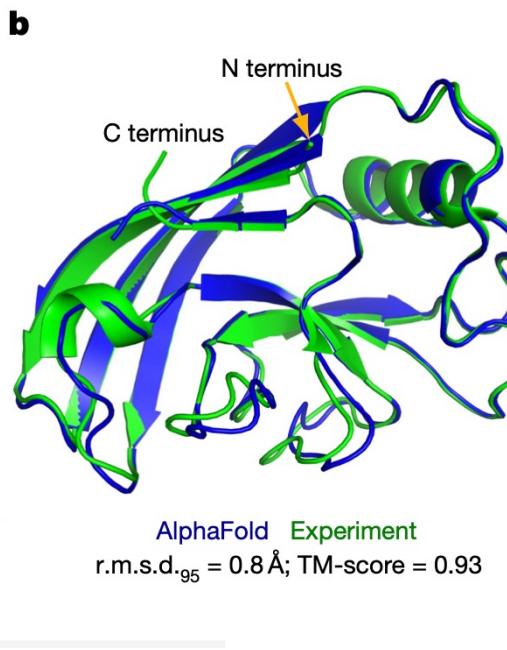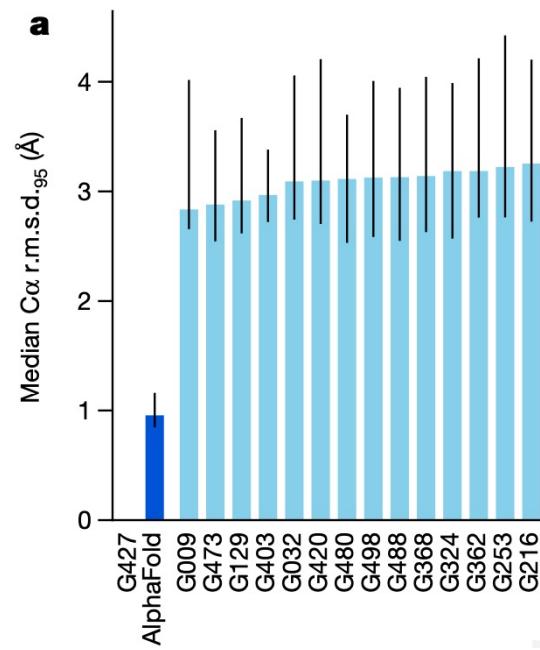
A photo of an Athenian vase with a painting of pangolins playing basketball in the style of Egyptian hieroglyphics.
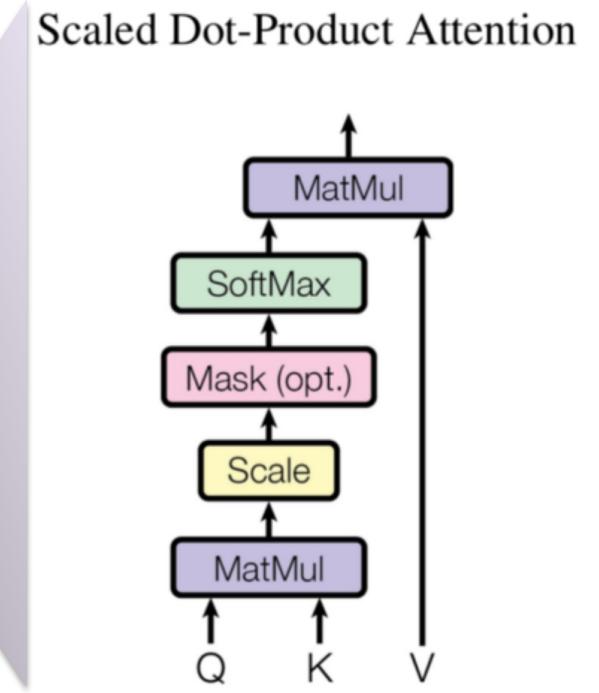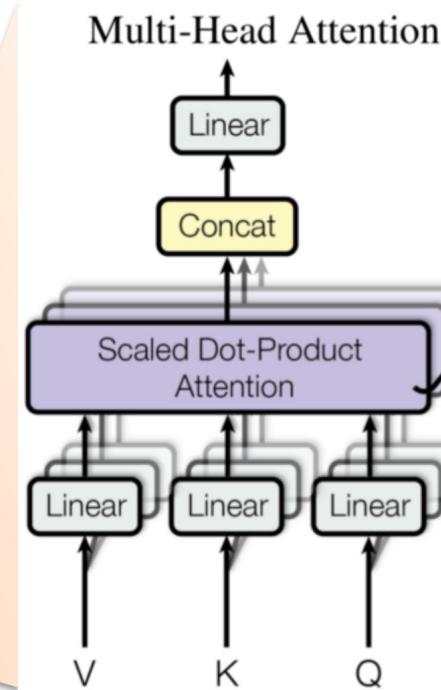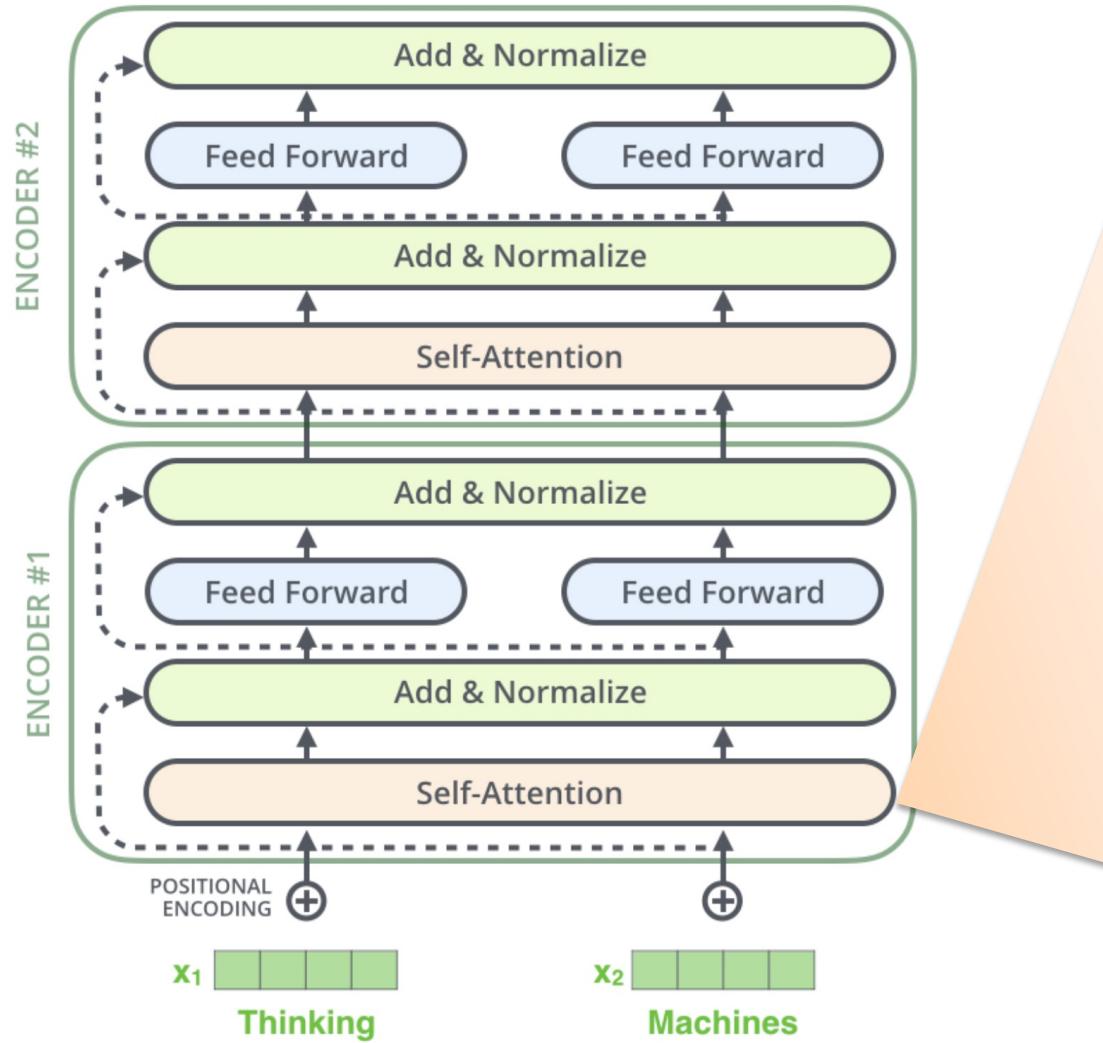
AlphaFold2

- DeepMind's protein structure prediction model
  - Using 48 layers of Evoformer
    - Special self-attention for graphs in 3D

a Median Cα r.m.s.d.$_{95}$ (Å) bar chart with categories: G427 AlphaFold, G009, G473, G129, G403, G032, G420, G480, G498, G488, G368, G324, G362, G253, G216

b AlphaFold Experiment
r.m.s.d.$_{95}$ = 0.8 Å; TM-score = 0.93

c AlphaFold Experiment
r.m.s.d. = 0.59 Å within 8 Å of Zn

d AlphaFold Experiment
r.m.s.d.$_{95}$ = 2.2 Å; TM-score = 0.96

Transformer Architecture

Goal

- Learn to build deep learning models.
  - So that you can replicate papers
  - So that you can realize your ideas
  - So that you can conduct AI research

- This course teaches only the very basics.
  - Practice makes perfect!

Structure

- Schedule:
  - Lecture on Tuesday
    - Conducted by the lecturer
  - Practice on Thursday
    - Conducted by the TA
- Assignments
  - Project 1
    - Image synthesis using GAN
  - Project 2
    - French-English Translation using Transformers
- Grading
  - Letter grade
  - Project 1: 45%, Project 2: 45%, Attendance: 10%

Weekly Plan

1. Intro + Numpy
2. Basic Machine Learning + Scikit-learn
3. PyTorch Intro + Logistic Regression + Multi-layer Perceptron
4. Autoencoders (& Denoising Autoencoders)
5. Variational Autoencoders
6. Generative Adversarial Networks
7. Convolutional Neural Networks
8. Midterm Week (Project 1)
9. Word2Vec + Subword Encoding
10. Recurrent Neural Networks & Sequence-to-Sequence
11. Transformers
12. BERT (& GPT)
13. Image-Text Multimodal Learning
14. Deep Diffusion Probabilistic Model
15. Graph Neural Networks
16. Final Week (Project 2)

Material & Discussion

- No textbook
- Materials will be posted on Classum if necessary.

- Classum
  - Join as Participant Link: www.classum.com/ej4fmx
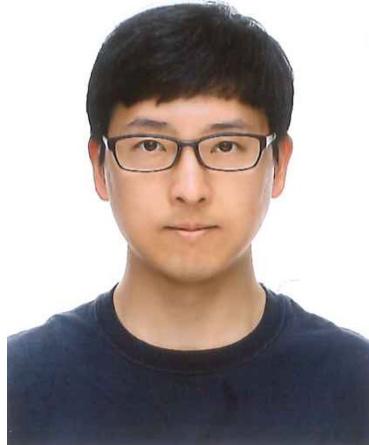
Expectation

- Lecture: Your are expected to attend
- Project
  - Individual effort
  - Deliverables:
    - Link to the model weights
    - Your model will be evaluated automatically
      - Project 1: FID score
      - Project 2: BLEU score

Teaching Team

- Lecturer
  - Edward Choi
    - edwardchoi@kaist.ac.kr
    - https://mp2893.com
- TA
 - TBA

Edward Choi, 최윤재
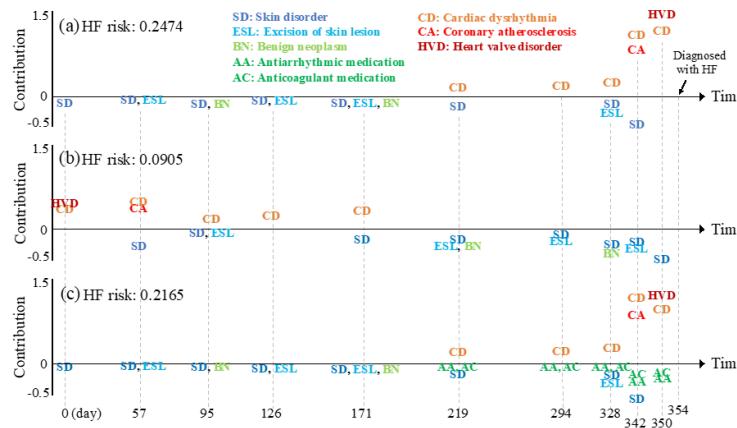
- Education
  - Ph.D. (computer science), Georgia Tech, 2014-2018
    - Thesis: Interpretable deep learning for longitudinal electronic health records
- Professional Experience
  - ETRI (2010-2014)
  - Sutter Health (2015, 2016)
  - DeepMind & Google (2017)
  - Google Brain & Google Health (2018-2020)
- Research Area
 - Machine Learning, Healthcare, NLP, Multi-modal

Research Topics
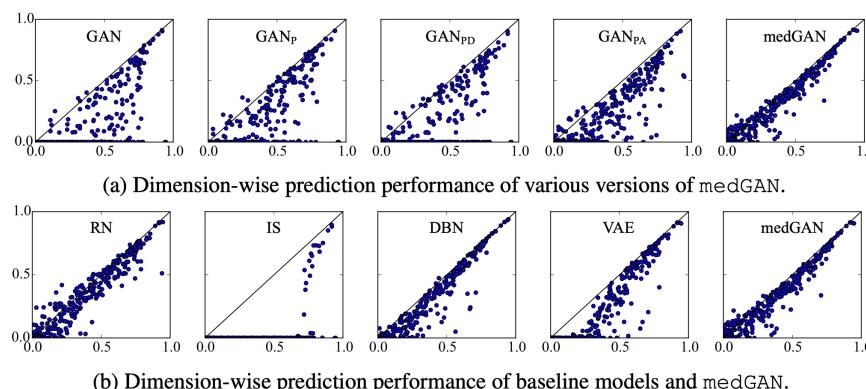
Interpretable Healthcare Prediction

- Predict medical events (e.g. diseae)
- Provide explanation for the prediction
- Recent focus on scaling up

(a) HF risk: 0.2474

SD: Skin disorder
ESL: Excision of skin lesion
BN: Benign neoplasm
AA: Antiarrhythmic medication
AC: Anticoagulant medication
CD: Cardiac dysrhythmia
CA: Coronary atherosclerosis
HVD: Heart valve disorder

(b) HF risk: 0.0905

(c) HF risk: 0.2165

Synthesizing Healthcare Data

- Healthcare data is hard to share due to privacy risk
- High-quality synthetic samples can accelerate research

GAN   GAN$_P$ GAN$_{PD}$ GAN$_{PA}$ medGAN

(a) Dimension-wise prediction performance of various versions of medGAN.

RN   IS   DBN   VAE   medGAN

(b) Dimension-wise prediction performance of baseline models and medGAN.
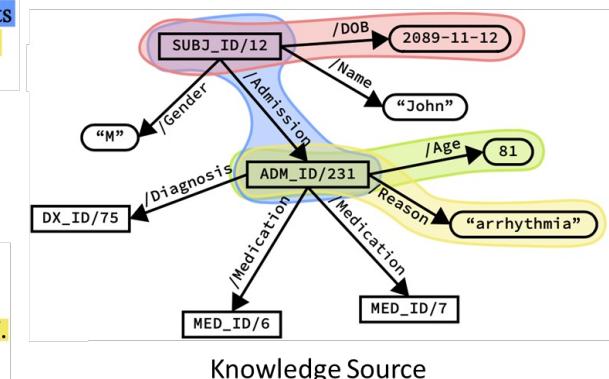
Question Answering with EHR

- Exploit clinical facts with human language
- Perform complex reasoning with clinical facts
- Have conversation with the AI agent
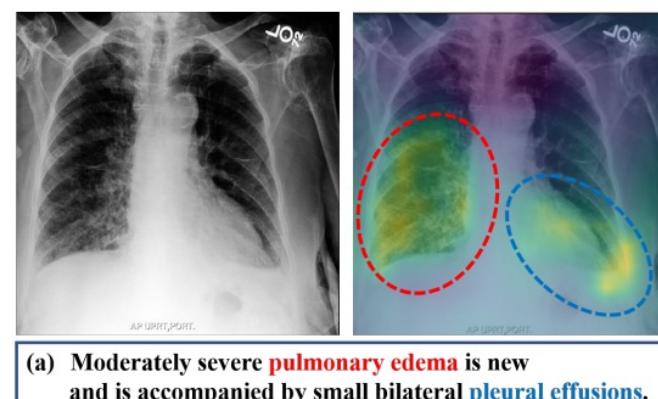
Calculate the maximum age of patients who have arrhythmia primary disease and were born after the year 2080?

A.I.

SELECT (MAX (?age) as ?agg)
WHERE { ?subj_id ⟨/Admission⟩ ?adm_id.
?adm_id ⟨/Age⟩ ?age.
?adm_id ⟨/Reason⟩ "Arrhythmia".
?subj_id ⟨/DOB⟩ ?dob.
filter (?dob > 2080-01-01). }

SUBJ_ID/12   /DOB   2089-11-12
/Name   "John"
/Gender   "M"
/Admission
/Age   81
ADM_ID/231   /Reason   "arrhythmia"
/Diagnosis   DX_ID/75
/Medication   MED_ID/6
/Medication   MED_ID/7

Knowledge Source

Multi-modal Learning

- Healthcare data consists of multiple modalities
- Must combine all information to accurately treat patients

(a) Moderately severe pulmonary edema is new and is accompanied by small bilateral pleural effusions.

First Assignment

- Install Anaconda
  - Python package for data science
  - Includes Jupyter, Numpy, Scikit-Learn, TensorFlow, PyTorch
  - https://www.anaconda.com/products/individual

- All practice sessions will be conducted with Google Colab
  - Python Notebook on the web
  - Can train models using Google's GPU/TPU
  - Session-based (why you need Anaconda)

Questions?

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