

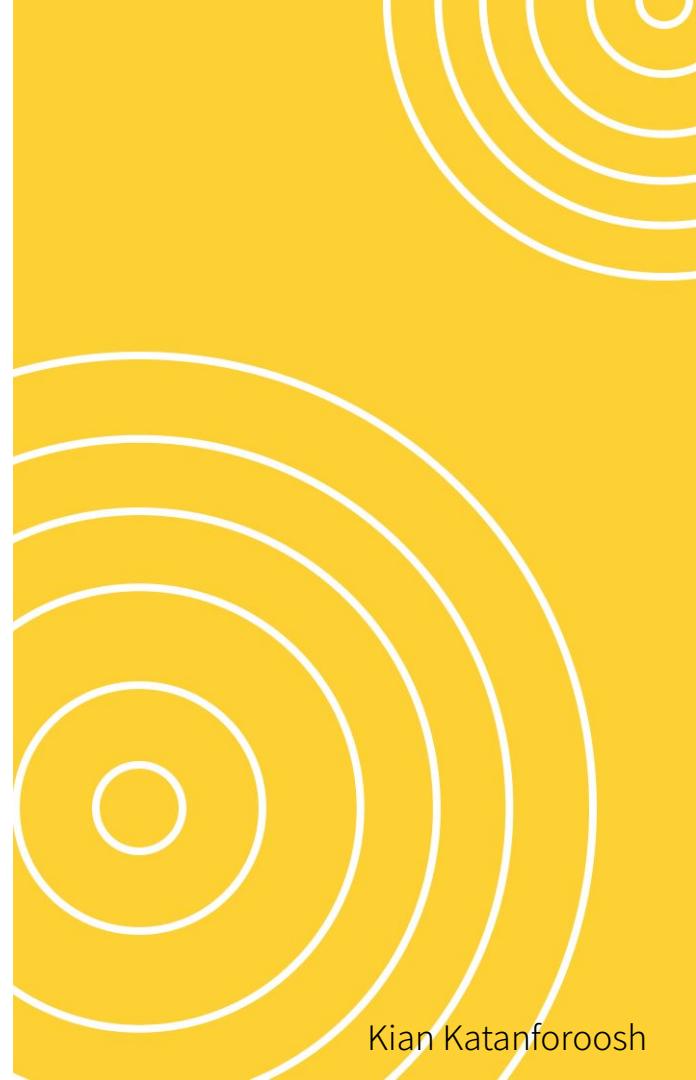
CS230 - Deep Learning

Lecture 1

September 2022 - Kian Katanforoosh

Agenda

- **Welcome!**
- **Introduction to Deep Learning**
- **About CS230**
 - Course logistics
 - Prerequisites, & Workera Competency Models
 - CS230 vs. CS229 vs. CS229A
 - Overview of CS230 programming assignments
 - Examples of student projects



Welcome to CS230!

Stanford's Deep Learning Class (Fall 2022 Edition)

Course Staff



Andrew Ng
Instructor



Kian Katanforoosh
Instructor



Amelie Byun
Course Manager



Swati Dube Batra
Course Advisor



Elaine Sui
Head TA

Course Assistants



Sarthak Consul



Hanson Lu



Surag Nair



Manasi Sharma



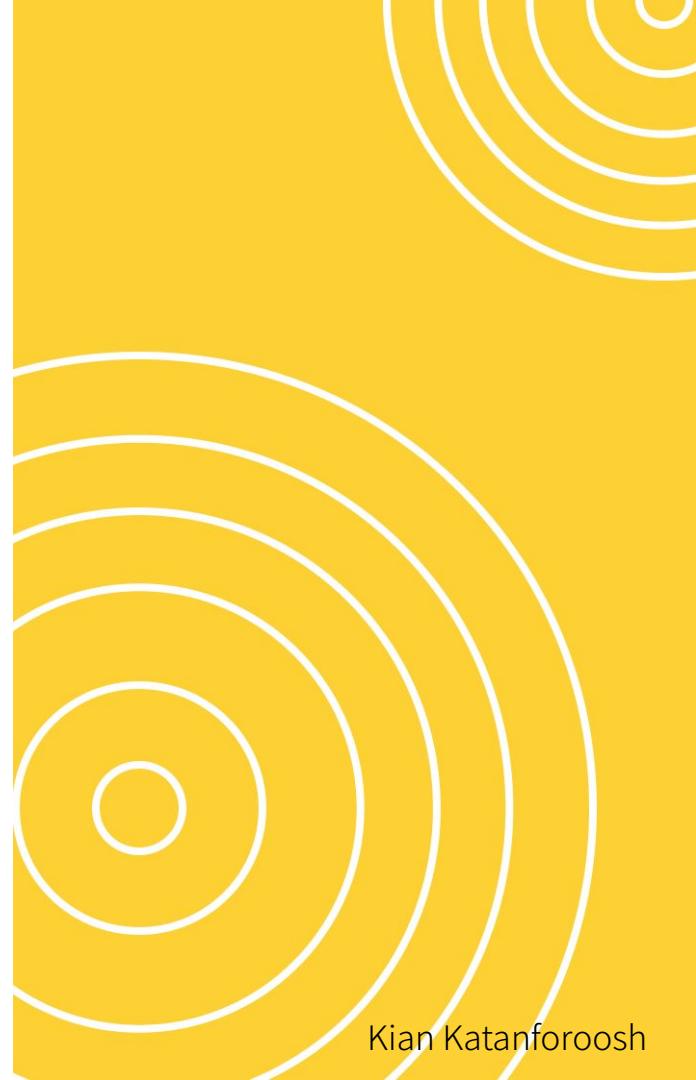
Skanda Vaidyanath



Yan Wang



Davey Huang

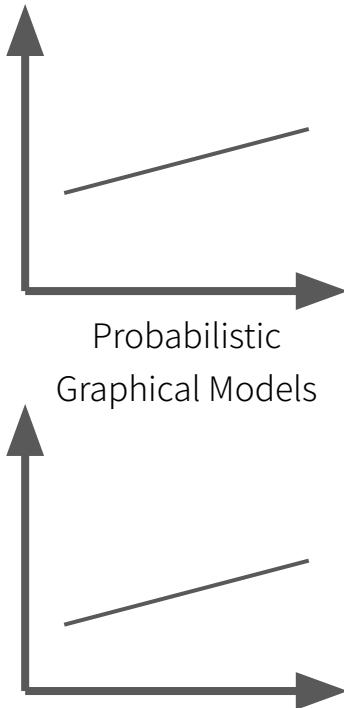


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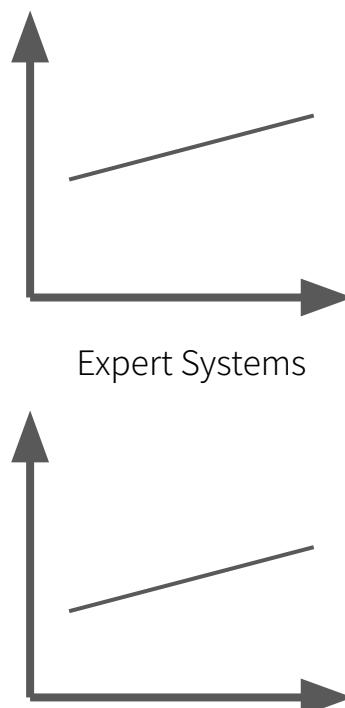
Introduction to Deep Learning



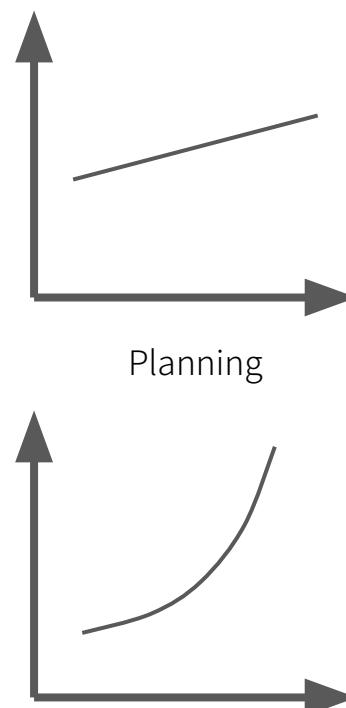
Why study Machine Learning / Deep Learning?



Knowledge
Representation



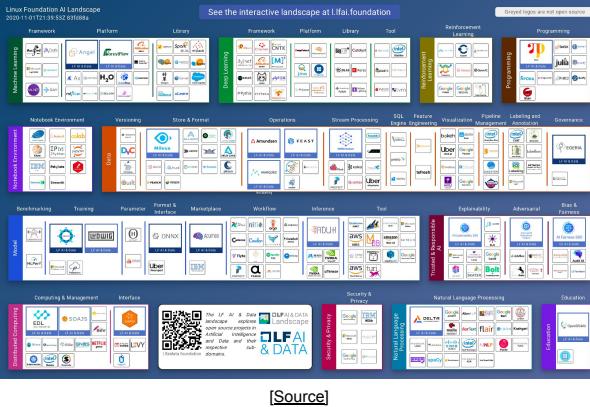
Search



Deep Learning /
Machine Learning

Andrew Ng
Kian Katanforoosh

Research and development in ML/DL progresses rapidly.



- 2021-22
- ## Large Language Models & Latent Diffusion Models
- Massive leaps forward in large language models and multimodal models that move between image and language.
- 2020
- ## Data-Centric AI
- Building AI systems with a focus on ensuring that the data clearly conveys what the AI must learn.
- 2019
- ## ML Ops Tools
- Emergence of a set of tools and practices aiming to deploy and maintain ML models in production reliably and efficiently.
- 2018
- ## Responsible AI
- Discussions on AI fairness, safety, reliability, transparency, and privacy become more prominent in the community.
- 2017
- ## Transformer Architecture
- Attention is all you need and the rise of the transformer architecture improved the performance of state-of-the-art systems in various tasks.
- 2016
- ## Generative Adversarial Networks
- Rapid adoption of GANs after the seminal paper from Goodfellow et al.
- 2015
- ## Modern Deep Learning Frameworks
- Google's TensorFlow and Facebook's PyTorch taking the lead over frameworks like Lua, Torch, Caffe, Lasagna, and Chainer.

[Non-exhaustive list!]



Generative Adversarial Nets

Ian J. Goodfellow,¹ Jean Pouget-Abadie,² Mehdi Mirza,² Bing Xu,² David Warde-Farley,² Sherjil Ozair,² Aaron Courville,² Yoshua Bengio²
Département d'informaticien et de recherche opérationnelle
Université de Montréal
Montréal, QC H3C 3J7

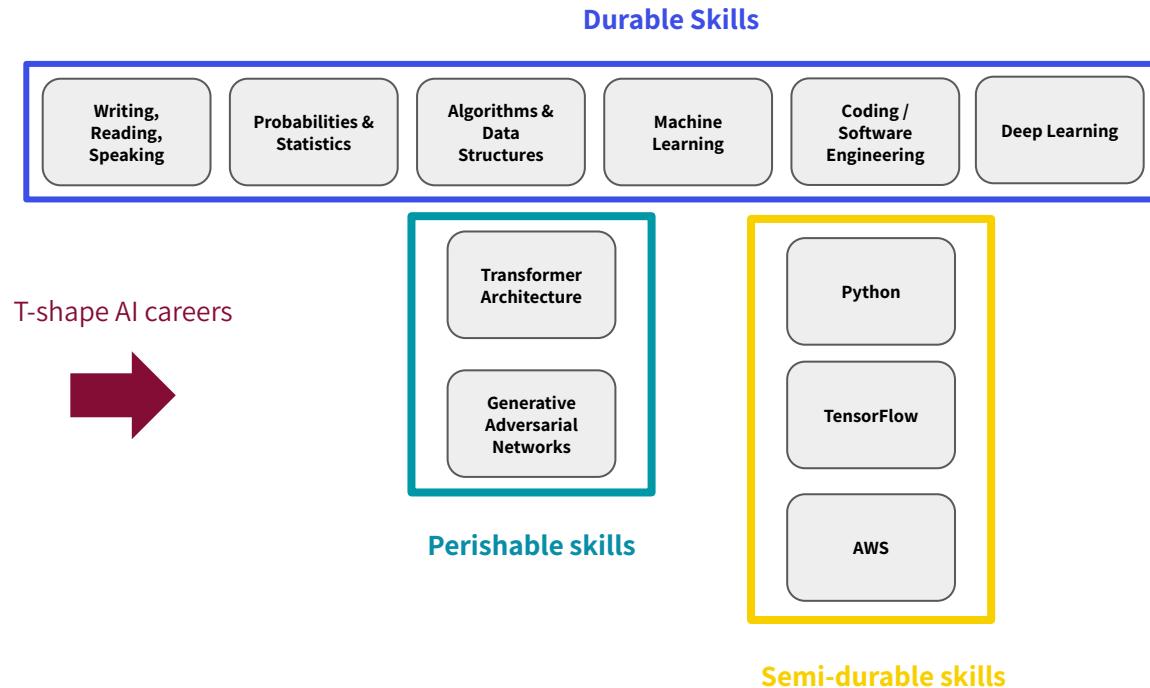
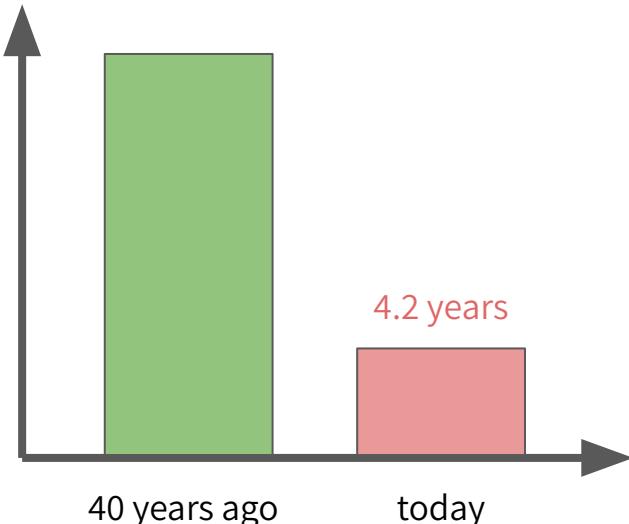
Abstract

We propose a new framework for estimating generative models via an adversarial process, in which we simultaneously train two models, a generative model G that captures the data distribution, and a discriminative model D that estimates the probability that a sample came from the training data rather than G . The training procedure for G is to maximize the probability of D making a mistake. This framework corresponds to a minimax two-player game. In the space of arbitrary functions G and D , a unique solution is found via a gradient descent method where D distribution and D equal to $\frac{1}{2}$ everywhere. In the case where G and D are defined via neural networks, minimizing this distributional divergence is equivalent to fitting the underlying manifold of the training data. This allows us to estimate complex distributions without ever referring to the underlying generating process. There is no need for any Markov chains or unrolled approximations. Experiments demonstrate the potential of the framework through qualitative and quantitative evaluation of the generated samples.

This affects ML as a discipline/job.

Learning is the new norm.

How long is a skill useful?



The half-life of skills is 80% shorter than 40 years ago. (More: [World Economic Forum](#))

Kian Katanforoosh

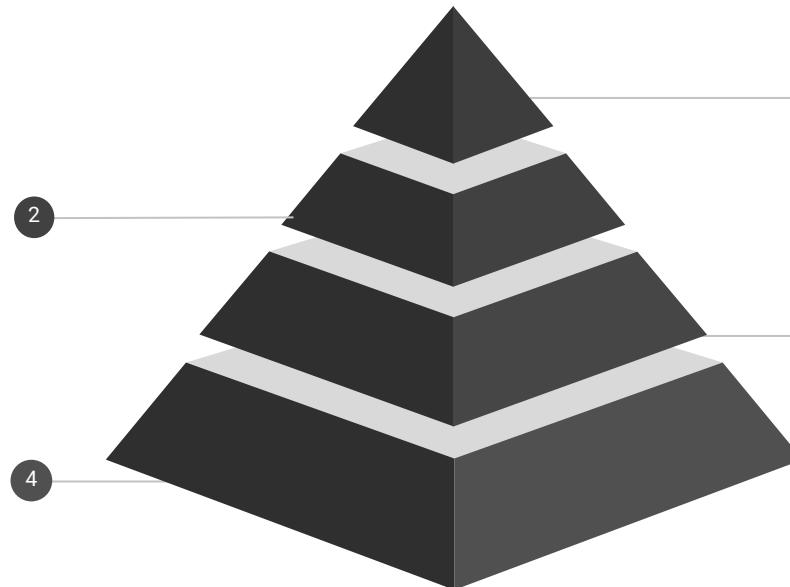
AI is becoming a horizontal skill that applies to large portions of the workforce.

AI & Data+X individuals

Engineers or analysts who are experts in specific domains and want to grow their AI skills (e.g., medical experts)

AI & Data literate

Everyone else in the company



Centers of Excellence

These are highly qualified AI & Data practitioners, including machine learning engineers, data scientists, software engineers, data engineers, data analysts.

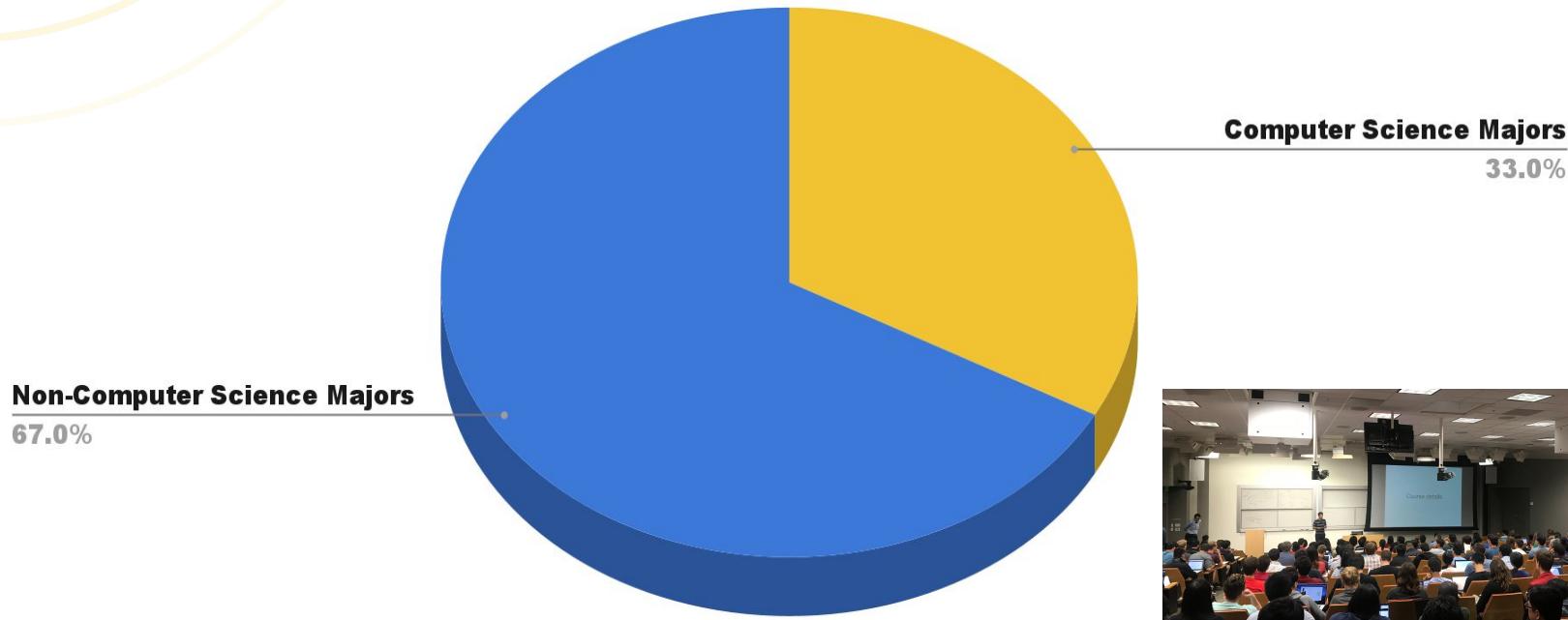
AI & Data fluent

People who have computational and analytical thinking, but aren't in the above category (e.g., product / project managers, recruiters, sellers, marketers, etc.)

Let's zoom on AI+X!

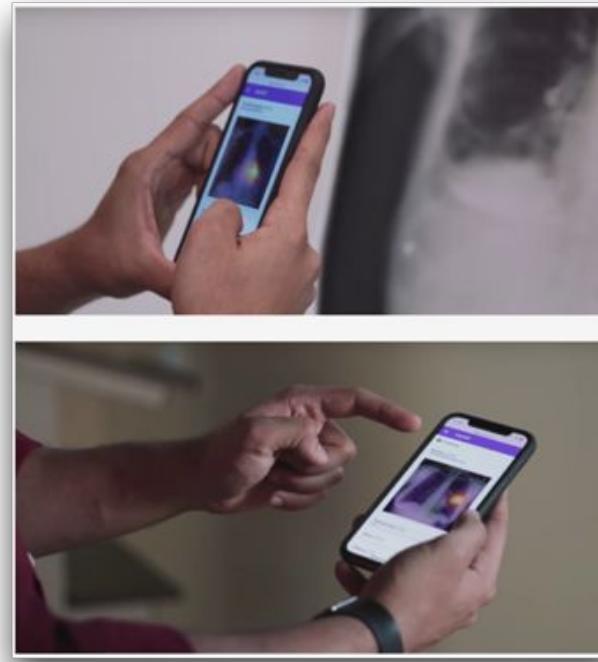
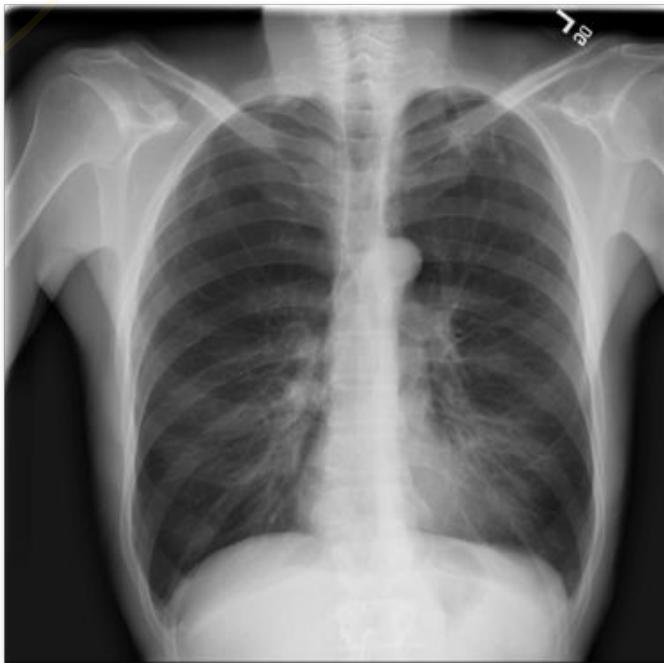
The Rise of AI+X practitioners

Combining subject matter expertise with AI skills



Kian Katanforoosh

Why AI+X practitioners have a critical advantage in projects

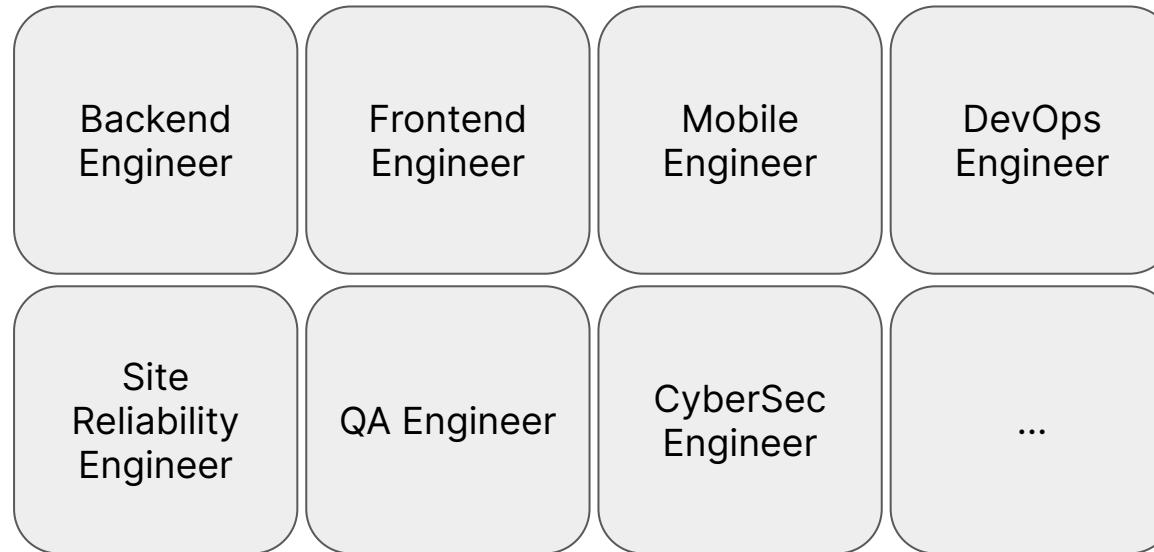


[Rajpurkar, Irvine et al. (2017): CheXNet]

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Let's zoom on roles typically
in the Center of Excellence!

Let's look at Software teams as a proxy for AI teams



Roles in software teams are better understood than roles in AI teams.
AI as a job category is still nascent!

AI is more than modeling.

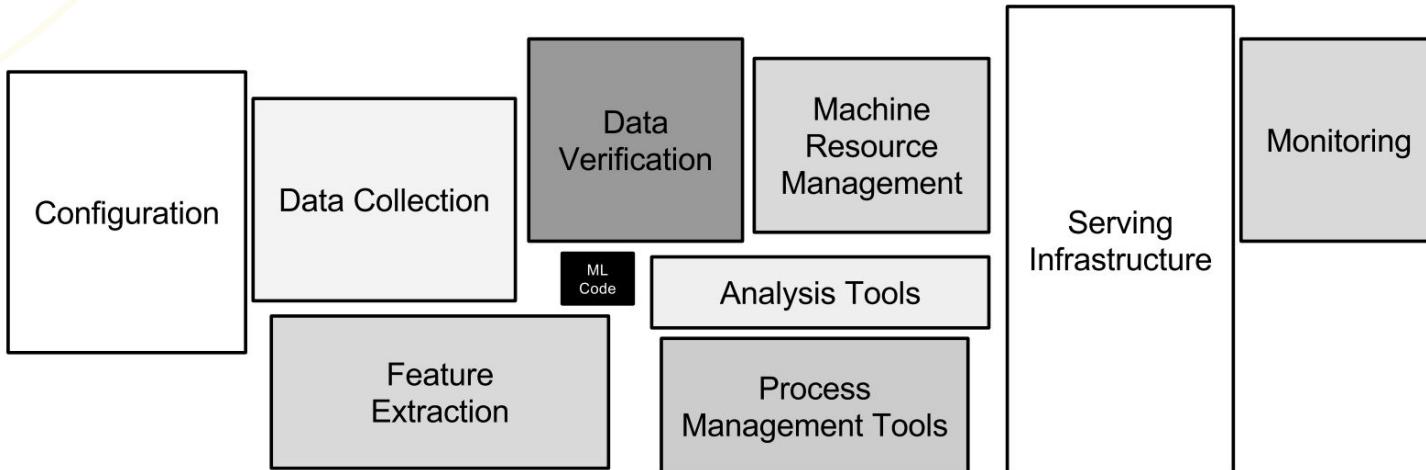
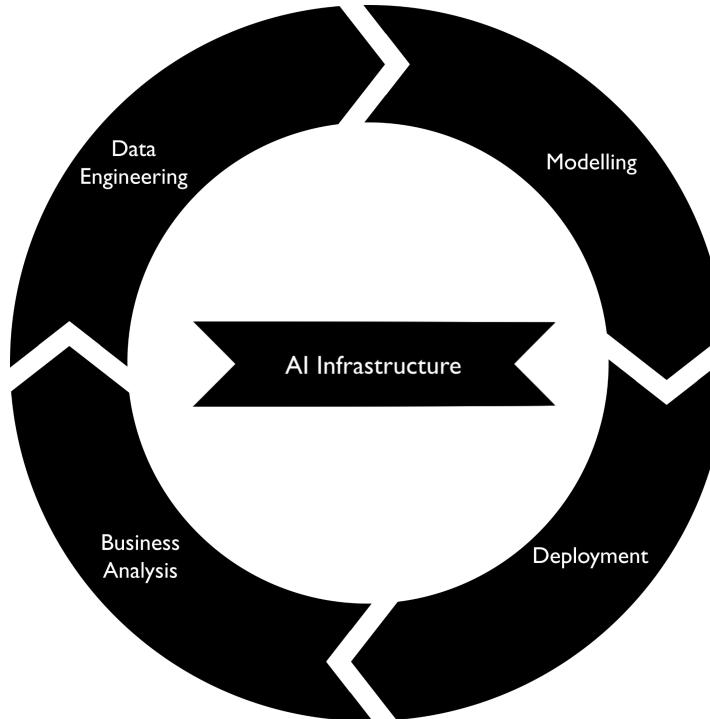
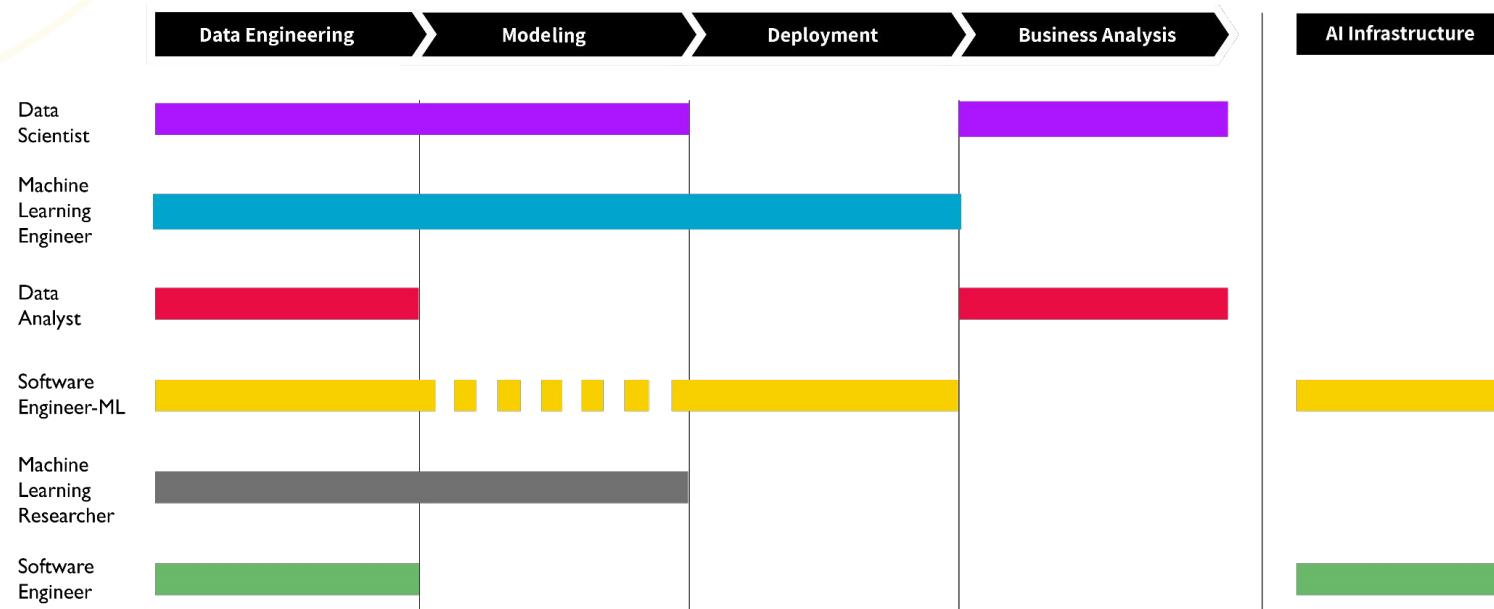


Figure 1: Only a small fraction of real-world ML systems is composed of the ML code, as shown by the small black box in the middle. The required surrounding infrastructure is vast and complex.

AI roles and tasks are becoming clearer as the industry matures.



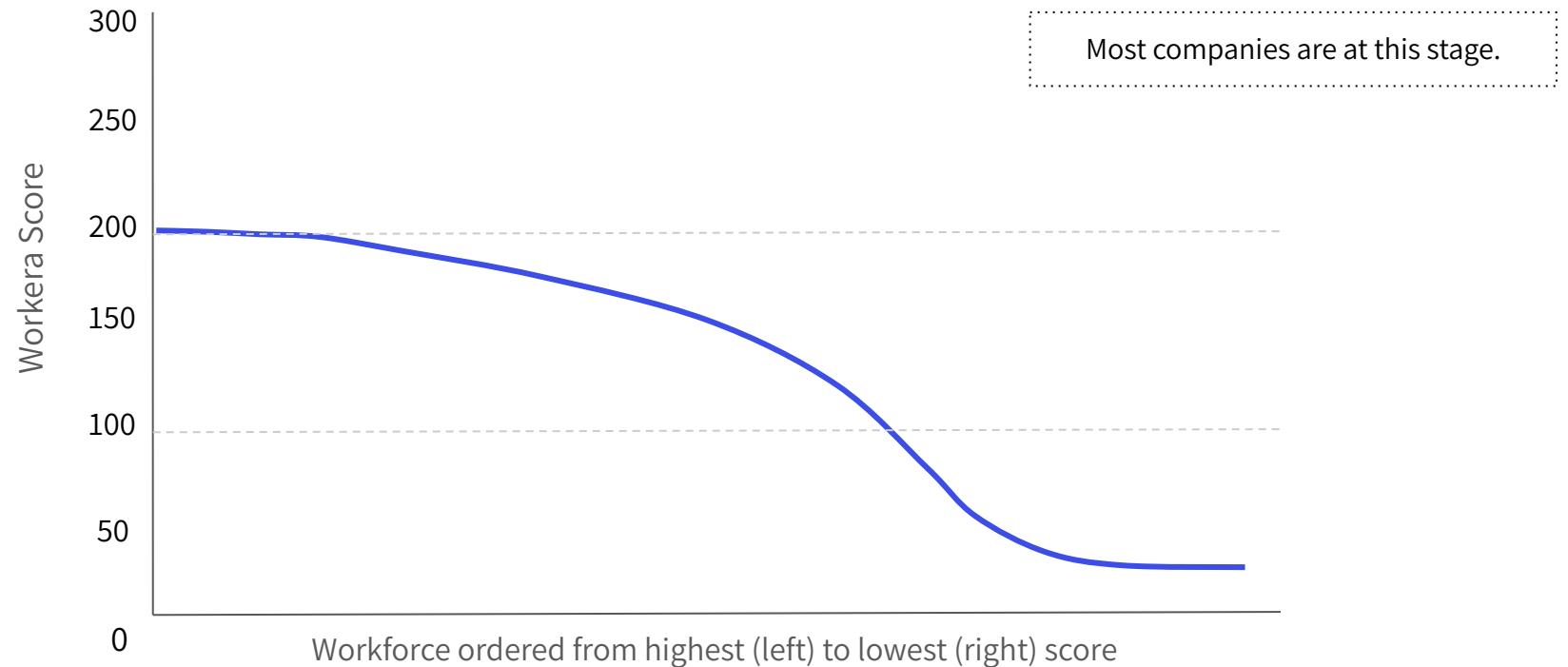
AI roles and tasks are becoming clearer as the industry matures.



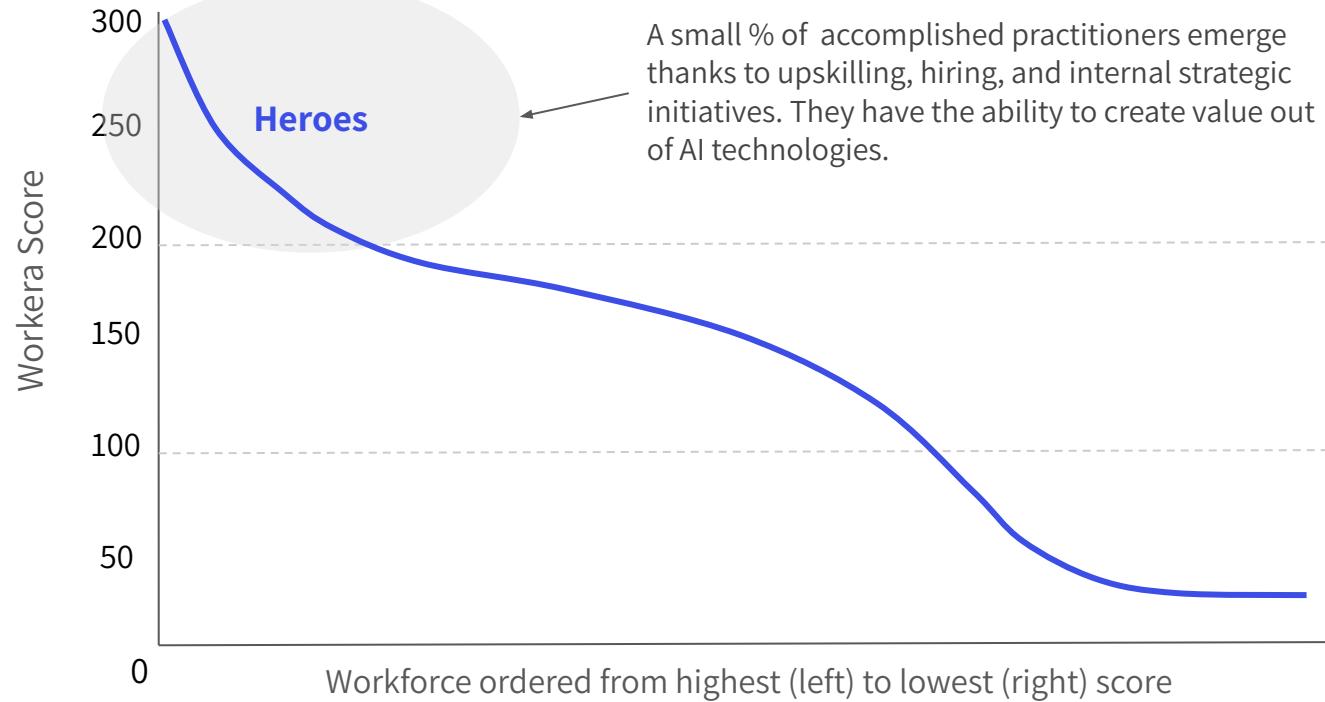
In enterprises, AI & Data transformations are typically company-wide.

How ready is the workforce in terms of AI capabilities?

Maturity 1: Getting started (Laggards Curve)



Maturity 2: Emergence of Heroes



Accomplished
~10%

Developing
~60%

Beginning
~30%

Maturity 2: Emergence of Heroes



Maturity 3: Raising the bar for everyone (Investigators curve)



Accomplished
~10%

Developing
~70%

Beginning
~20%

About CS230



Course Logistics

- **CS230 is composed of 5 “courses”**

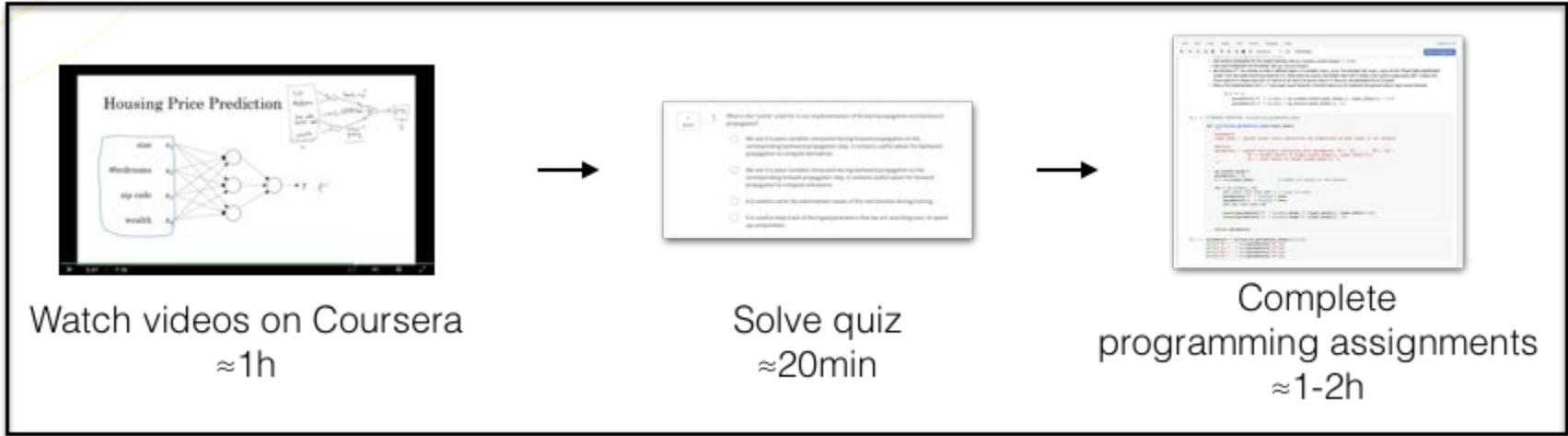
- C1: Neural Networks and Deep Learning
- C2: Improving Deep Neural Networks
- C3: Strategy for Machine Learning Projects
- C4: Convolutional Neural Networks
- C5: Sequence Models

- **Class Terminology & Websites**

- Terminology: “C2M3” = “Course 2 Module 3”
- The schedule is on <http://cs230.stanford.edu/syllabus/>
- We use Coursera: www.coursera.org
- The class forum is on [Ed discussion](#), which is accessible through Canvas under “Ed Discussion” tab.

A week in the life of a CS230 student

= 1 module



$$\text{1 week in CS230} = \text{2 modules} + \text{1 Zoom Lecture (Wednesday)} + \text{1 TA section (Friday)} + \text{15min project mentorship session (every ~2 weeks)}$$

Assignments and quizzes are due every week before lecture

Kian Katanforoosh

Grading Formula

$$Grade = 0.02A + 0.08Q + 0.25Pa + 0.25M + 0.40Pr$$

A = Attendance

Q = Quizzes

Pa = (Programming) assignments

M = Midterm

Pr = Final-project

Active Ed participation = 1% bonus

Late Days

Example: For next Wednesday at 9.45am PDT you have to complete the following assignments:

- **2 Quizzes:**

- Introduction to deep learning
- Neural Network Basics

- **2 Programming assignments:**

- Python Basics with Numpy
- Logistic Regression with a neural network mindset

At 7am on Wednesday: you submit 1 quiz and the 1 PA.

At 3pm on Wednesday: you submit the second quiz.

At 2pm on Thursday: you submit the second PA.

3 late days

How many late days did you use?

(Soft) Prerequisites

Students are expected to have the following background, and are invited to take the Workera technical assessments prior to the class to self-assess themselves prior to taking the class:

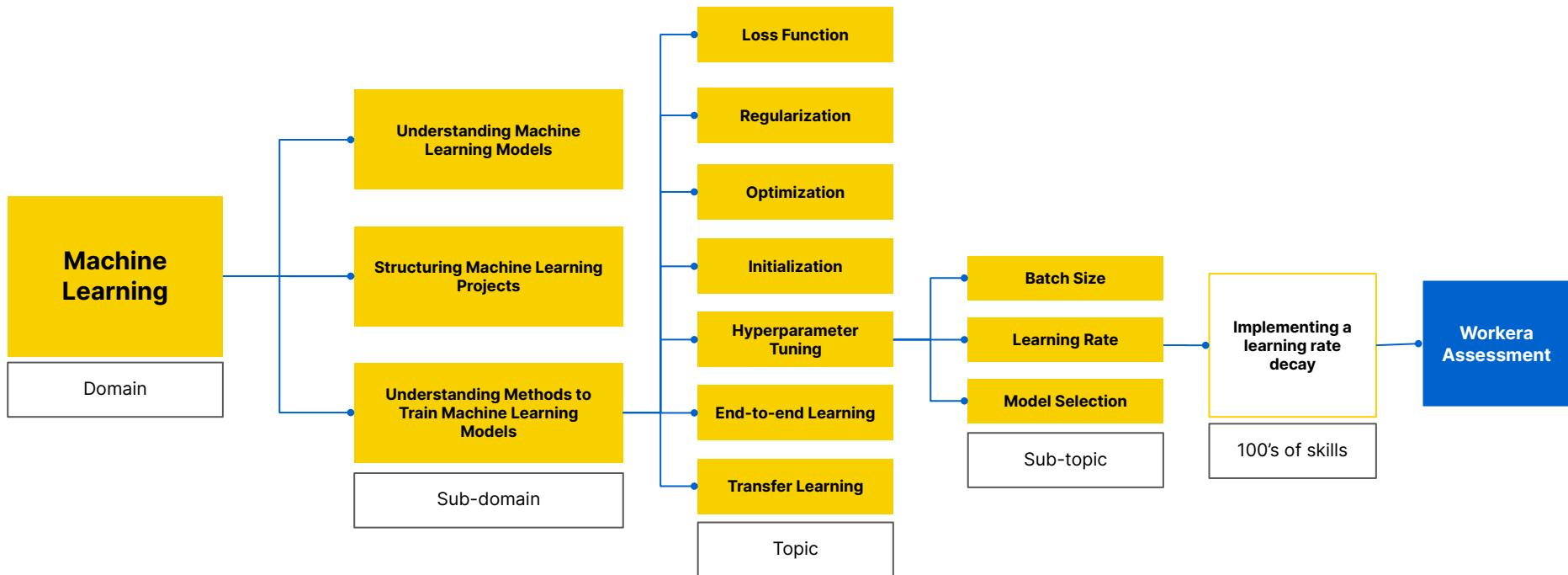
- Knowledge of **basic computer science principles and skills**, at a level sufficient to write a reasonably non-trivial computer program. This corresponds to a Developing level (or badge) in the “Algorithmic Coding” section on Workera.
- Familiarity with the **probability theory** (CS 109 or STATS 116), which students can assess by taking the “Data Science” section on Workera.
- Familiarity with **linear algebra** (MATH 51), which students can assess by taking the “Mathematics” section on Workera.

(Recommended) Take the Workera assessment (<https://workera.ai/for-individuals/>) prior to starting the class, you’ll take it again at the end of the class to measure your progress!

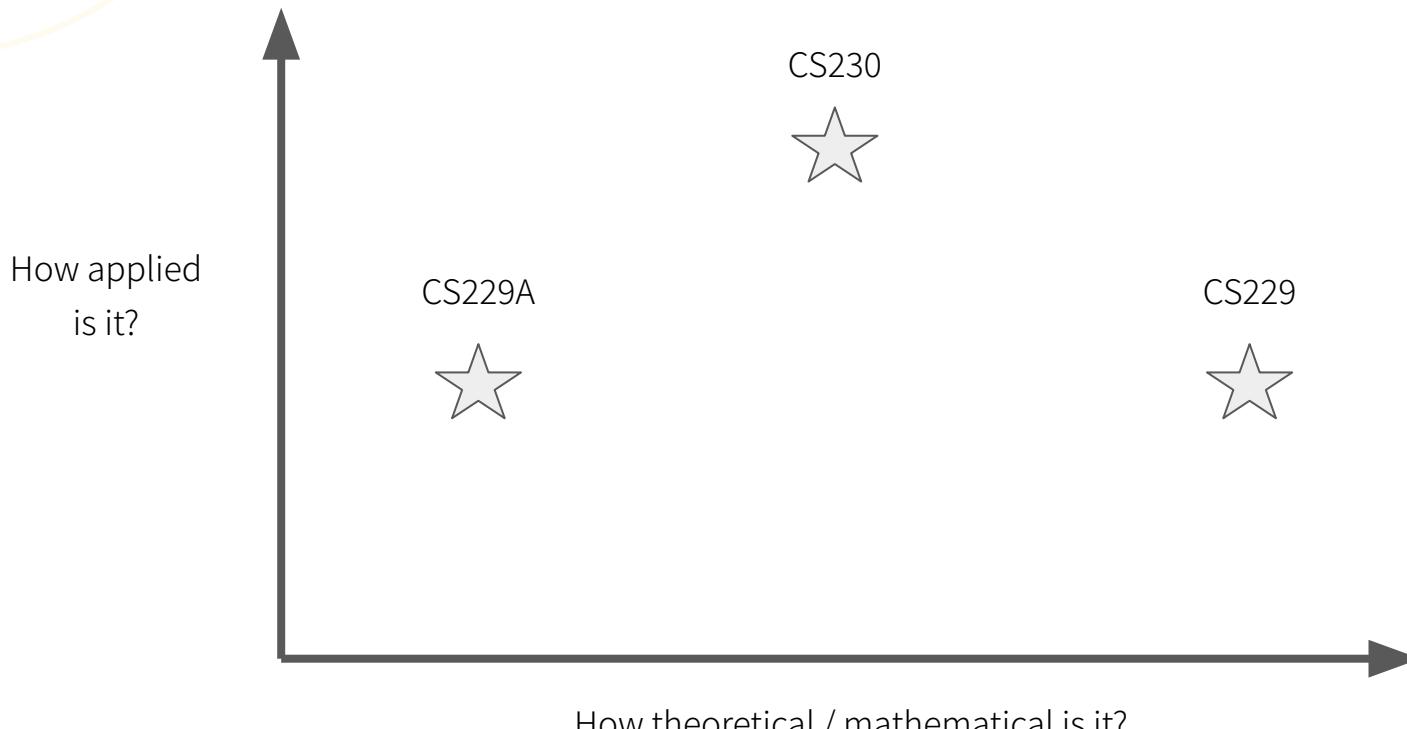
Take Workera assessments (DLE) at the end of the class. We recommend (at least) the domains:

- **Deep Learning** on Workera, try to reach the Accomplished level at the end of the class
- **Tensorflow (or Pytorch)** on Workera, try to reach Developing level at the end of the class
- **AWS** on Workera, try to reach Developing level at the end of the class

Workera competency models



CS230 vs. CS229 vs. CS229A

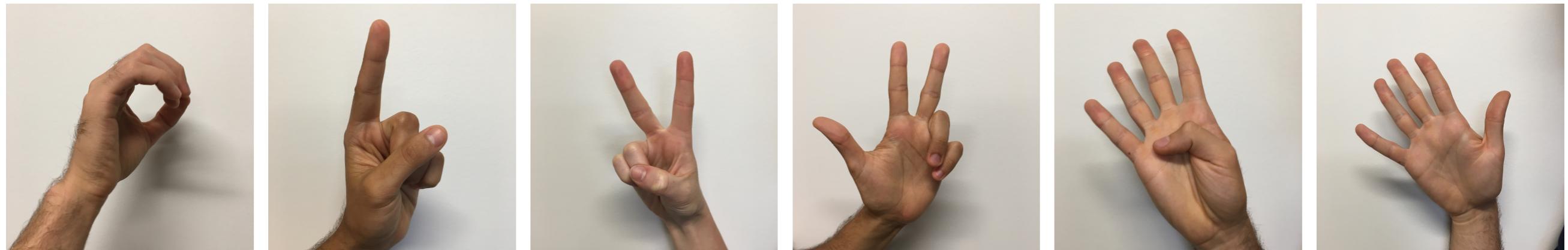


CS230 Projects Overview

A sneak peak at what you'll work on!

- I. Overview of CS230 programming assignments
- II. Examples of student projects

Projects: SIGN language image classification



$$y = 0$$



$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$y = 1$$



$$\begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$y = 2$$



$$\begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$y = 3$$



$$\begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$y = 4$$



$$\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}$$

$$y = 5$$

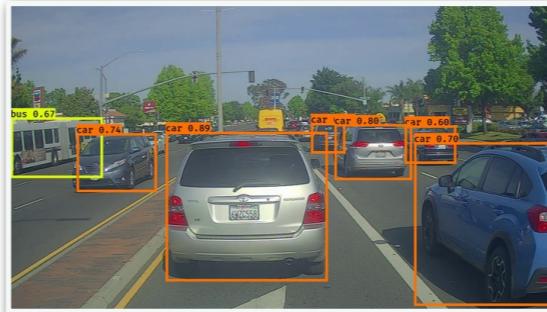


$$\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

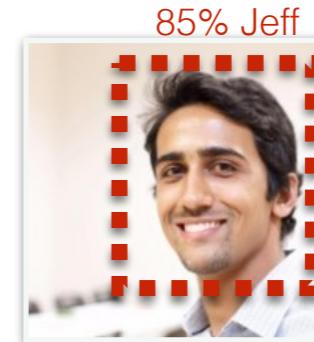
Projects: others



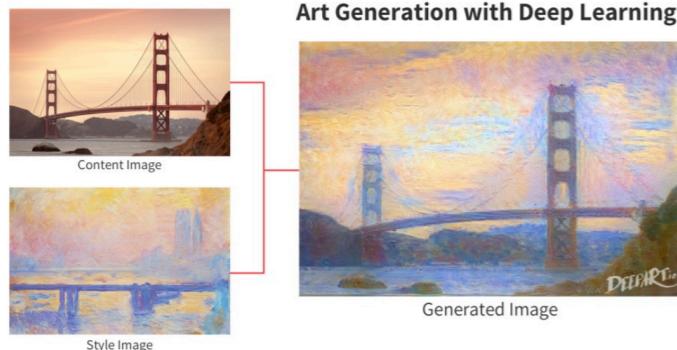
Optimal goalkeeper shoot prediction



Car detection



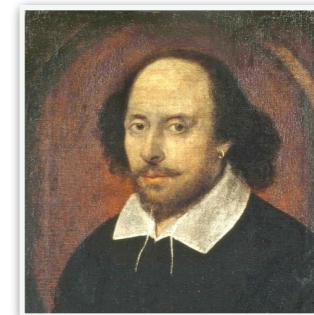
Face recognition



Art generation



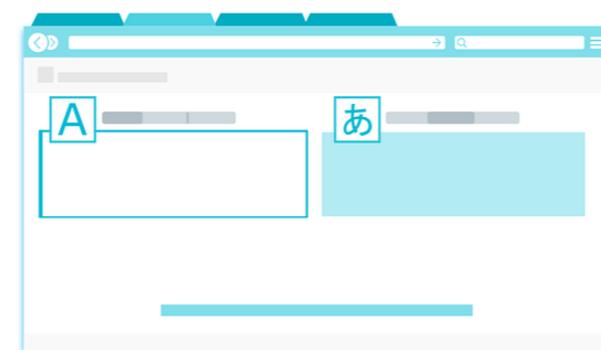
Music generation



Text generation

“I love you”
↓

Emojifier



Machine translation



Trigger word detection

And many more...

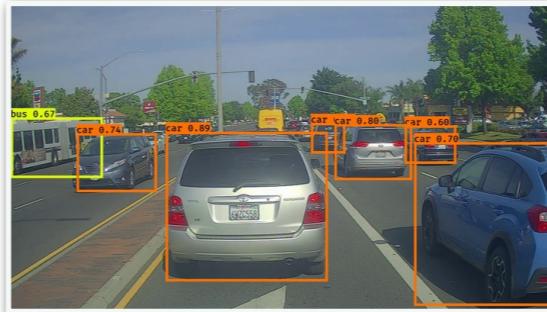
Assignment: Car detection for autonomous driving



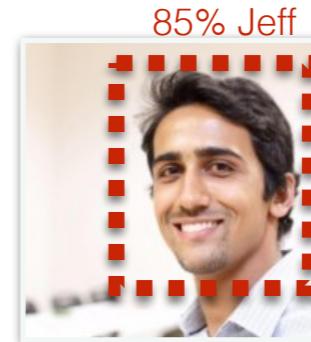
Projects: others



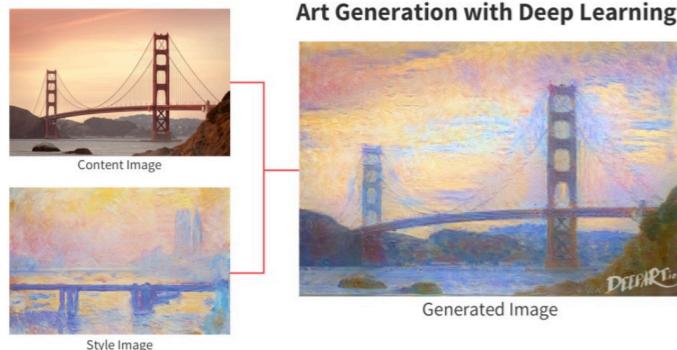
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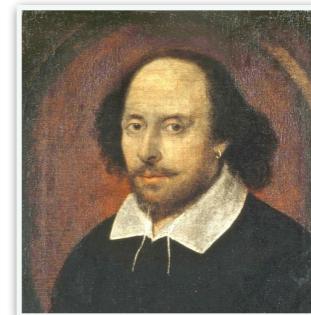
Face recognition



Art generation



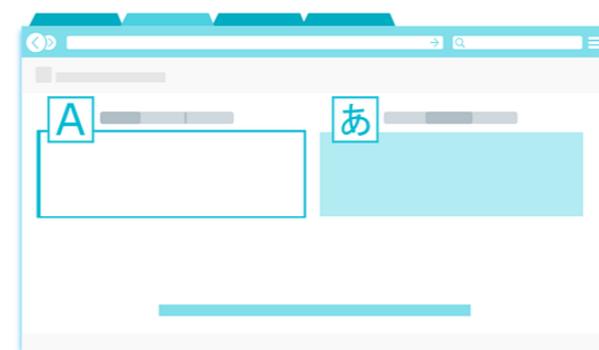
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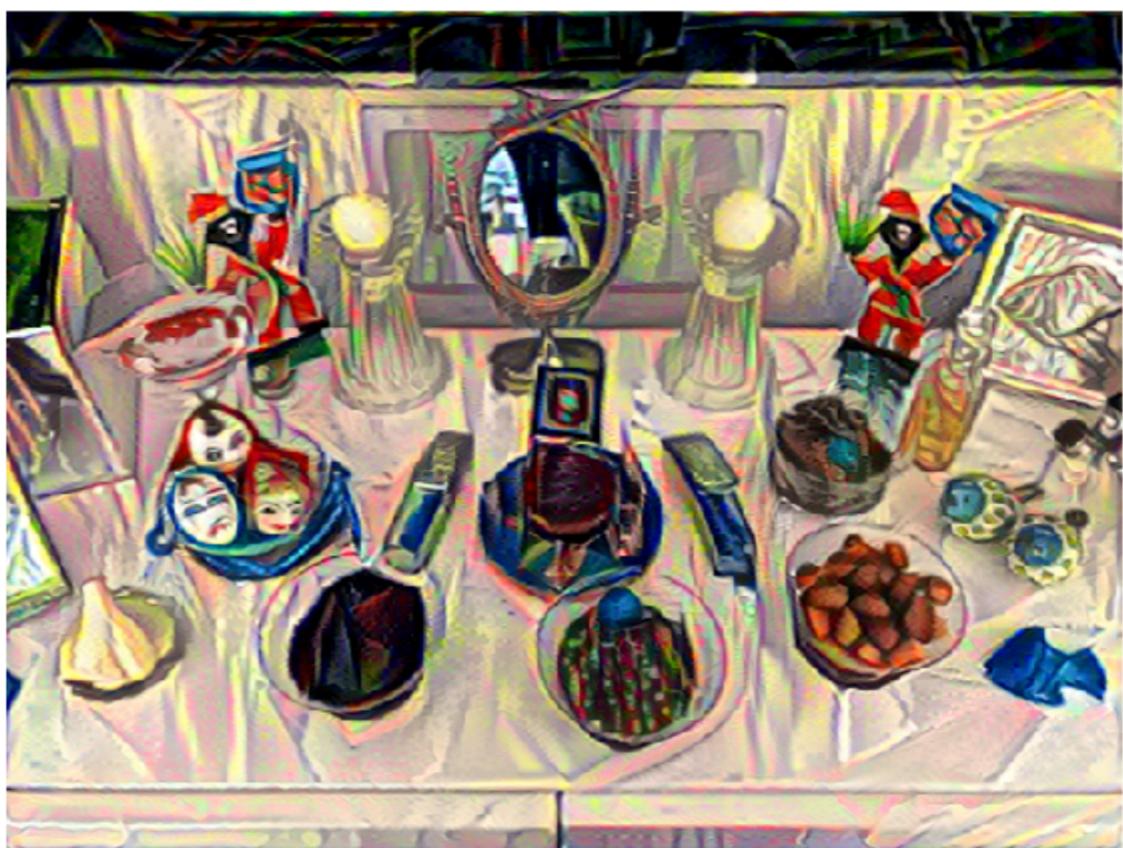
In the style of Claude Monet



In the style of Yayoi Kusama



In the style of Piet Mondrian



In the style of Pablo Picasso



In the style of Hilma af Klint



In the style of Jamini Roy



In the style of Eiichiro Oda

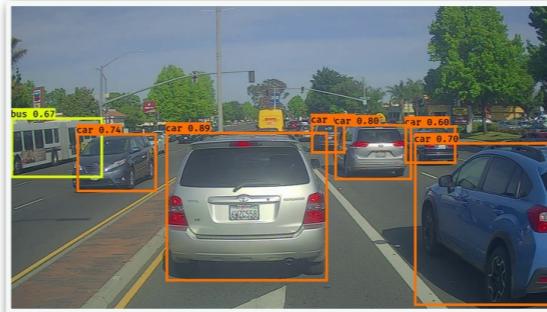


In the style of Salvador Dali

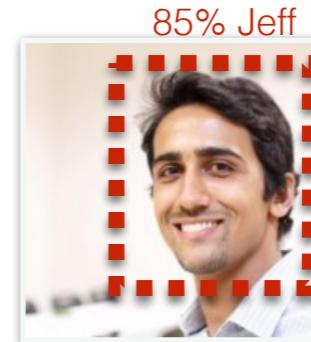
Projects: others



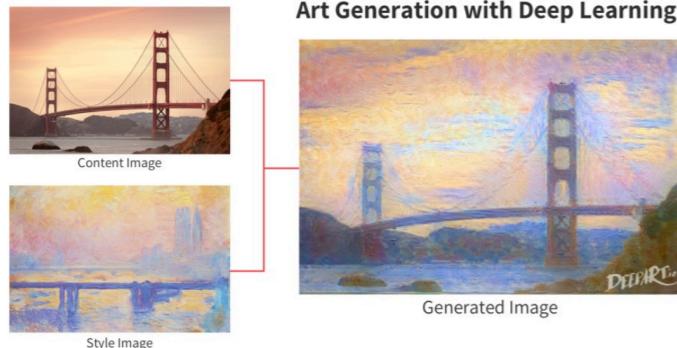
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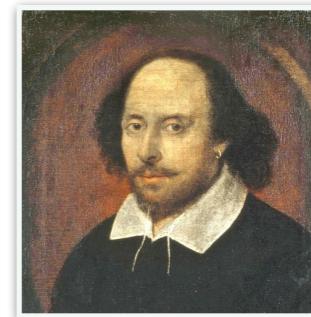
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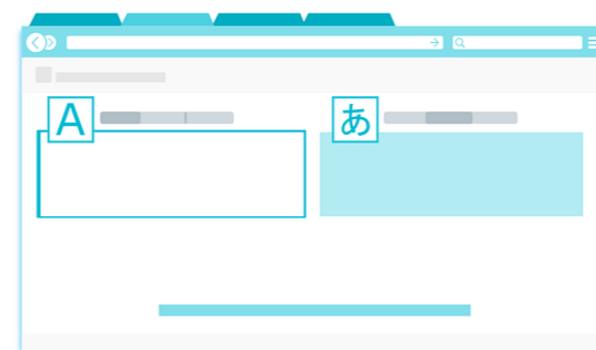
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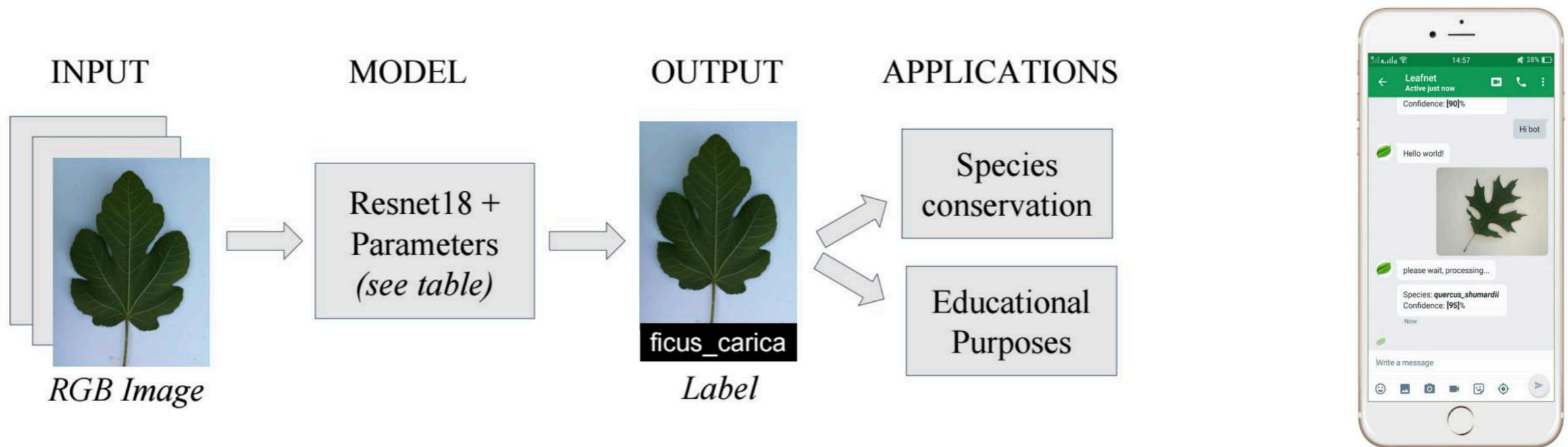
And many more...

I. Overview of CS230 programming assignments

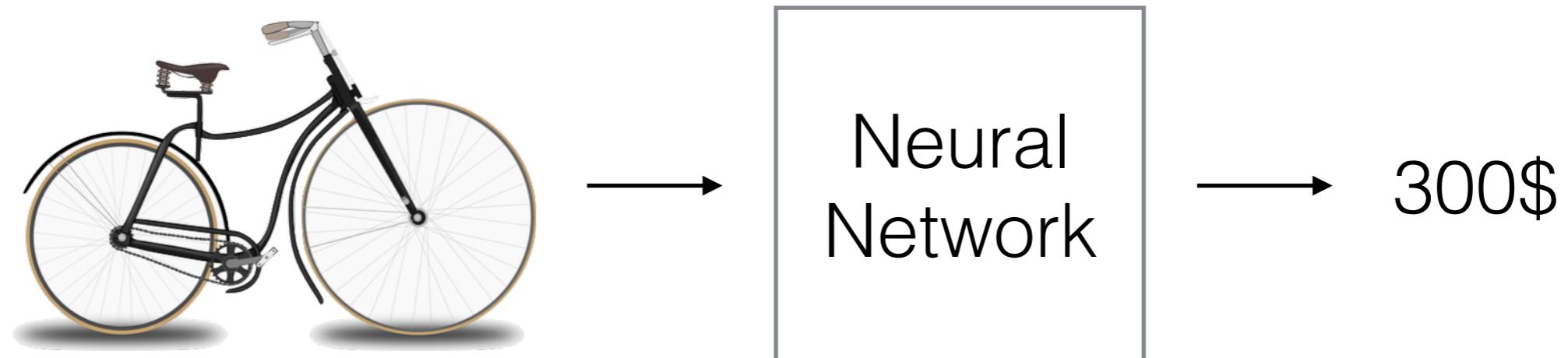
II. Examples of student projects

Projects: others

LeafNet: A Deep Learning Solution to Tree Species Identification



Predicting price of an object from a picture



Projects: others

Detect cards from real-time video of tournaments to improve viewer understanding and accessibility

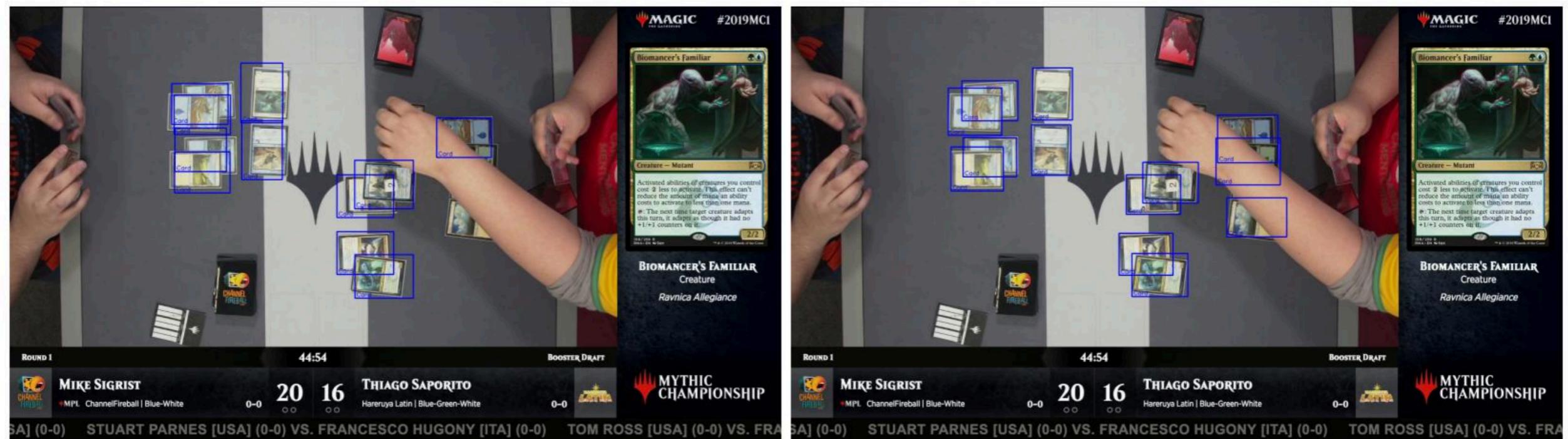
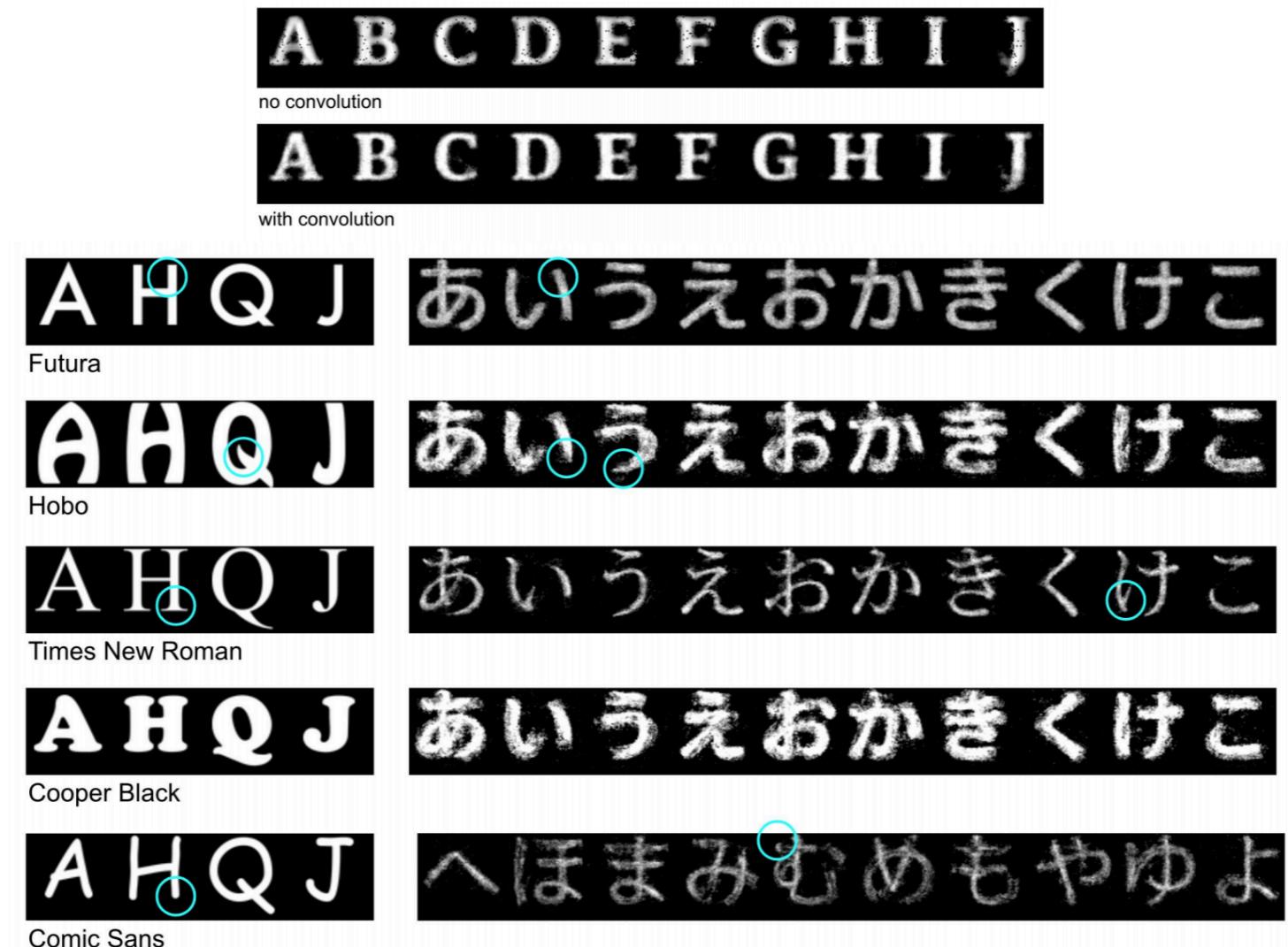


Figure 2: Predicted objects on a single frame from Dataset 1 produced by my model (left) and the YOLOv3 baseline (right).

Projects: others

font-gen: Deep Models for Inferring Alternate Language Sets from Fonts



Figures 5-6: Convolution; predicting Japanese sets.

Projects: others

NBA 2k19 DeepBaller: A NN-Controlled Real-Time video game AI

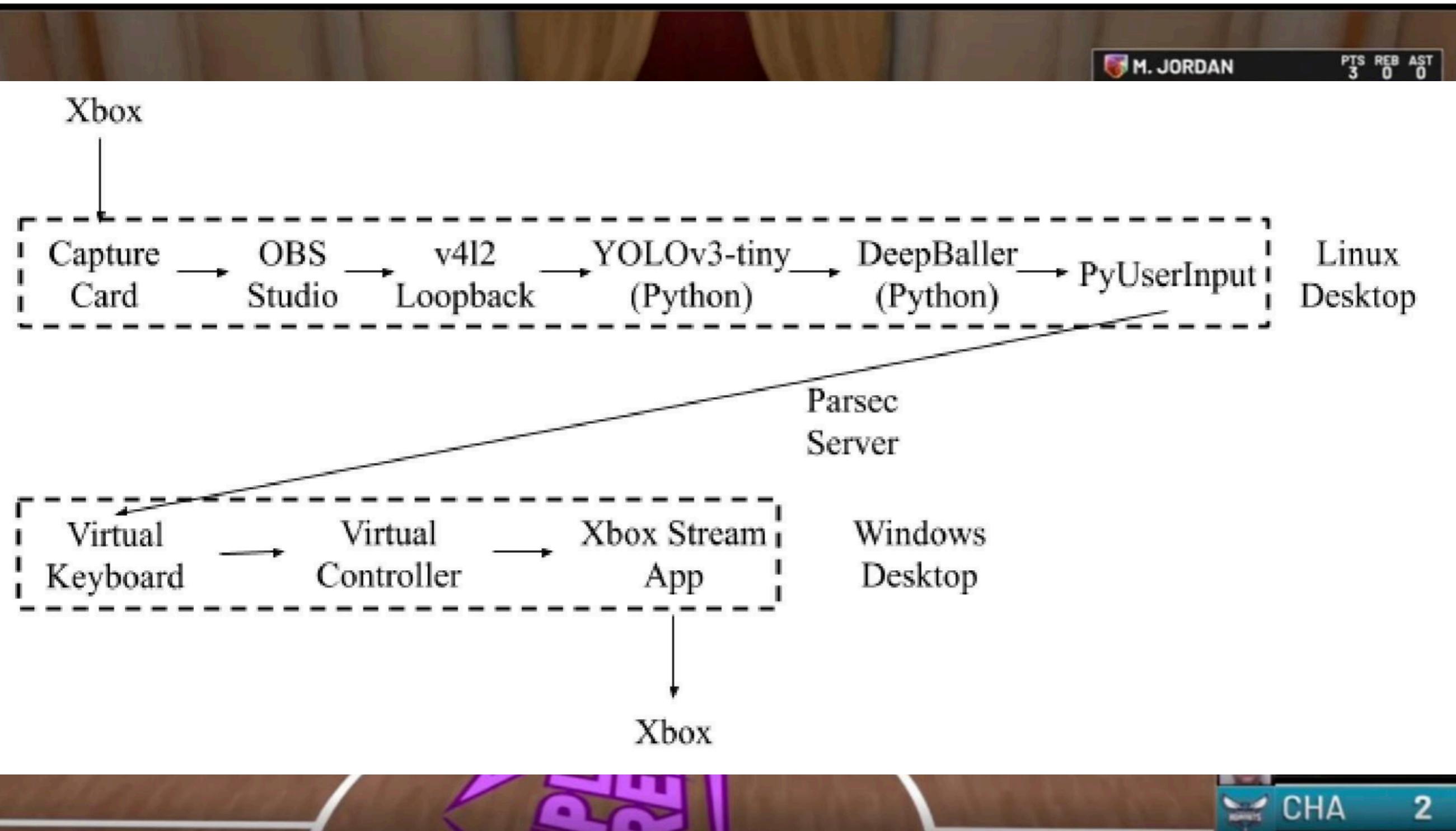


Image-to-Image translation with Conditional-GAN

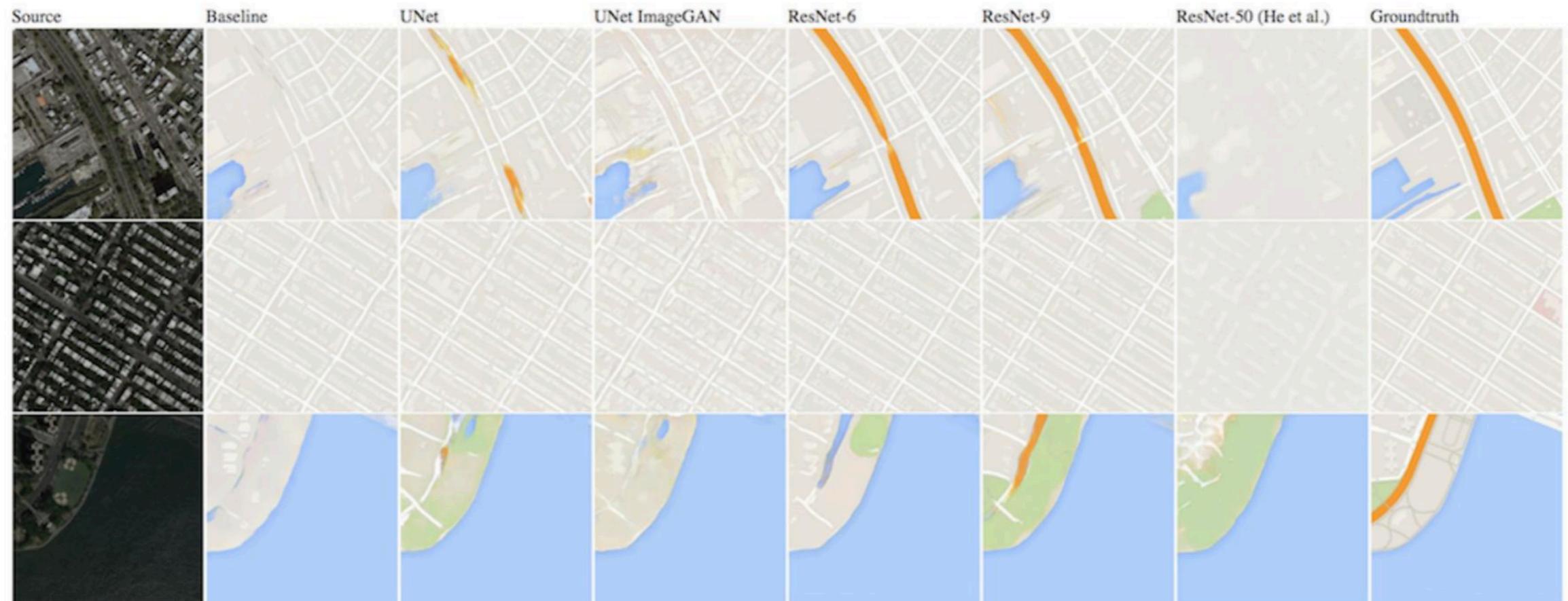


Figure 3: Generated map images of different architecture and hyperparameters. From left to right are source aerial images, baseline, U-Net, U-Net with ImageGAN, ResNet-6, ResNet-9, ResNet-50, and ground truth map images

Projects: others

Discrete reasoning in natural language processing

Reasoning	Passage (some parts shortened)	Question	Answer	BiDAF
Subtraction (28.8%)	That year, his Untitled (1981) , a painting of a haloed, black-headed man with a bright red skeletal body, depicted amid the artists signature scrawls, was sold by Robert Lehrman for \$16.3 million, well above its \$12 million high estimate.	How many more dollars was the Untitled (1981) painting sold for than the 12 million dollar estimation?	4300000	\$16.3 million
Comparison (18.2%)	In 1517, the seventeen-year-old King sailed to Castile . There, his Flemish court In May 1518, Charles traveled to Barcelona in Aragon.	Where did Charles travel to first, Castile or Barcelona?	Castile	Aragon
Selection (19.4%)	In 1970, to commemorate the 100th anniversary of the founding of Baldwin City, Baker University professor and playwright Don Mueller and Phyllis E. Braun, Business Manager, produced a musical play entitled The Ballad Of Black Jack to tell the story of the events that led up to the battle.	Who was the University professor that helped produce The Ballad Of Black Jack, Ivan Boyd or Don Mueller?	Don Mueller	Baker
Addition (11.7%)	Before the UNPROFOR fully deployed, the HV clashed with an armed force of the RSK in the village of Nos Kalik, located in a pink zone near Šibenik, and captured the village at 4:45 p.m. on 2 March 1992 . The JNA formed a battlegroup to counterattack the next day .	What date did the JNA form a battlegroup to counterattack after the village of Nos Kalik was captured?	3 March 1992	2 March 1992
Count (16.5%) and Sort (11.7%)	Denver would retake the lead with kicker Matt Prater nailing a 43-yard field goal , yet Carolina answered as kicker John Kasay ties the game with a 39-yard field goal Carolina closed out the half with Kasay nailing a 44-yard field goal In the fourth quarter, Carolina sealed the win with Kasay's 42-yard field goal .	Which kicker kicked the most field goals?	John Kasay	Matt Prater

AI+X: Leveraging your subject-matter expertise

- Roy, Quill, and Tuchman **from Material Science & Engineering** predicted the melting point and viscosity of ionic liquids based on the component anion and cation chemical structures ([report poster](#)).
- Buechler **from Mechanical Engineering** developed a deep learning framework to approximate the outputs from a power flow simulation, and evaluate performance for a variety of power network characteristics ([report poster](#)).
- Sokol and Aguirre **from the Biomedical Informatics Training Program** leveraged deep learning to estimate the ancestral composition of a genomic sequence at high resolution ([report poster](#)).
- Peng, Zhao, Yu **from Computer Science, Civil Engineering, and Biomedical Engineering** used deep learning to classify gestures from divers communicating with an autonomous robot companion in dangerous underwater environments ([report poster](#)).
- O'Day, Seagers, and Lee **from Bioengineering and Mechanical Engineering** studied neural signals of patients with Parkinson's disease while walking to predict freezing behaviors ([report poster](#)).

And many more...

Predicting atom energy based on atomic-structure

Visual Question Answering

Cancer/Parkinson/Alzheimer detection

Activity recognition in video

Music genre classification / Music Compression

Accent transfer in a speech

Generating images based on a given legend

Detecting earthquake precursor signals

...

Check out past projects: <http://cs230.stanford.edu/past-projects/>

To sum up

1. You will learn about wide range of deep learning topics
2. The course is very applied, you will code these applications
3. You have access to mentorship to build an outstanding project in 10 weeks

For next week:

- Create Coursera account and join the private session using the invitation
- Finish **C1M1 & C1M2**
- 2 Quizzes:
 - ★ Introduction to deep learning
 - ★ Neural Network Basics
- 2 Programming assignments:
 - ★ Python Basics with Numpy
 - ★ Logistic Regression with a neural network mindset
- Find project team-mates and fill-in the Google form that will be posted on Ed soon.
- The GPU credit registration form will be posted with instructions on Ed soon. Upon forming a team, students should sign up for GPU credits.
- The teaching staff will create an open thread on Ed so that students can use it to find project teammates as we are all remote and this can prove cumbersome as compared to normal times.

This Friday: TA section “Getting Started with Your Project”

Download your iPython notebooks after you finished them!

You can find all deadlines on the website Syllabus

Kian Katanforoosh