CSCI 5922, Spring 2020

Lecture 1

- Course outline
- Introduction
- Life of a DL practitioner
- Course logistics

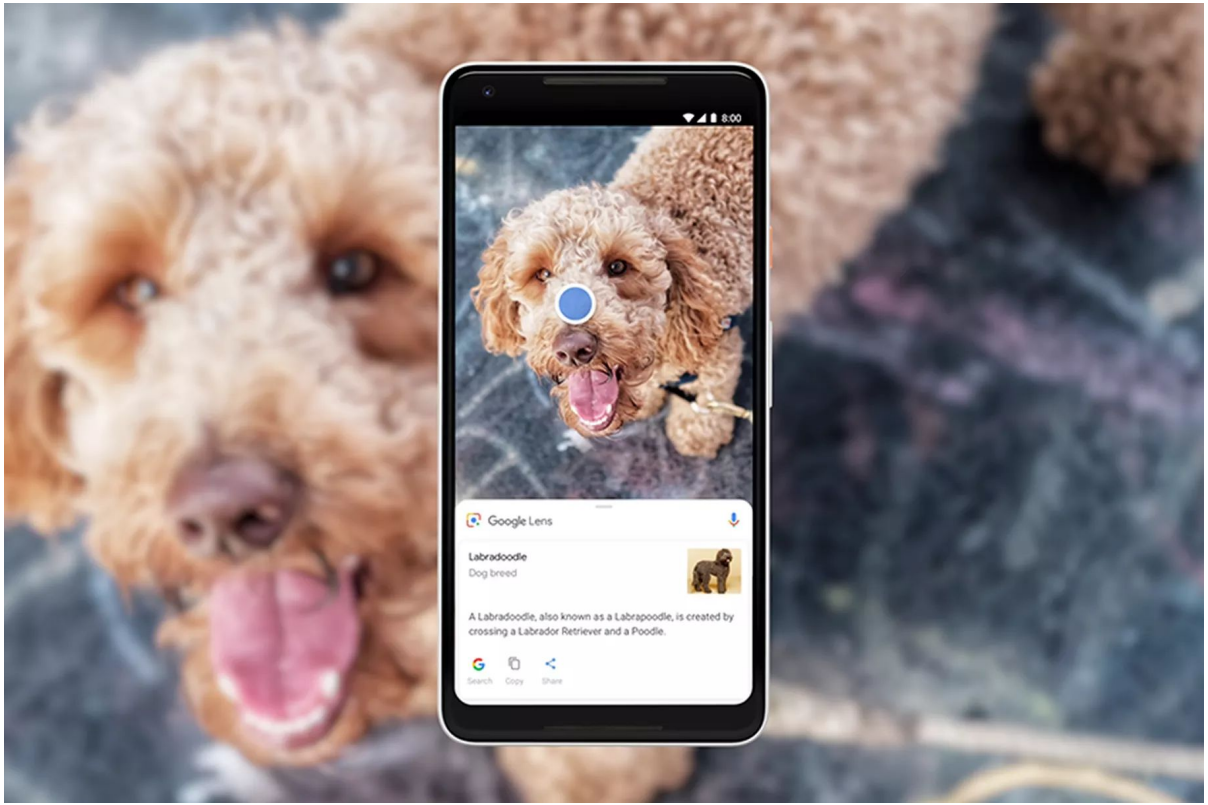
Course topics

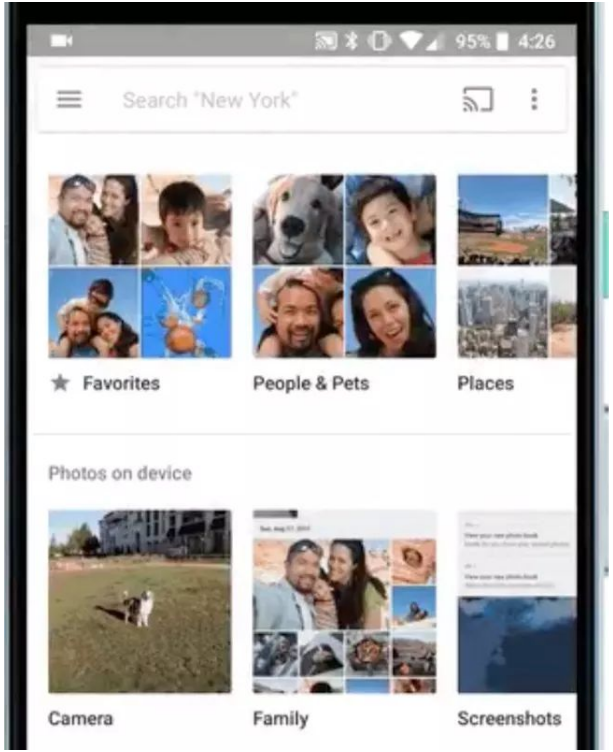
Fundamentals of deep learning

- Linear / logistic regression
- Multi-layer perceptrons
- Differentiable programming: auto-differentiation and back-prop
- Activation functions
- Training and optimization
  - Stochastic gradient descent and its variants
  - Regularization
  - {batch, layer, group}-norm

DL in computer vision

- Understand architectures
  - Image classification
  - Object detection
  - Embedding / few-shot learning

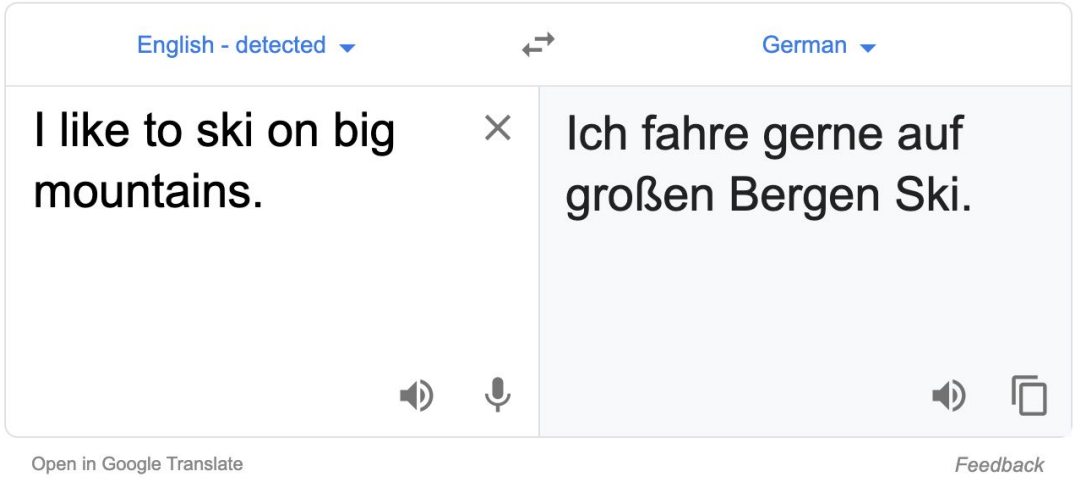

8:00
Google Lens
Labradoodle
Dog breed
A Labradoodle, also known as a Labrapoodle, is created by crossing a Labrador Retriever and a Poodle.
Search
Copy
Share

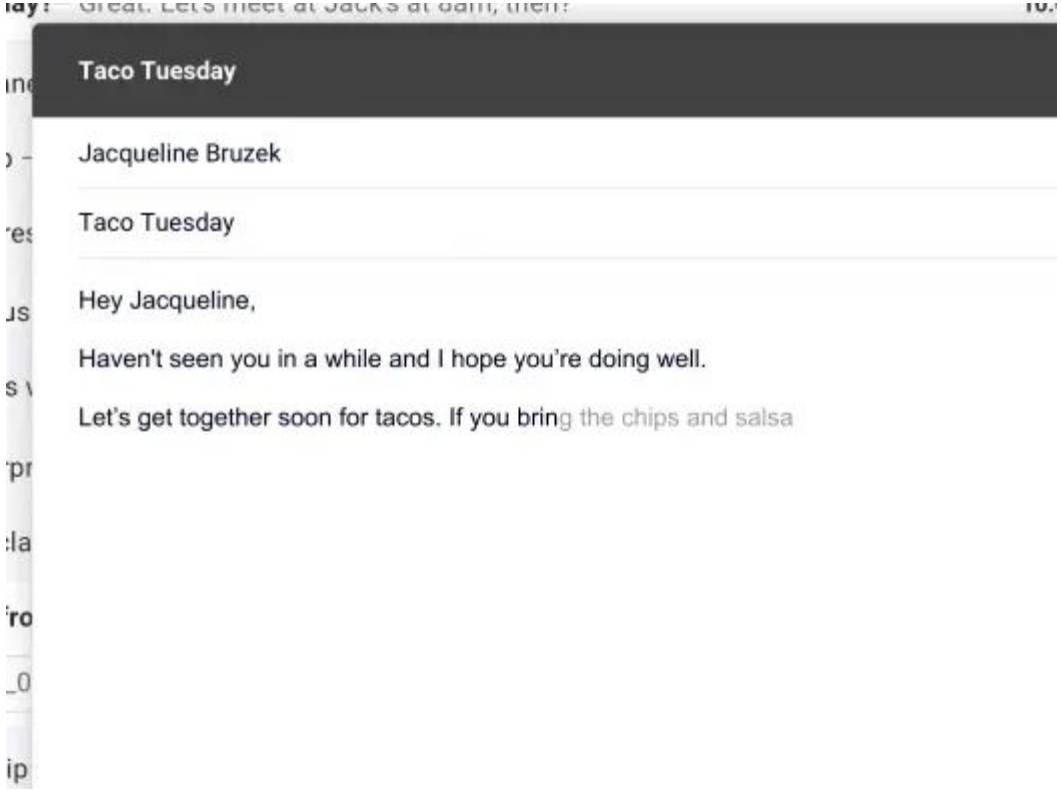

95% 4:26
Search "New York"
Favorites
People & Pets
Places
Photos on device
Camera
Family
Screenshots


Kumail Nanjiani
@kumailn
Following
Hey this one ain't so bad.
59%
match
Portrait
Mohammed Al Mazrouie
Barjeel Art Foundation
Google Arts & Culture
3:59 PM - 13 Jan 2018

DL in NLP

- Word embeddings
- Sequence modeling (mostly RNNs)
- Attention mechanisms
- Transformers, BERT


English - detected
German
I like to ski on big mountains.
Ich fahre gerne auf großen Bergen Ski.
Open in Google Translate
Feedback

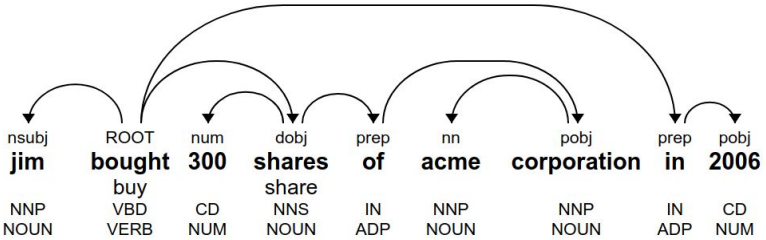

Taco Tuesday
Jacqueline Bruzek
Taco Tuesday
Hey Jacqueline,
Haven't seen you in a while and I hope you're doing well.
Let's get together soon for tacos. If you bring the chips and salsa

Other NLP tasks

- Named-entity recognition

  [Jim]$_{\text{Person}}$ bought 300 shares of [Acme Corporation]$_{\text{Organization}}$ in [2006]$_{\text{Time}}$.

- Part-of-speech tagging/syntactic parsing



- Question Answering (Information Retrieval)

  Q: What is the tallest landmark in Paris?

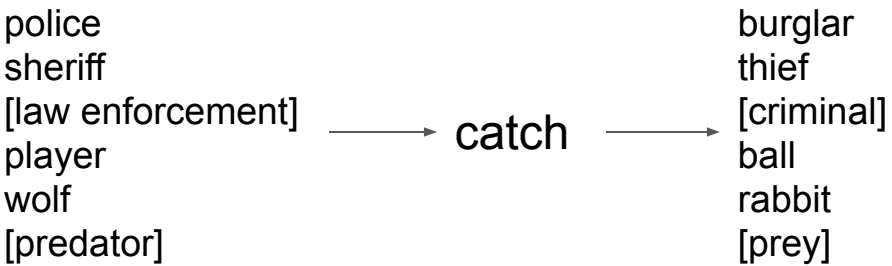
  A: Eiffel Tower at 300 meters high.

Selectional Preference

- Coreference resolution

[The thieves] are worried that once [the police] increase patrol of the street, [they] will ***caught*** more easily.

[The thieves] are worried that once [the police] increase patrol of the street, [they] will ***catch*** more criminals.



Selectional Preference

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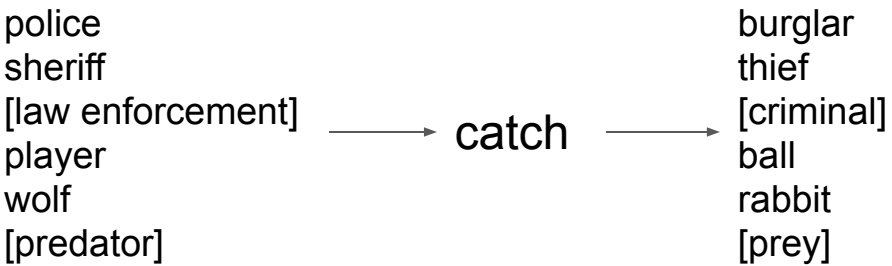


Word Meaning in Context

- Word sense disambiguation

  I went to deposit a check at the bank [financial institute].

  He went fishing by the bank [land alongside a river].

Unsupervised learning

- Autoencoders
- Variational autoencoders
- GANs

Karras, T., Aila, T., Laine, S., & Lehtinen, J. (2017). Progressive growing of gans for improved quality, stability, and variation. arXiv preprint arXiv:1710.10196.

Gatys, L. A., Ecker, A. S., & Bethge, M. (2016). Image style transfer using convolutional neural networks. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 2414-2423).

Computing

- Tensorflow 2.0
- Python

Other topics?

- Model interpretability
- Speech recognition
- Reinforcement learning
- Non-euclidean DL (graph NNs)

Logistics

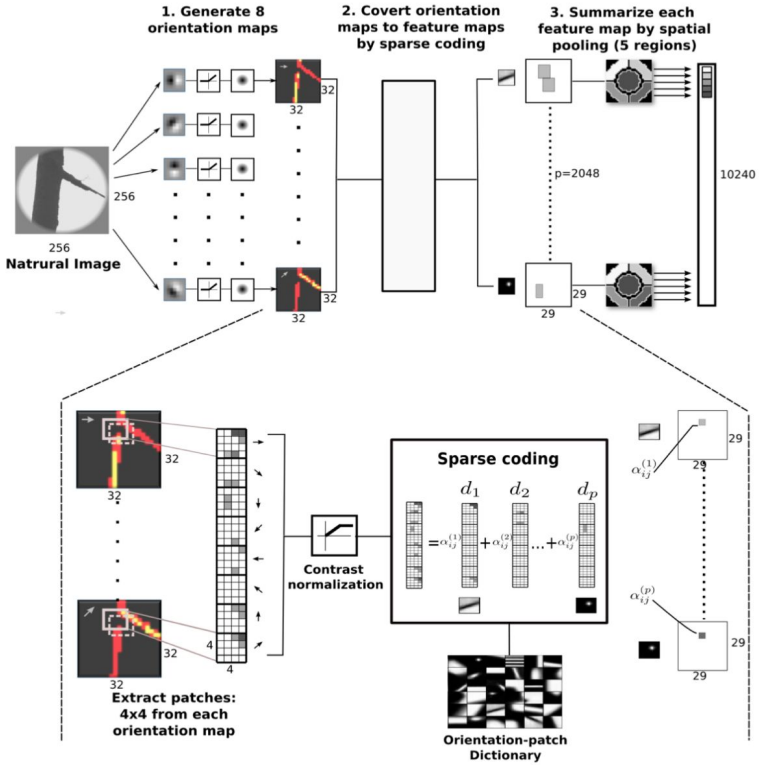
- Grading (tentative)
  - 40% Assignments
  - 20% Midterm
  - 5% Project proposals
  - 30% Final project
  - 5% Participation
- Office hours
  - TBD

Instructors

Neuroscience and computer vision

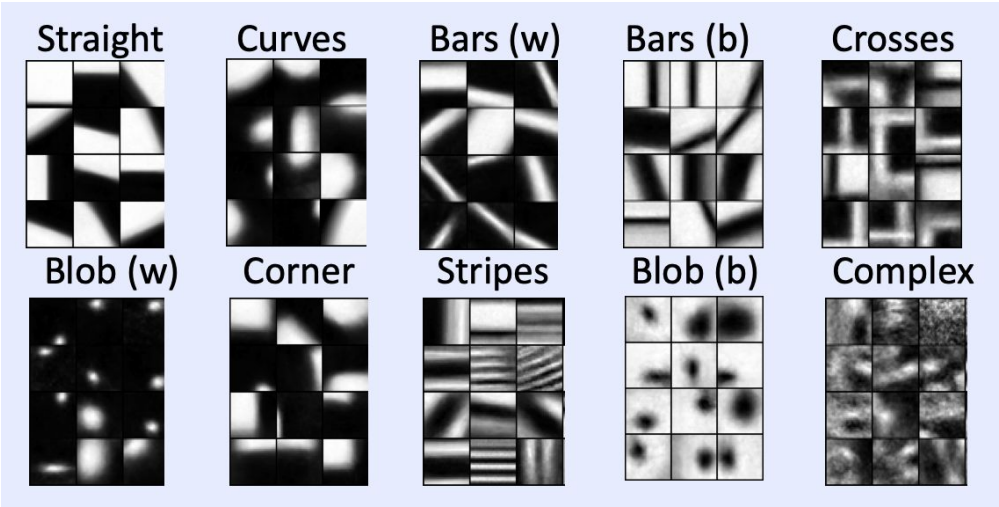
- Seek image representations that enable modeling of brain response to visual stimuli
- Pixels-to-voxel modeling is challenging because of limited data size, noisy signal
- Borrow architecture from computer vision, train on fMRI data

Visual bag-of-words

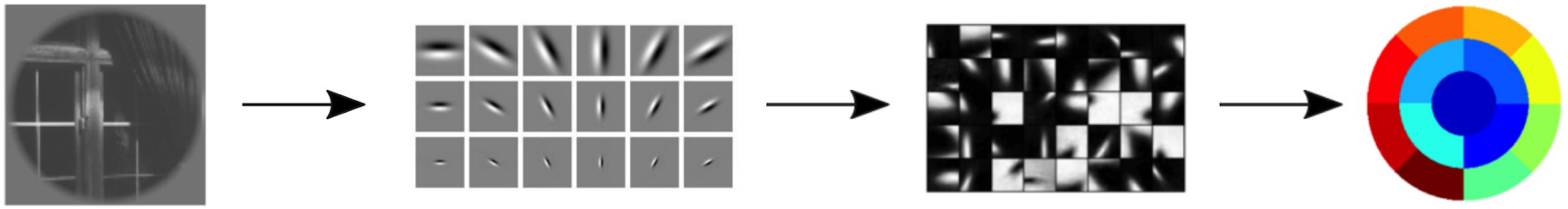


Dictionary learning

$$\min_{\mathbf{A}\in\mathbb{R}^{p\times n},\mathbf{D}\in\mathcal{D}} \sum_{i=1}^{n} \underbrace{\frac{1}{2}\|\mathbf{x}^i - \mathbf{D}\boldsymbol{\alpha}^i\|_2^2}_{\text{data fitting}} + \underbrace{\lambda\|\boldsymbol{\alpha}^i\|_1}_{\text{sparsity}}$$



2-layer sparse coding network



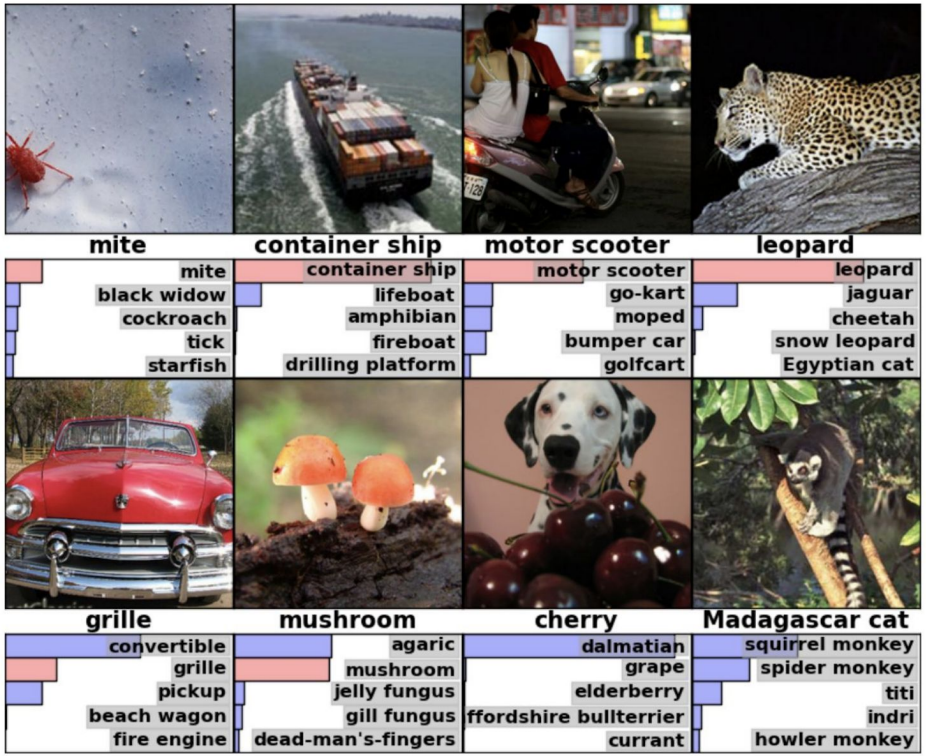
video frames
or images

Filter Bank
(e.g. Gabors with
different orientations and scales)

Sparse coding

Pooling

ILSVRC Challenge (ImageNet)



ILSVRC Challenge (1.2 million images)

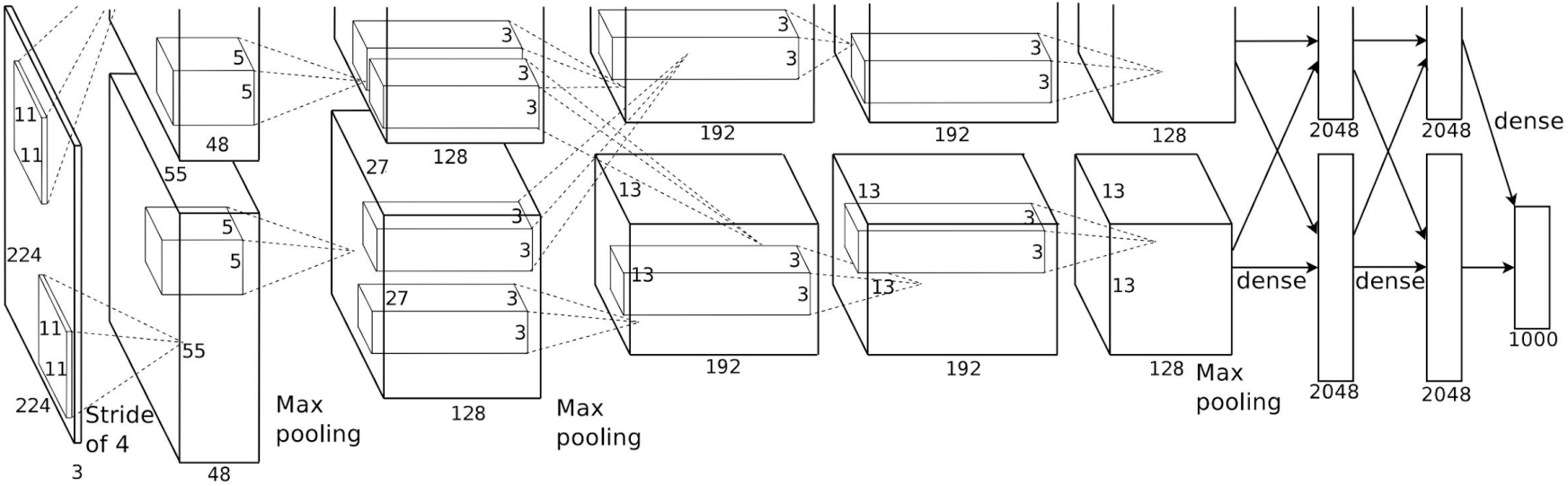
CNN
non-CNN

2012 Teams	%error
Supervision (Toronto)	15.3
ISI (Tokyo)	26.1
VGG (Oxford)	26.9
XRCE/INRIA	27.0
UvA (Amsterdam)	29.6
INRIA/LEAR	33.4

2013 Teams	%error
Clarifai (NYU spinoff)	11.7
NUS (singapore)	12.9
Zeiler-Fergus (NYU)	13.5
A. Howard	13.5
OverFeat (NYU)	14.1
UvA (Amsterdam)	14.2
Adobe	15.2
VGG (Oxford)	15.2
VGG (Oxford)	23.0

2014 Teams	%error
GoogLeNet	6.6
VGG (Oxford)	7.3
MSRA	8.0
A. Howard	8.1
DeeperVision	9.5
NUS-BST	9.7
TTIC-ECP	10.2
XYZ	11.2
UvA	12.1

AlexNet



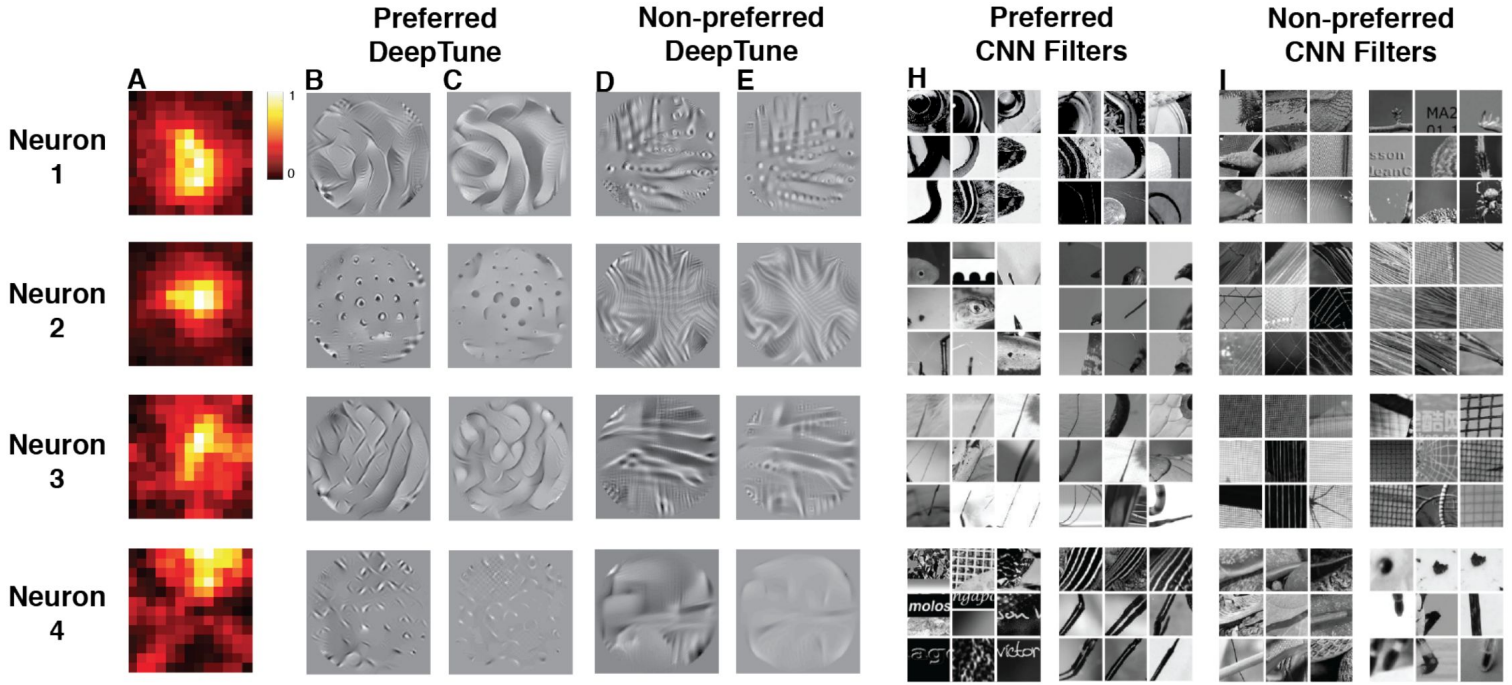
Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems (pp. 1097-1105).

What is DL?

“DL is constructing networks of parameterized functional modules & training them from examples using gradient-based optimization. That's it.”

-Yann LeCun

CNNs for area V4



Abbasi-Asl, R., Chen, Y., Bloniarz, A., Oliver, M., Willmore, B. D., Gallant, J. L., & Yu, B. (2018). The DeepTune framework for modeling and characterizing neurons in visual cortex area V4. bioRxiv, 465534.

Other research interests

- Biological neural networks in *c. elegans*
- Causal inference: improving randomized experiments with ML
- Parallelized training of random forests

ML SWE @ Google

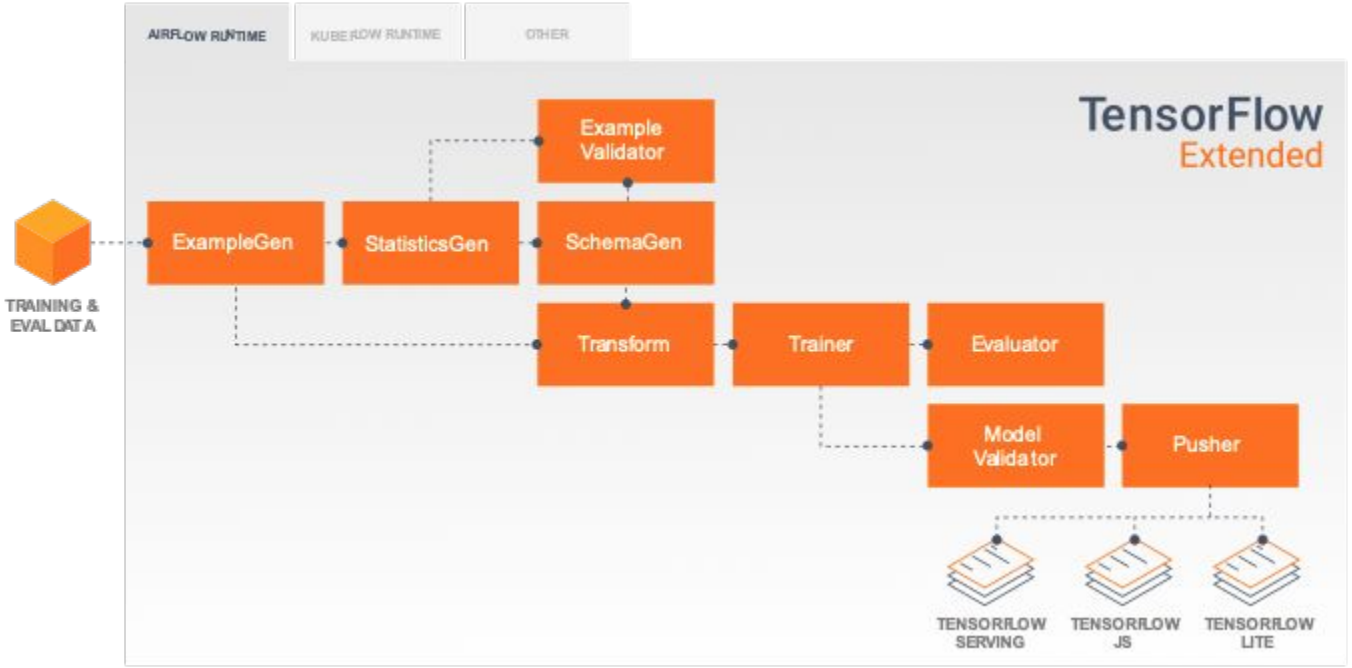
Full-stack ML SWE

- Gathering training data
- Maintaining training database
- Designing non-ML baselines
- Training ML models
- Continuous benchmarking
- Regression testing
- Serving models
- Monitoring servers
- On-call

Model robustness

- Training vs test-time distribution
  - Input changes from dependent services
- Understanding possible infrastructure weaknesses
- Harden against adversarial attacks

TFX


AIRFLOW RUNTIME
KUBEFLOW RUNTIME
OTHER
TensorFlow
Extended
TRAINING &
EVAL DATA
ExampleGen
StatisticsGen
Example
Validator
SchemaGen
Transform
Trainer
Evaluator
Model
Validator
Pusher
TENSORFLOW
SERVING
TENSORFLOW
JS
TENSORFLOW
LITE