

EECS 510: Social Media Mining

Spring 2016

Introduction to Deep Learning

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Outline

- Deep learning: what and why
- Success stories
- Technical explanation
- A touch of Artificial Intelligence
- Next time: software!
 - caffe, theano, torch, tensorflow

Deep learning: is it overhyped?

You question if it's overhyped when...

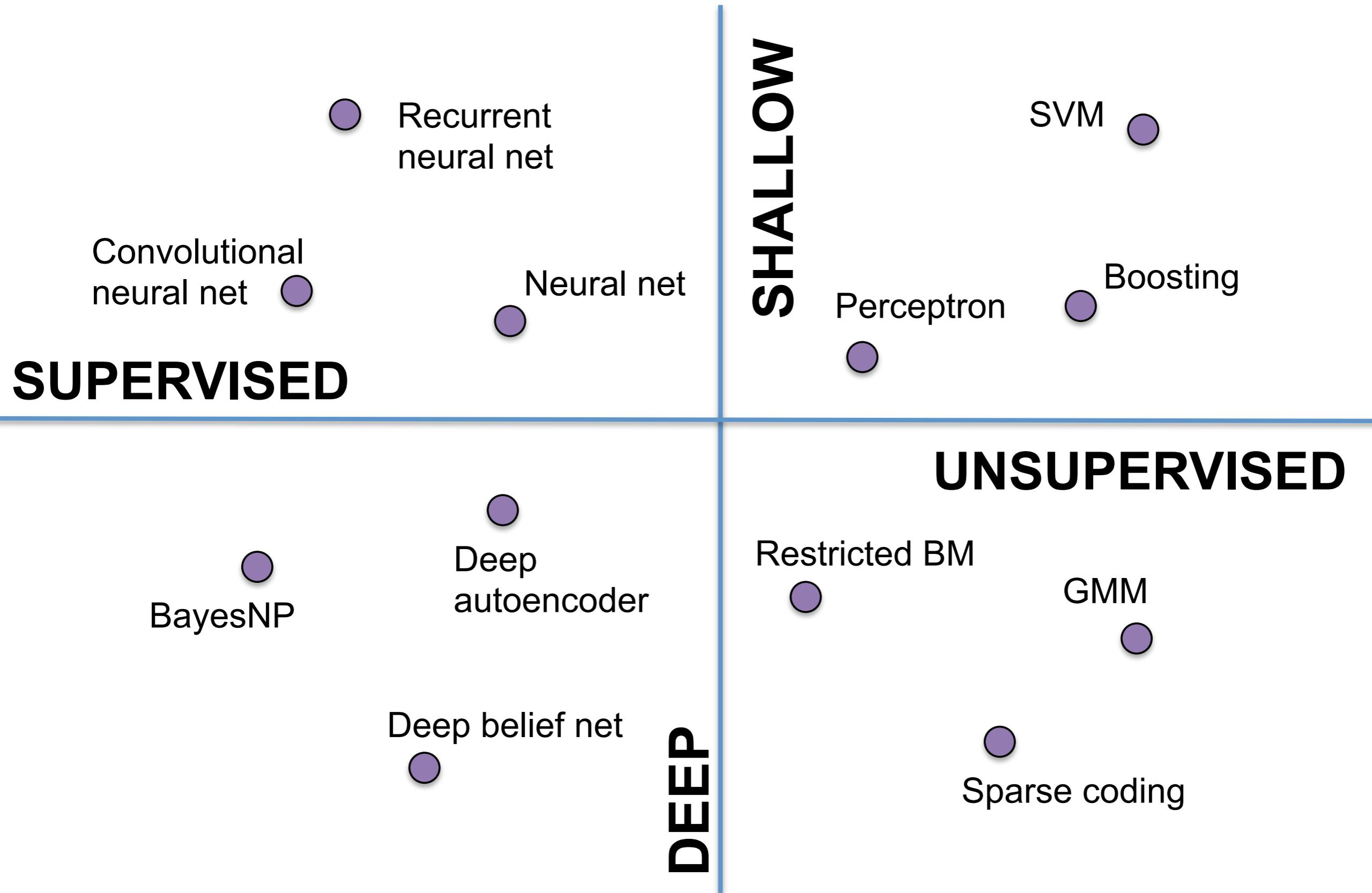
- People, even outside of the field, is talking about it
- Almost all conferences have a session about it
 - and becomes the hottest session
- Big companies are investing in it
- Startups everywhere are doing it
- 99% papers appear on arxiv
- Major universities/MOOCs offer to teach it
 - an instructor feels embarrassing to use last year's slides 

Deep learning: what is it?

What is deep learning, really?

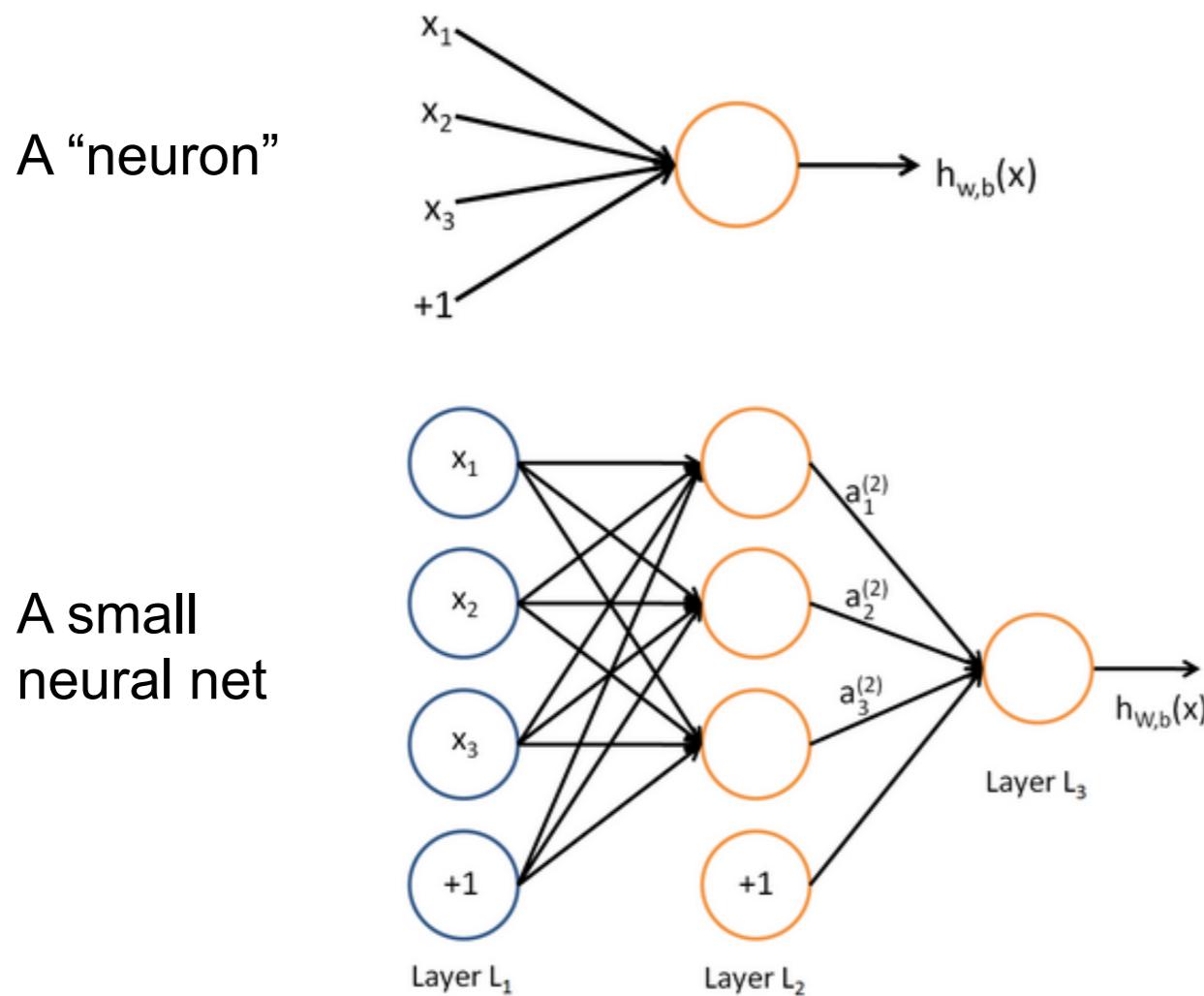
- First you need to know ML + AI
 - ML: the study of algorithms that make predictions on data
 - AI: the study of how computer systems emulate human intelligence
- Deep learning: the most cutting edge ML/AI research
- “A method which makes predictions by using a **sequence of non-linear processing stages**. The resulting intermediate representations can be interpreted as feature hierarchies and the whole system is jointly learned from data.”
 - Facebook Research
- “Machines that learn to represent the world”
- “End-to-end machine learning.”
 - Yann LeCun

The space of machine learning methods



What is deep learning, really?

- ~~First you need to know ML + AI~~
- Second you need to know neural networks
 - biology inspired, supervised, weights, activation, backpropagation



Training of a NN

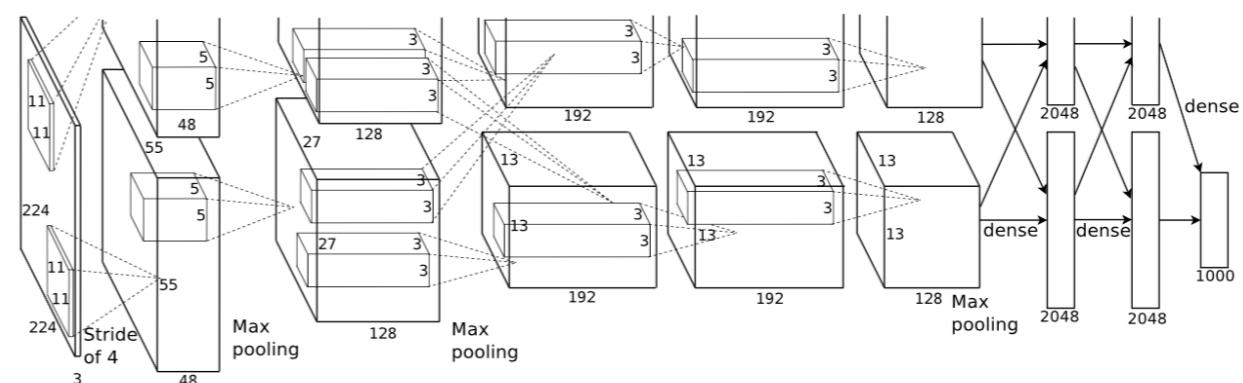
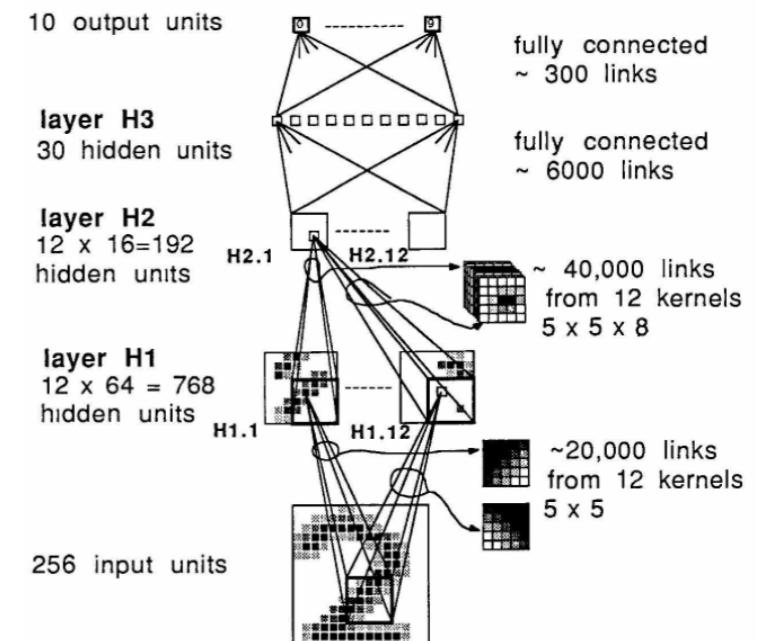
Loop until tired:

1. **Sample** a batch of data.
2. **Forward** it through the network to get predictions.
3. **Backprop** the errors.
4. **Update** the weights.

Deep learning: why is it happening now?

Why the resurgence of neural networks?

- The theory has existed for over 35 years
 - Backpropagation, 1970
 - Neocognition by K. Fukushima, 1980
 - Zipcode recognition by Y. LeCun, 1989
- It once nearly died
 - AI winter (1979, 1990, 2000)
 - SVM (kernel machines) success
- Big data + GPU to the rescue
 - AlexNet on ImageNet



Success stories: what can it do? who's using it?

An obvious favorite baby

- Front page stories in NYT, Wired
- Big acquisitions
 - Facebook launched FAIR, Yann LeCun
 - Google acquired DeepMind (\$500 million), Geoff Hinton
 - Baidu silicon valley research lab, Andrew Ng
 - Salesforce acquired MetaMind
 - LinkedIn, Twitter, Pinterest, ...
- Workshops in top ML conferences
 - NIPS, ICML, CVPR, KDD, AAAI, ICLR...

DNNs better than humans at image recognition



lens cap



abacus



slug



hen

ImageNet

reflex camera
Polaroid camera
pencil sharpener
switch
combination lock



tiger

tiger
tiger cat
tabby
boxer
Saint Bernard

abacus
typewriter keyboard
space bar
computer keyboard
accordion



chambered nautilus

lampshade
throne
goblet
table lamp
hamper

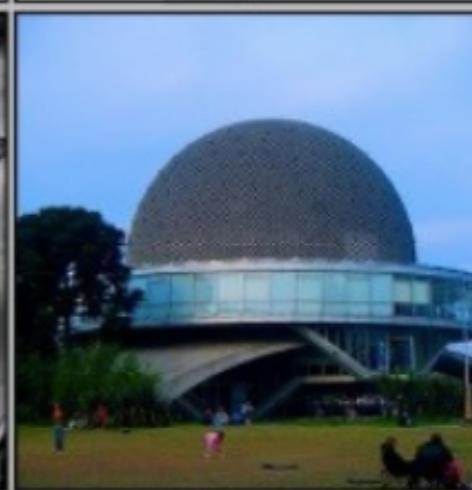
slug
zucchini
ground beetle
common newt
water snake



tape player

cellular telephone
slot
reflex camera
dial telephone
iPod

hen
cock
cocker spaniel
partridge
English setter



planetarium

planetarium
dome
mosque
radio telescope
steel arch bridge

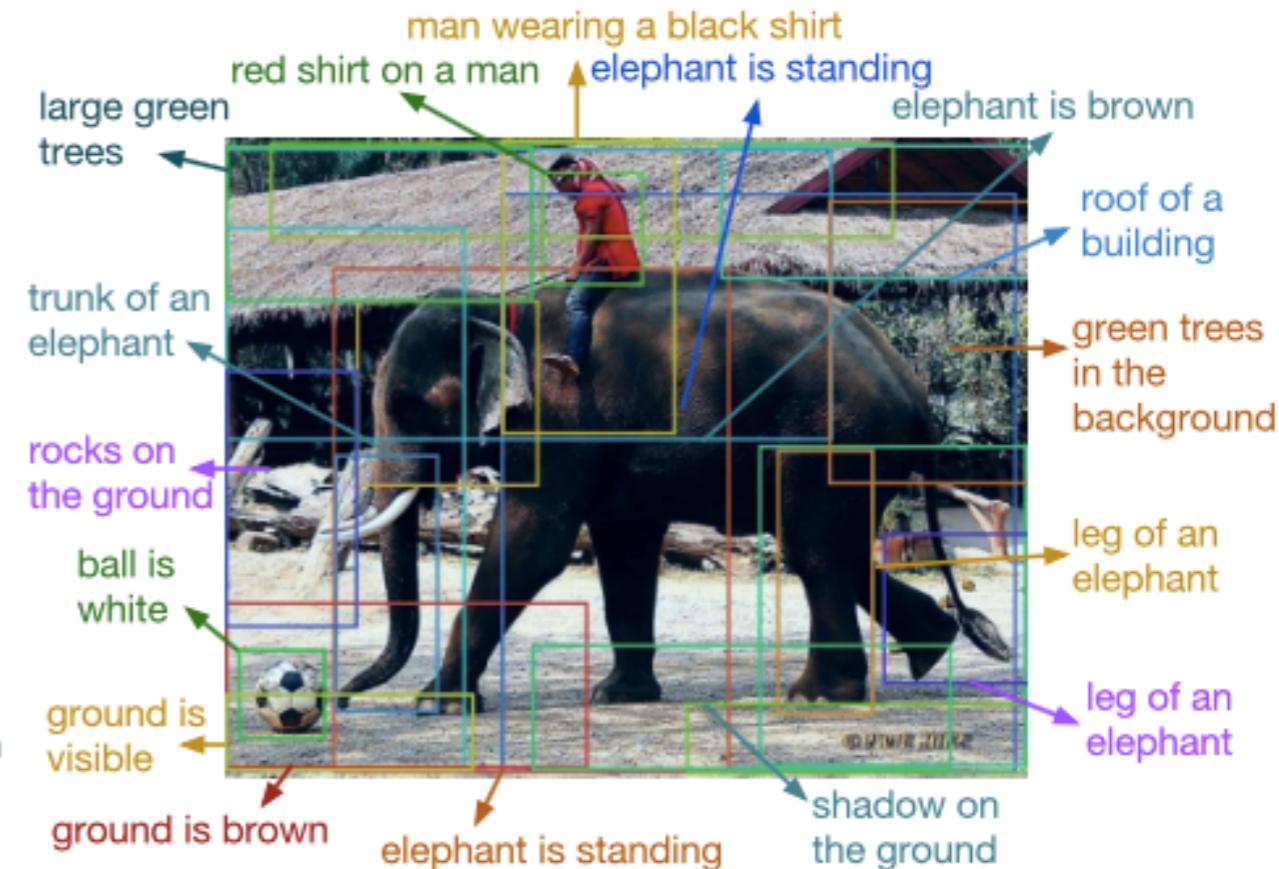
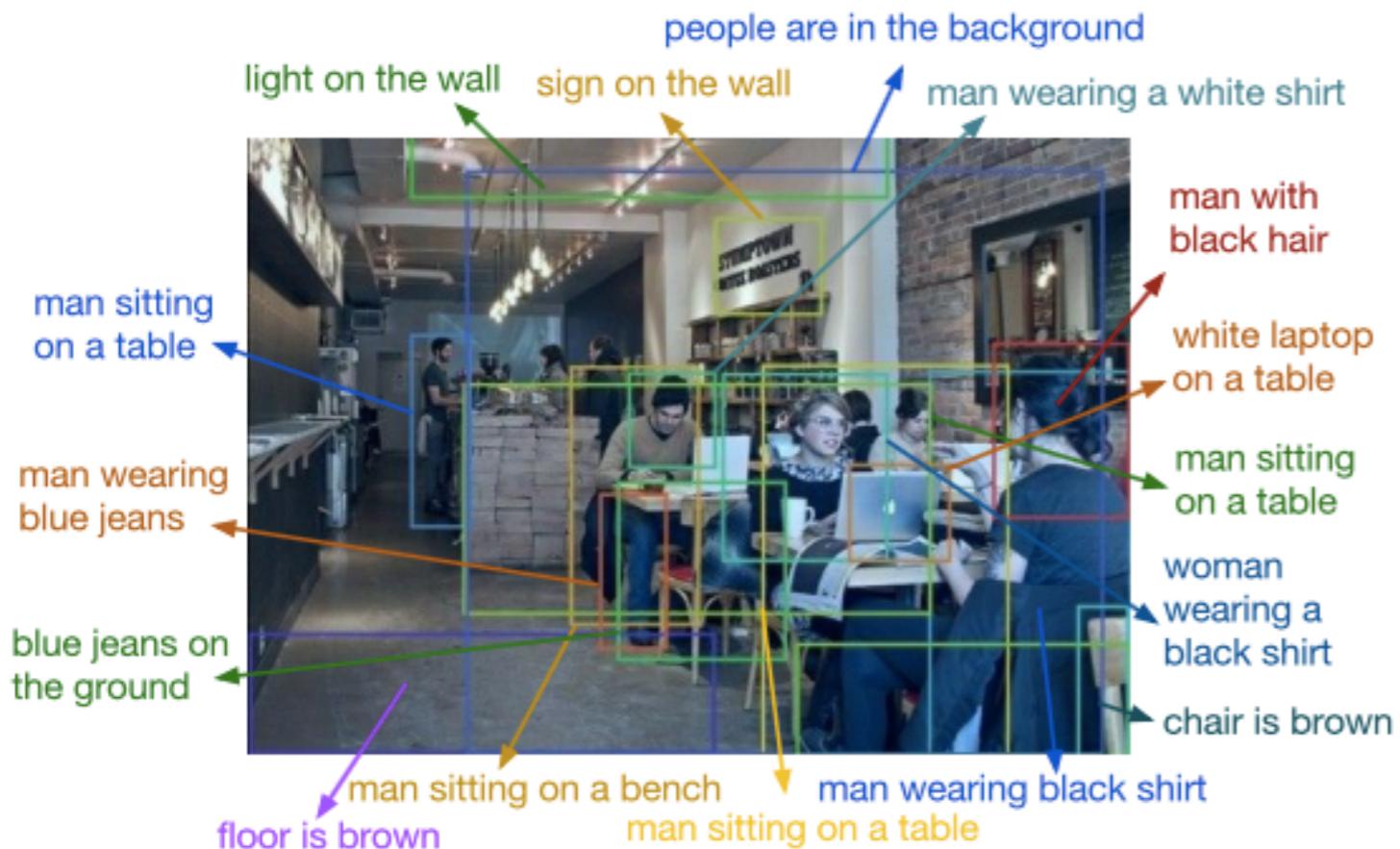
1000 categories

1.3M images

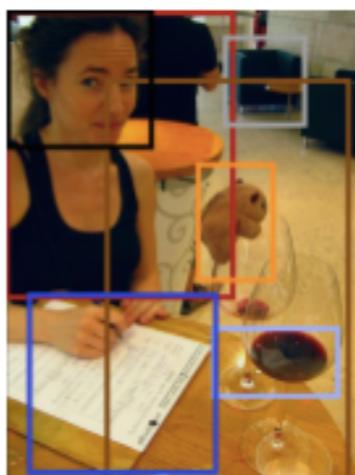
Human error: 5%

DNN: 3%

Image captioning [DenseCap]



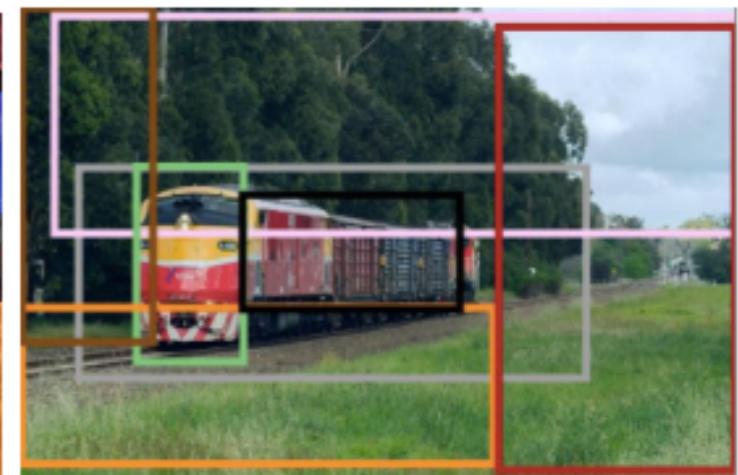
Our Model: plane is flying, tail of the plane, red and white plane.
plane is white, engine on the plane, windows on the plane, nose of the plane.



woman wearing a black shirt, teddy bear is brown, chair is black, glass of wine, table is brown, woman with brown hair, paper on the table.



teddy bear is wearing a red shirt, red and white teddy bear, bear is wearing a red hat, red and white shirt, table is brown, black nose of a bear.



train on the tracks, trees are green, front of the train is yellow, grass is green, green trees in the background, photo taken during the day, red train car.

Full Image RNN: A large jetliner flying through a blue sky.

A man and a woman sitting at a table with a cake.

A teddy bear with a red bow on it.

A train is traveling down the tracks near a forest.

Deep reinforcement learning



 AlphaGo

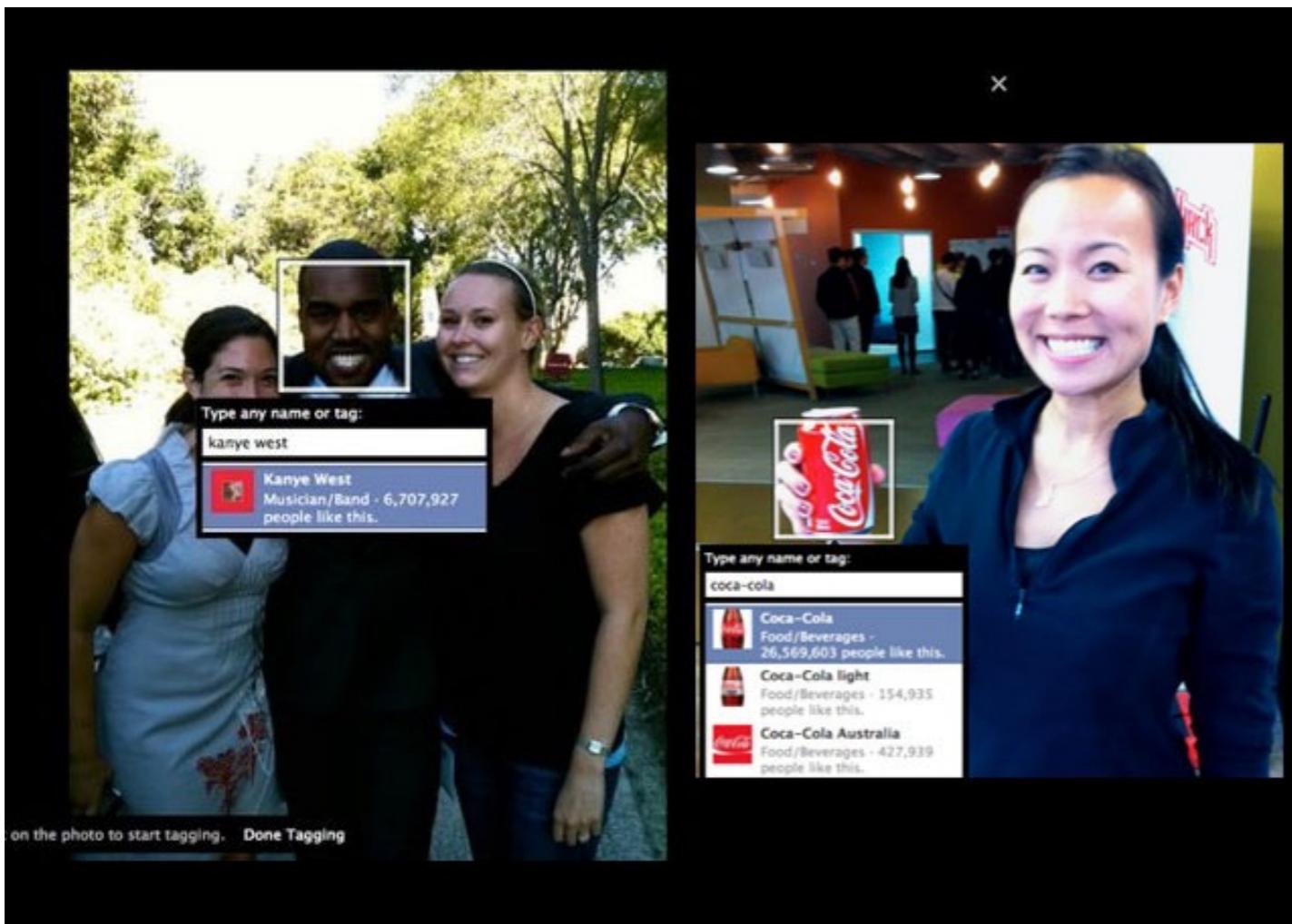
Just within Google

- Search
- Search by image
- Driverless cars
- Youtube recommendation
 - videos
 - thumbnails
- Maps
 - reading street addresses



Facebook

- Every image on Facebook goes into two deep networks
 - tagging
 - determining close friends?



A screenshot of a Facebook post. The post is shared by 'Arindam Paul' and says 'Arindam Paul shared HuffPost Good News's video.' It was posted '14 hrs · '. The caption reads 'Northwestern should also have one 😊'. The post includes a photo of a man in a green shirt kissing a ginger cat in front of a cardboard sign that says 'Kissing Booth' and '25¢'. Below the photo, it says '76,927 Views'. The post is from 'HuffPost Good News' and was posted '14 hrs · '. The caption continues: 'Mondays are hard. Here's a cat kissing booth by Cole & Marmalade to brighten your day (via Outspeak)'. At the bottom, there are 'Like', 'Comment', and 'Share' buttons, and a comment section with '1 Like' and 'Write a comment...'. There are also camera and other icons at the bottom right.

Two prominent perception tasks

- Image recognition
 - <https://vimeo.com/109982315>
- Speech recognition
 - <https://www.youtube.com/watch?v=yxxRAHVtafI>

DeepMind

- Best (beating human) general purpose video game player
 - <http://www.nature.com/nature/journal/v518/n7540/full/nature14236.html#videos>
- Best Go chess player
 - <https://www.youtube.com/watch?v=SUbqykXVx0A>
- Generative
 - <https://www.youtube.com/watch?v=Zt-7MI9eKEo>

Openness

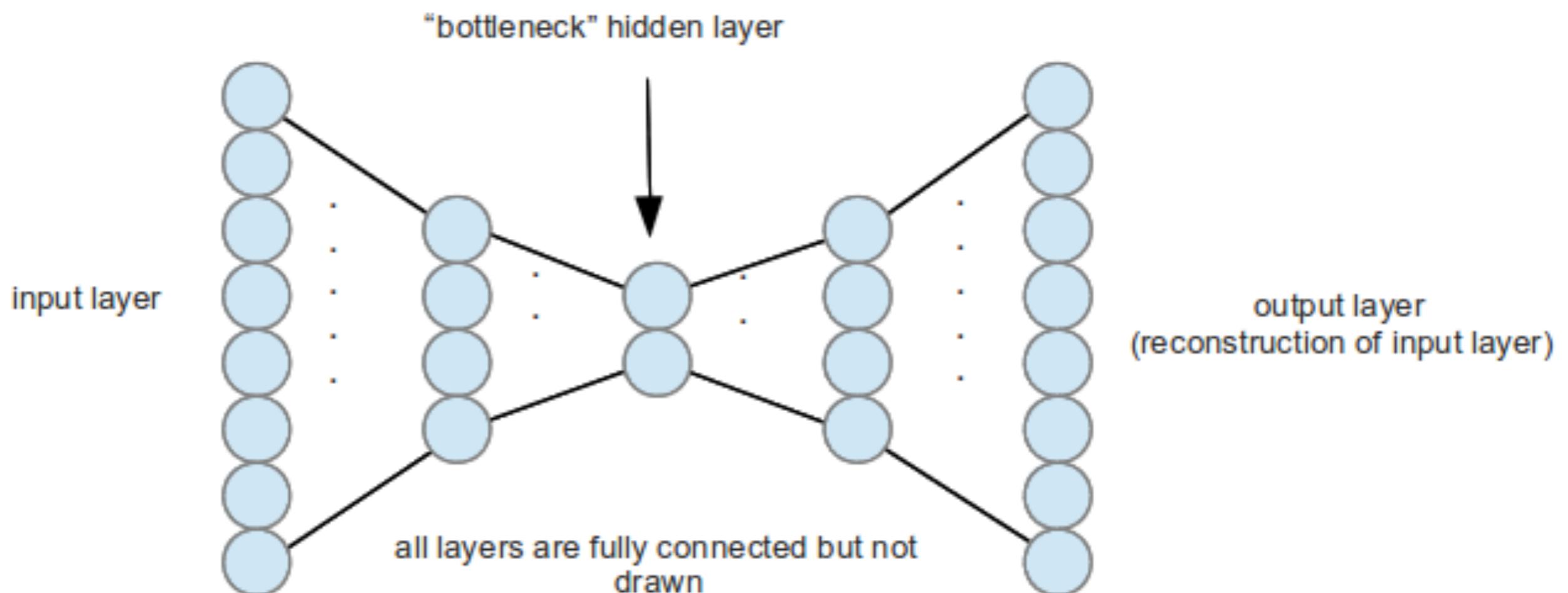
- Open source, open data, open hardware design
 - Google: TensorFlow
 - Microsoft: DMTK
 - Samsung: VELES
 - IBM: SystemML
 - Facebook: Big Sur
- arxiv.org, arxiv-sanity.com
 - <https://www.youtube.com/watch?v=S2GY3gh6qC8&feature=youtu.be>

Technical Explanation

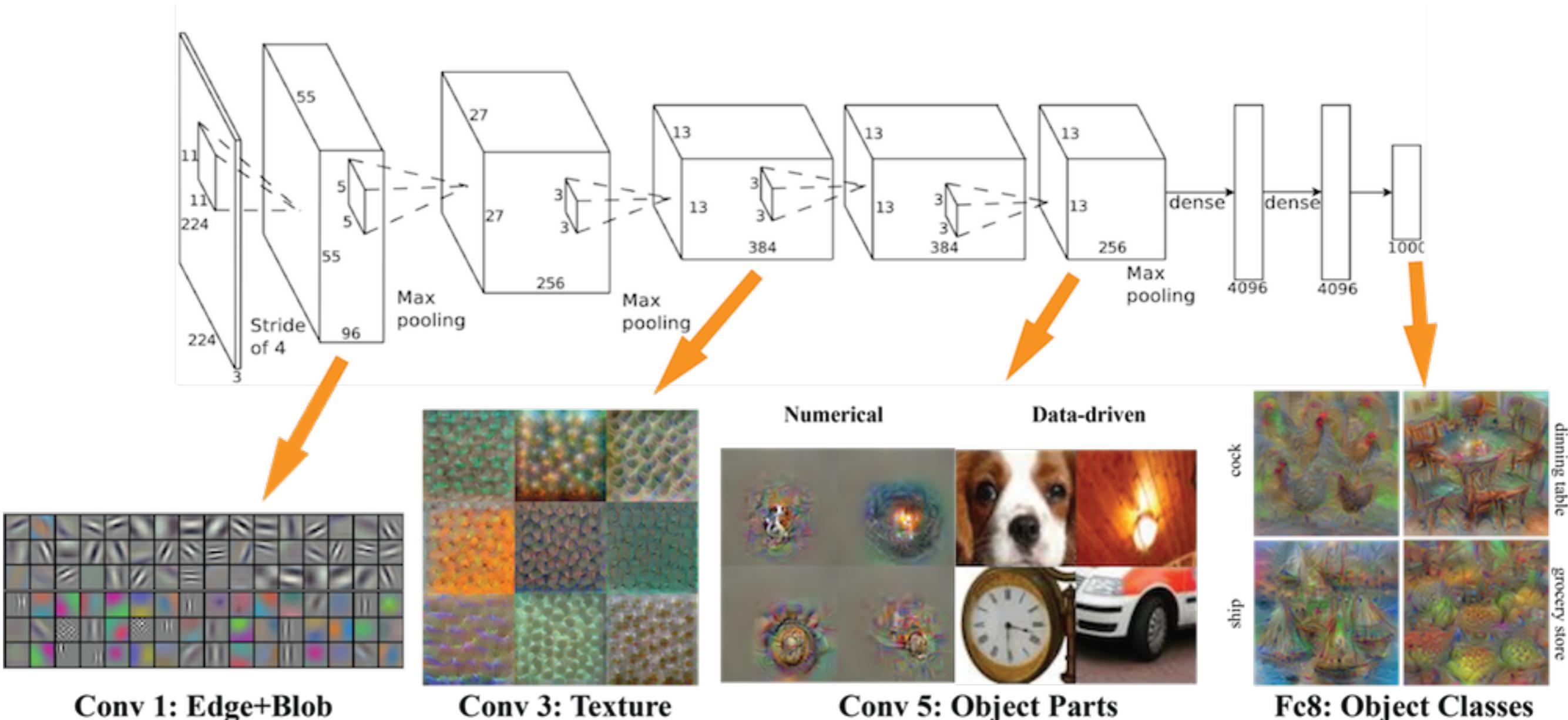
Many types of learning protocols

- Purely supervised
 - Backprop + SGD
 - Good when there are lots of labeled data
- Layer-wise supervised + supervised linear classifier
 - Train each layer in sequence
 - Hold fix the feature extractor, train linear classifier on features
 - Good when labeled data is scarce but lots of unlabeled data
- Layer-wise unsupervised + supervised backprop
 - Train each layer in sequence
 - Backprop through the whole system
 - Good when learning problem is very difficult

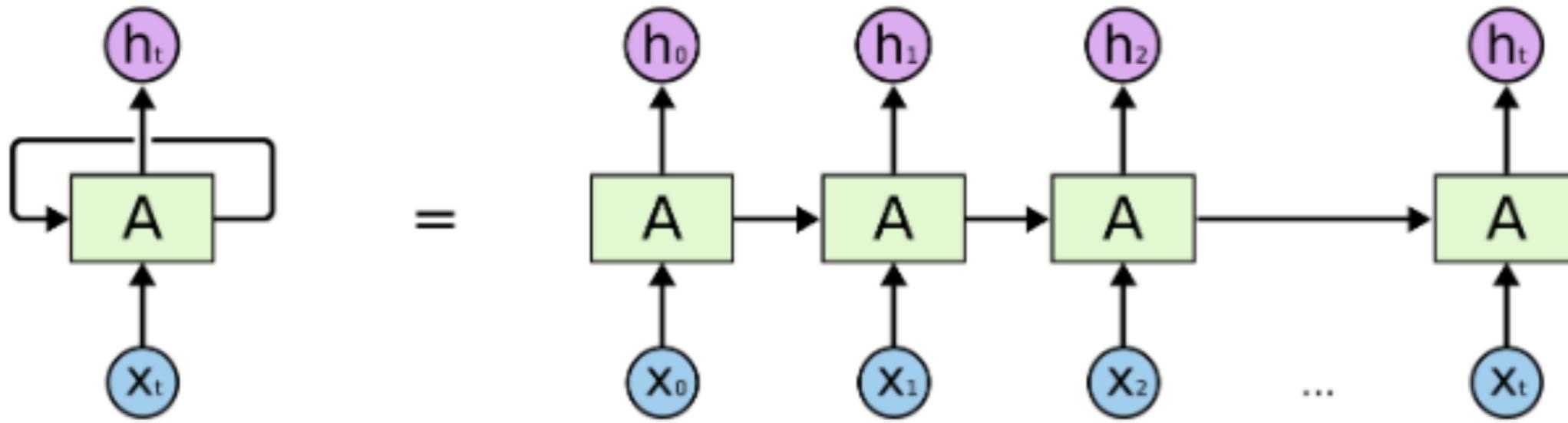
Auto-encoder



Convolutional neural networks



Recurrent neural networks



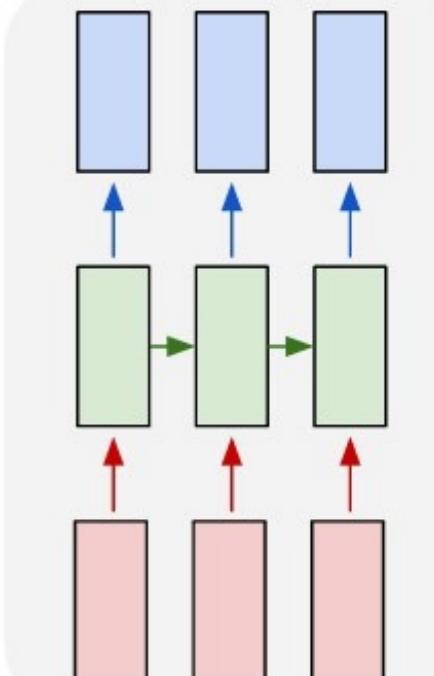
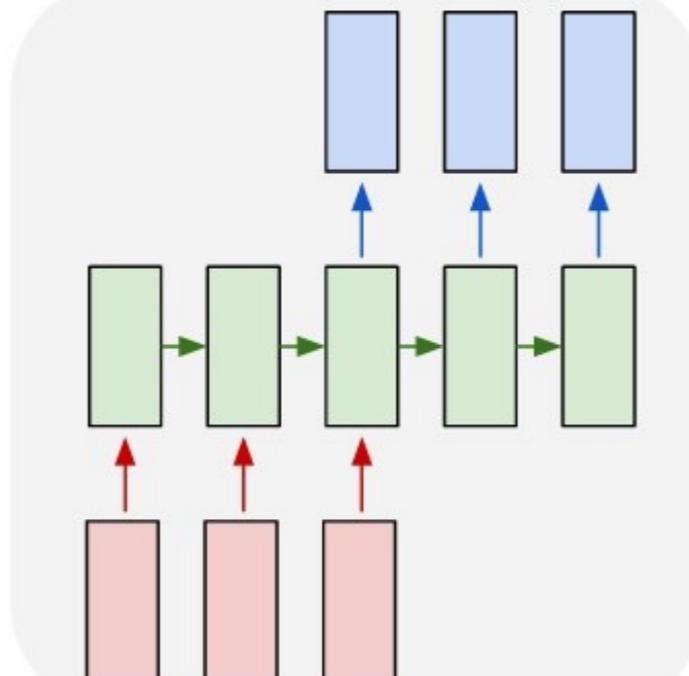
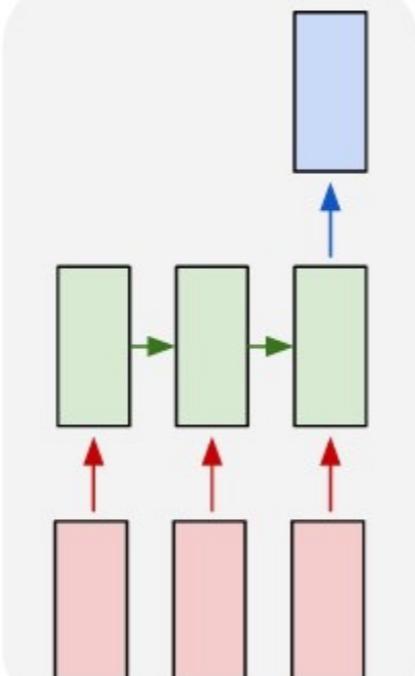
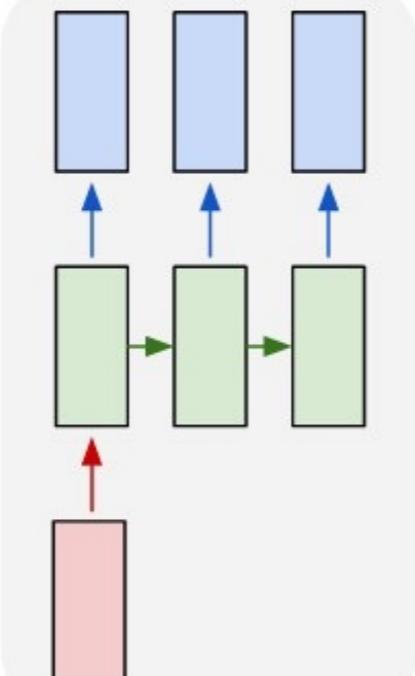
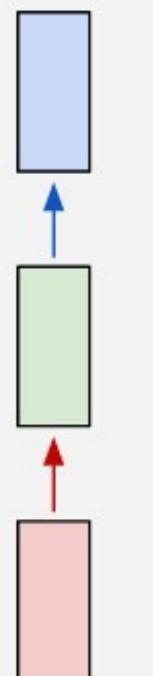
one to one

one to many

many to one

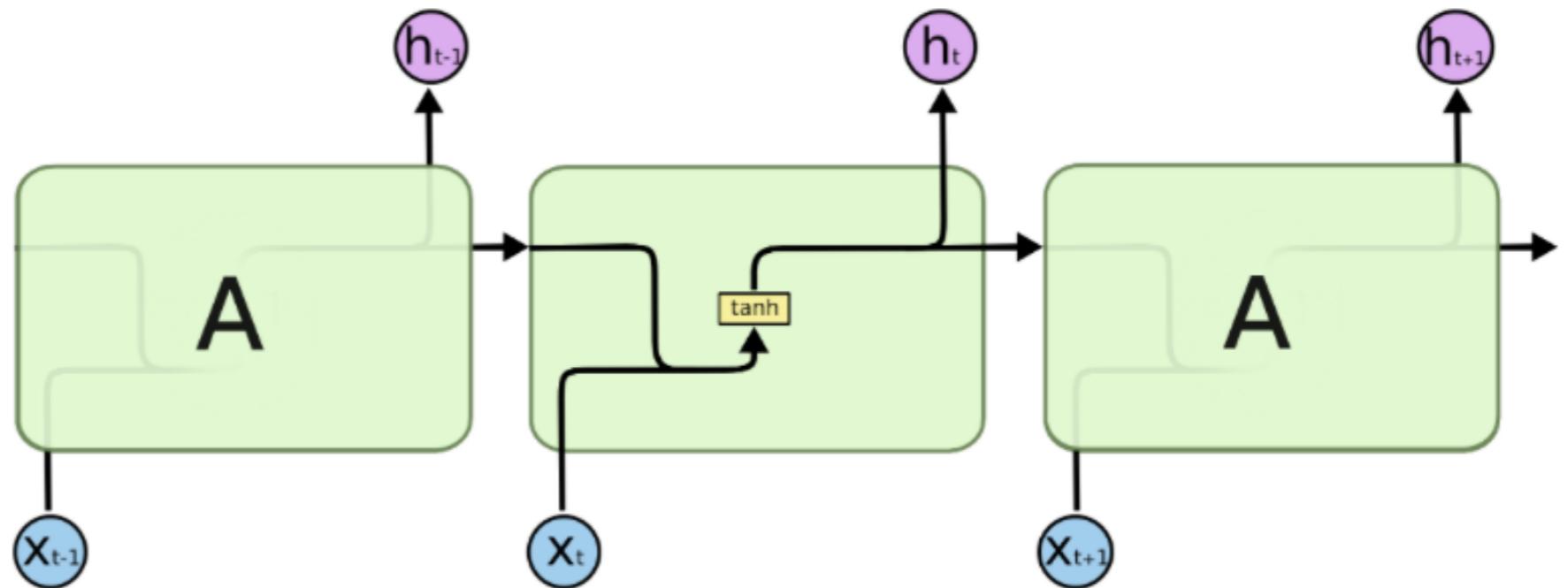
many to many

many to many

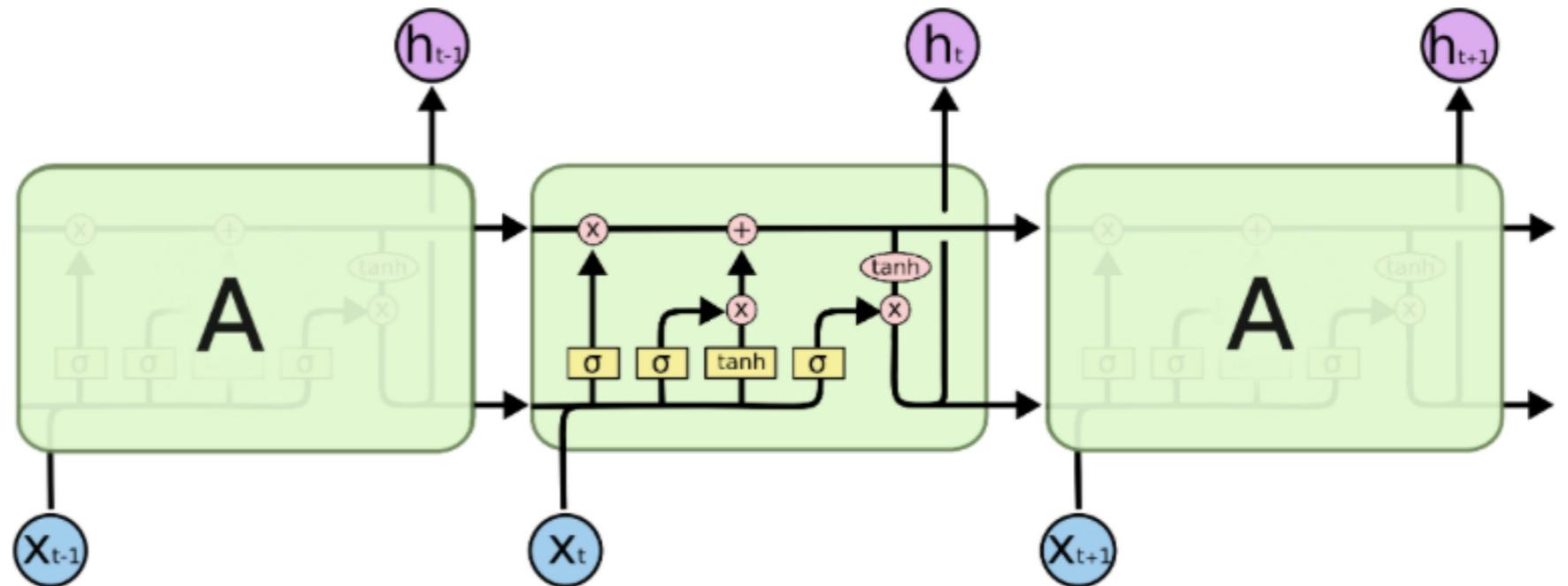


Long short term memory (LSTM)

standard RNN



LSTM



Limitations & Room for improvements

- Limited to recognition tasks (better than human)
- Rely on big data (and hence expensive hardware)
- Only solves narrow AI problems
- Deep neural networks are easily fooled
 - <https://www.youtube.com/watch?v=M2lebCN9Ht4>

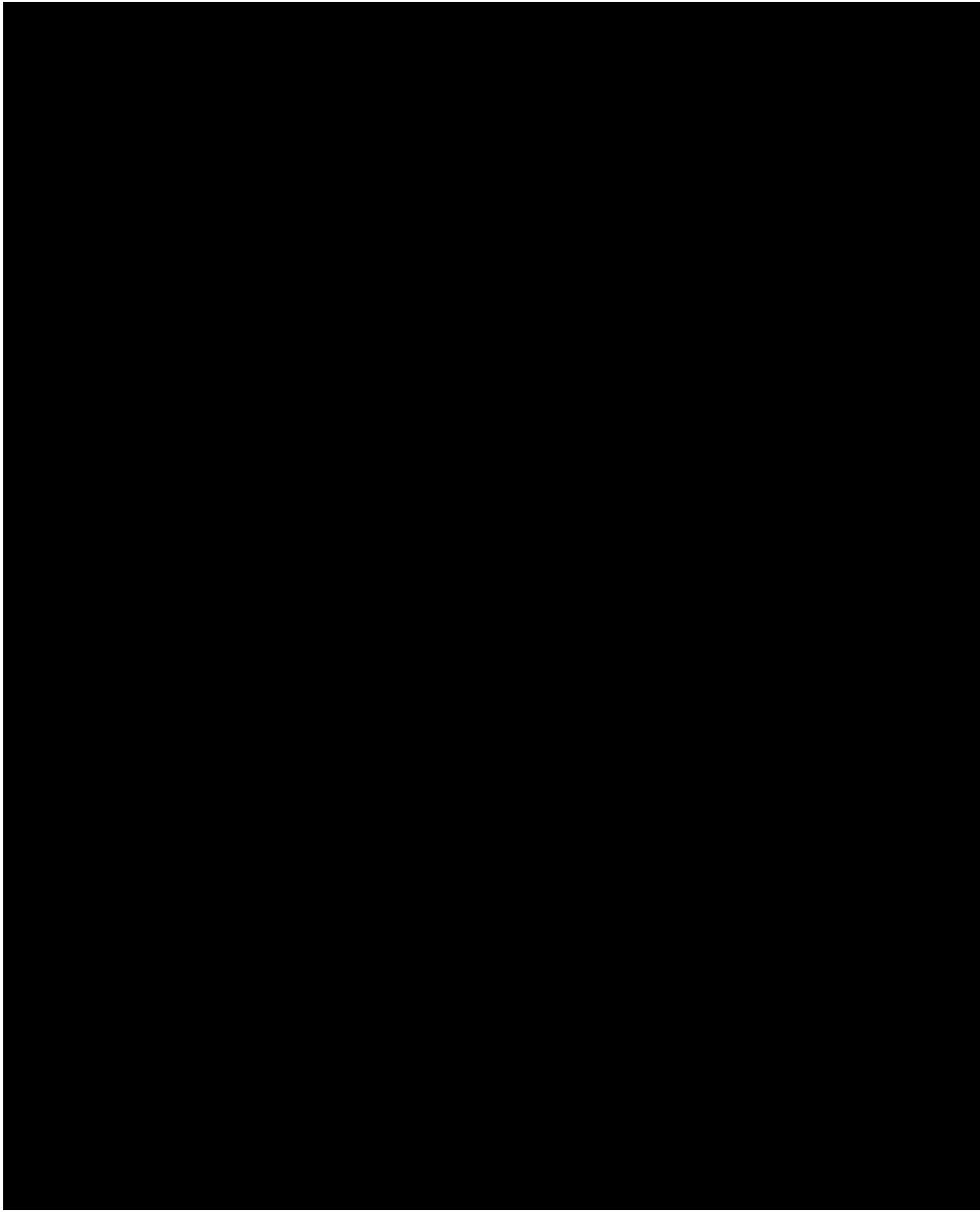
Next time: software & projects

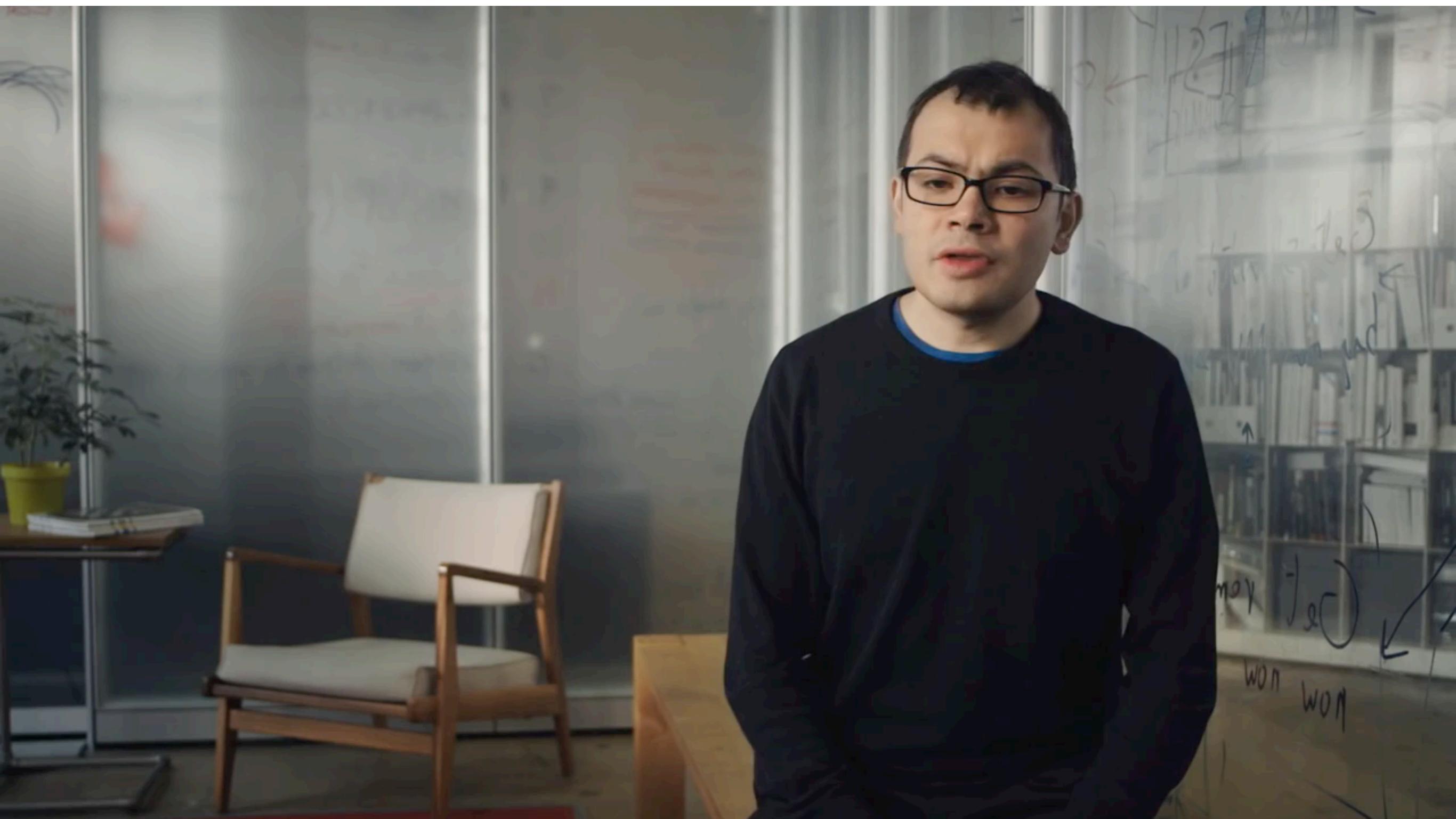
- Backend
 - Krizhevsky (AlexNet) first built CNN in CUDA (`cunn`)
 - Then Nvidia took the charge and built `cudnn`
- Berkeley's Caffe
 - modular CNN package in C++
 - with both CPU/GPU training
- Bengio's Theano
 - Python project (w/ numpy & scipy)
 - works with GPU through `cunn`, `cudnn`
 - compile to C on-the-fly
- Facebook/NYU's Torch7
 - LuaJIT interface to C
- Google's TensorFlow
 - C with python interface

Video Backups









Reading MNIST



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25 Jan 2016: A project update, including a brief summary of activities in 2015, has been posted

1 Jan 2016: New members join arXiv Scientific Advisory Board

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- [High Energy Physics – Lattice \(hep-lat new, recent, find\)](#)
- [High Energy Physics – Phenomenology \(hep-ph new, recent, find\)](#)
- [High Energy Physics – Theory \(hep-th new, recent, find\)](#)
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- [Nuclear Theory \(nucl-th new, recent, find\)](#)
- [Physics \(physics new, recent, find\)](#)
includes: Accelerator Physics; Atmospheric and Oceanic Physics; Atomic Physics; Atomic and Molecular Clusters; Biological Physics; Chemical Physics; Classical Physics;

Deep Neural Networks are Easily Fooled

High Prediction Scores for Unrecognizable Images