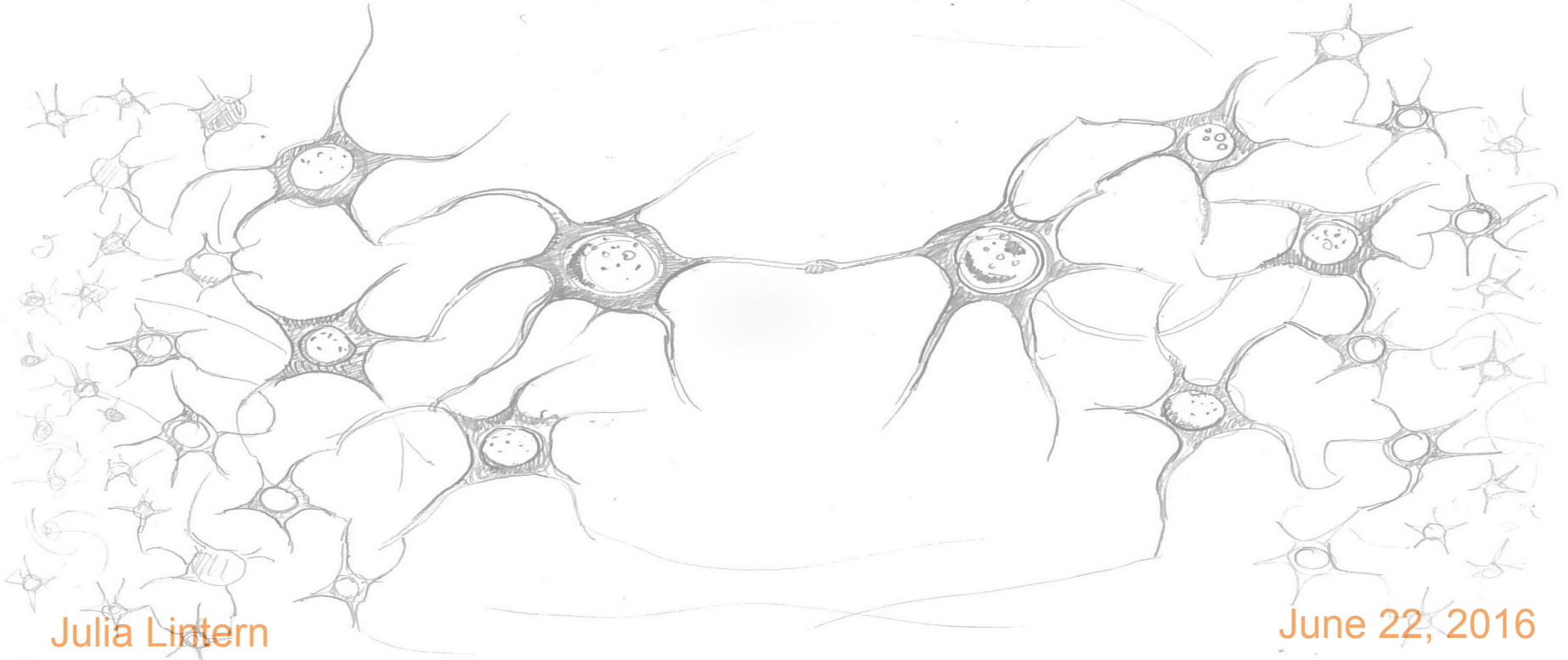
Navigating the Neural Net Terrain

A 45 min. Tour

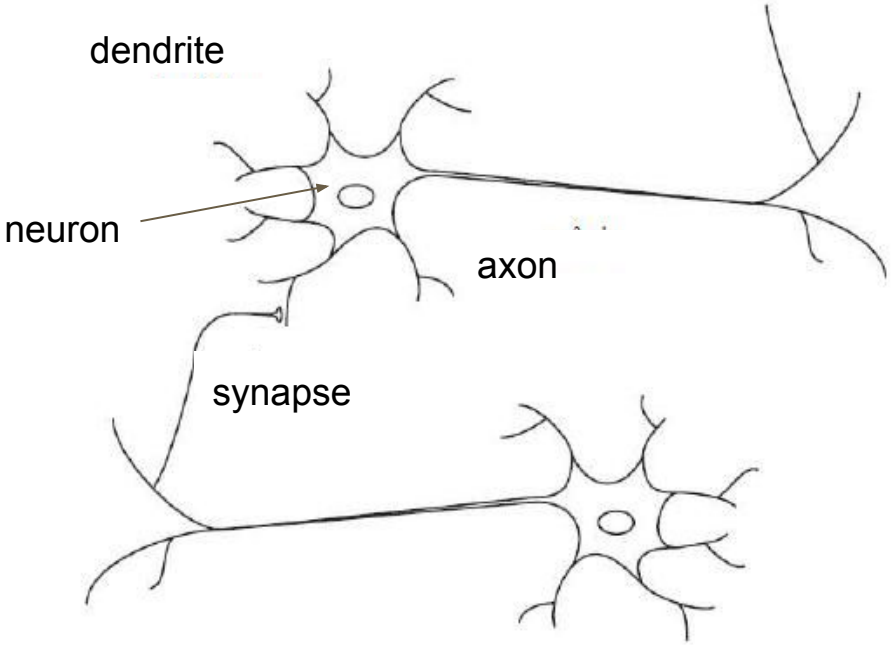


Julia Lintern

June 22, 2016

The Brain Analogy

(our cartoon neuron)

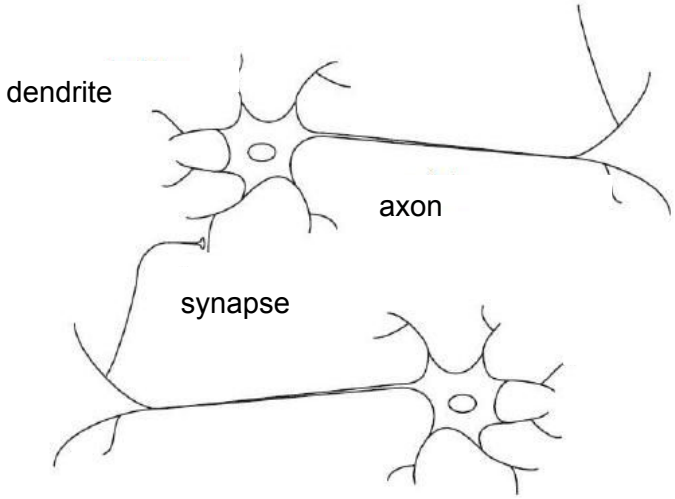


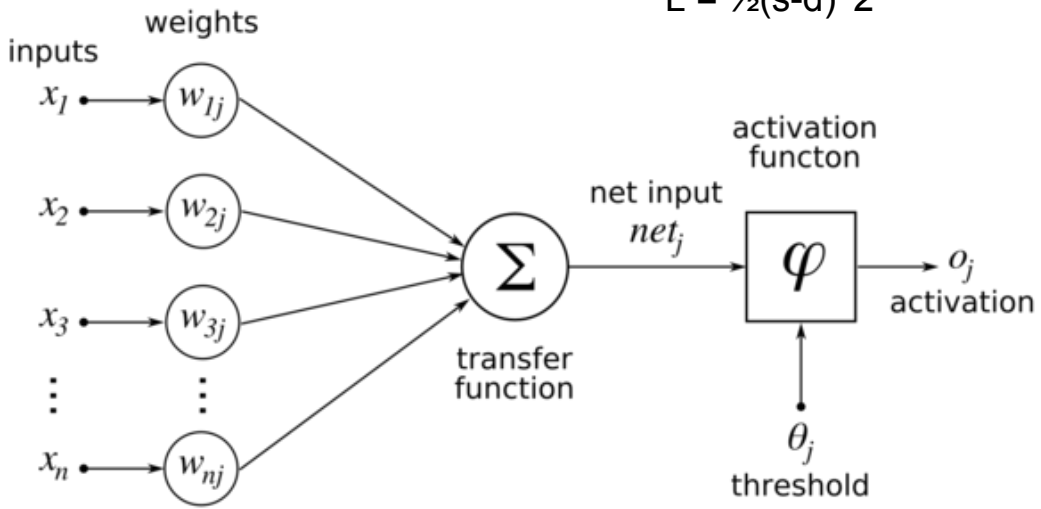
The Brain Analogy

(cartoon neuron & mathematical neuron)

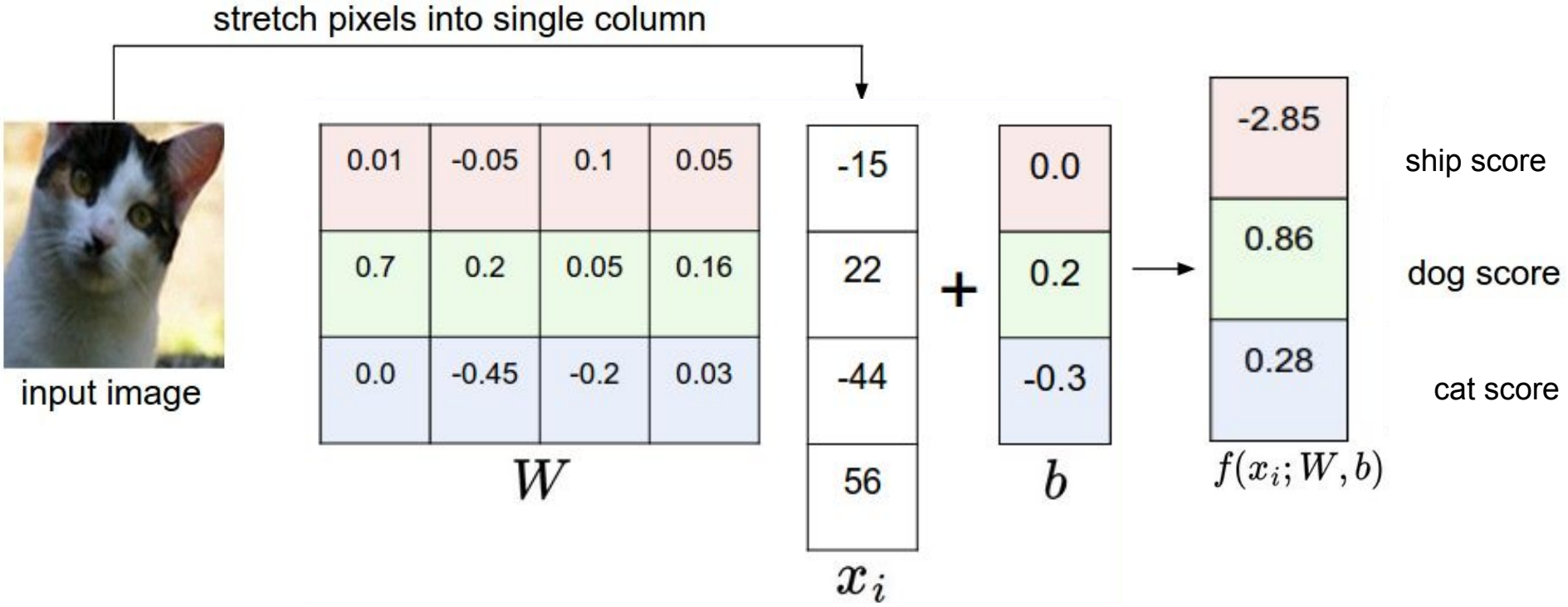
s= f(x,w)

L = ½(s-d)^2



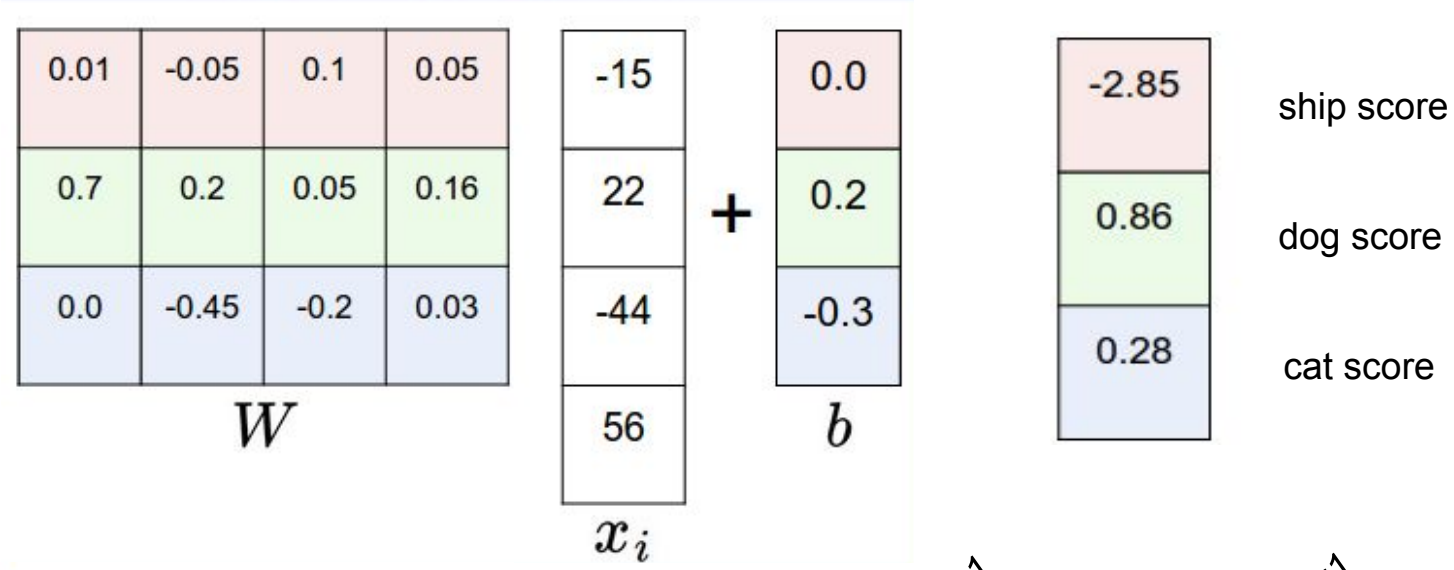


The Linear Classifier Analogy



Losses:

Multiclass SVM (Hinge) Loss

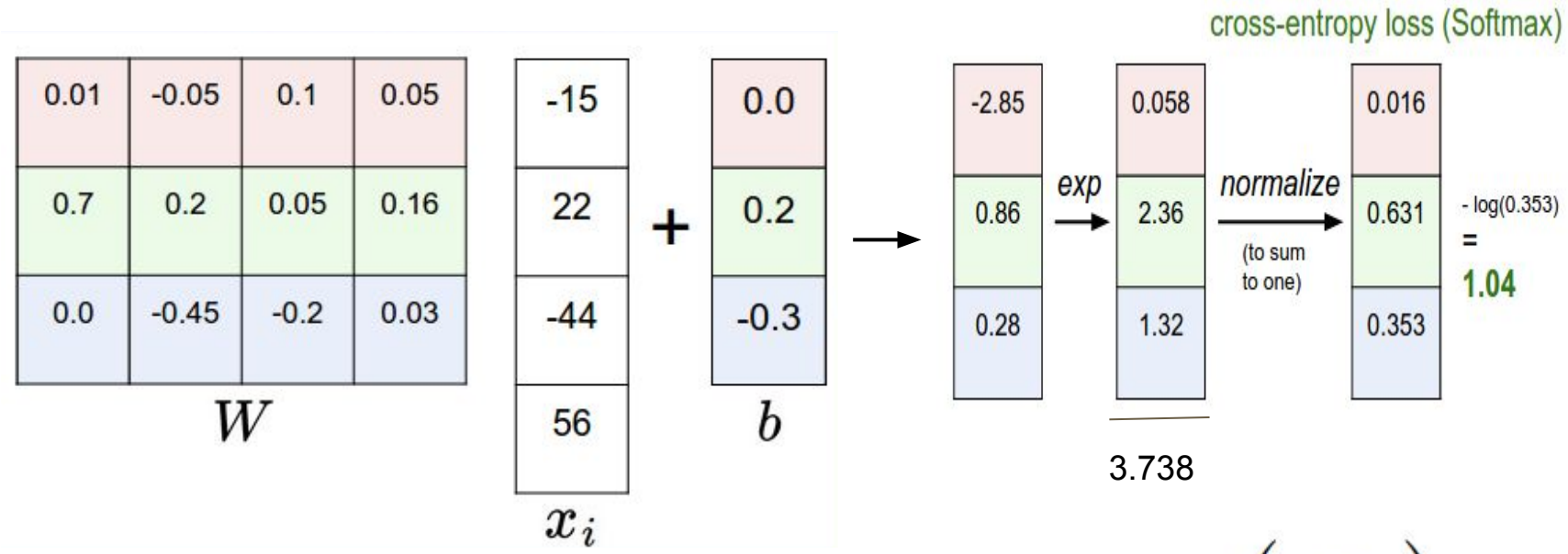


$$L_i = \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + \Delta)$$

= max(0, -2.85-.28 + Δ) + max(0, 86-0.28 + Δ) = 0 + 1.58

Losses:

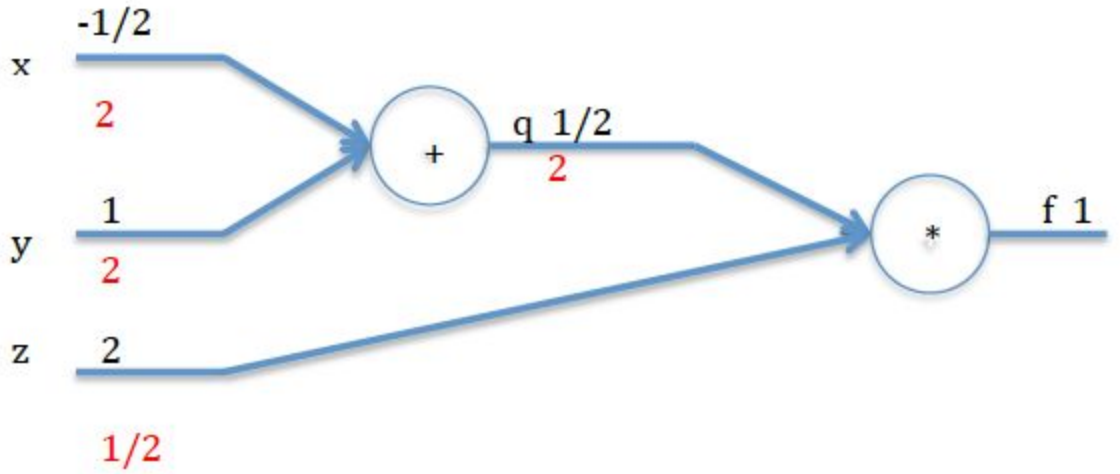
Softmax (Cross-Entropy) Loss



Softmax: $f_j(z) = \frac{e^{z_j}}{\sum_k e^{z_k}}$

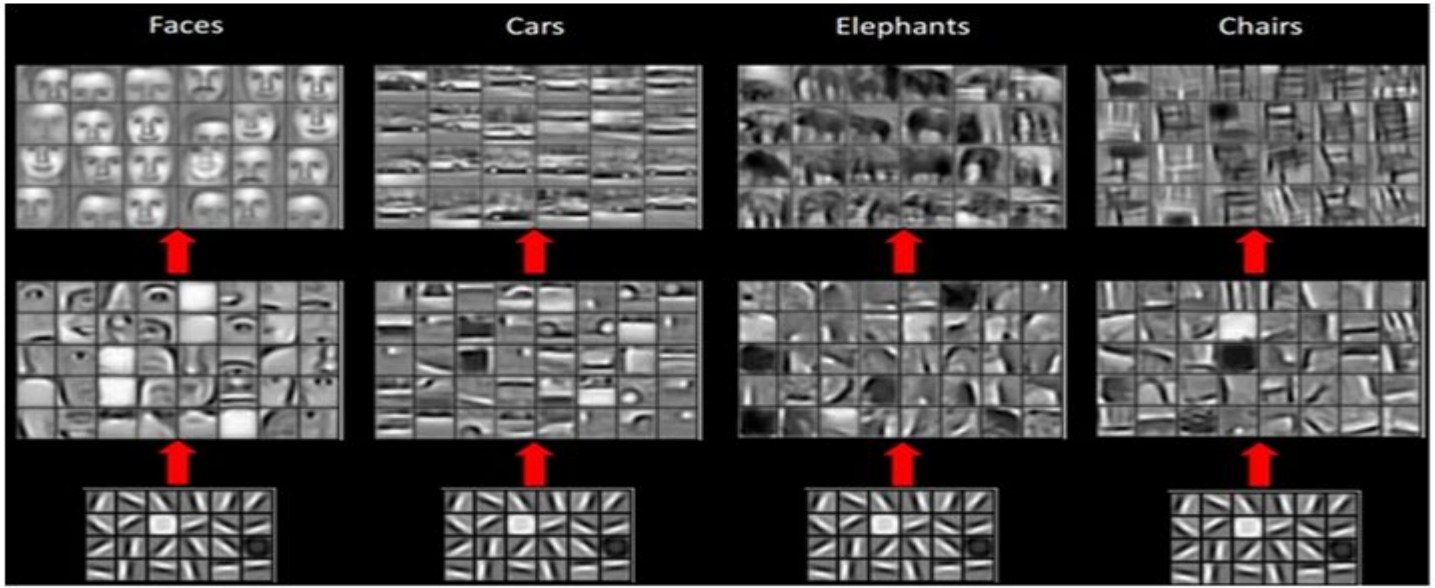
Cross-Entropy $L_i = -\log\left(\frac{e^{f_{y_i}}}{\sum_j e^{f_j}}\right)$

BackPropagation



Convolutional Neural Nets

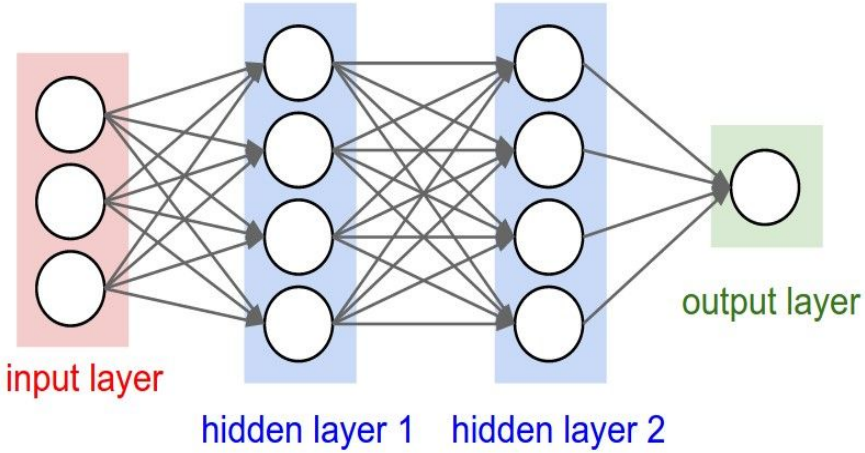
Very similar to Neural Nets.. But how are they different ?

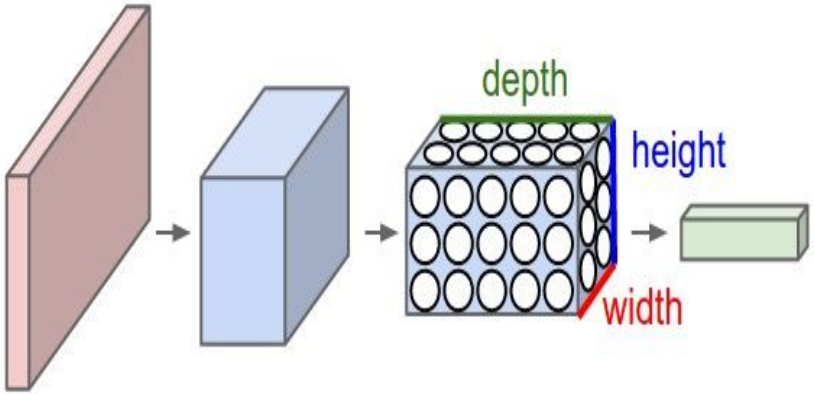


Convolutional Neural Nets

Vs. Neurals Nets

- Input is an image: Leverage 3D Structure
- Fully Connected ? **Fuhgeddaboudit**





The CNN Family

Winners of the ILSVRC ImageNet challenges

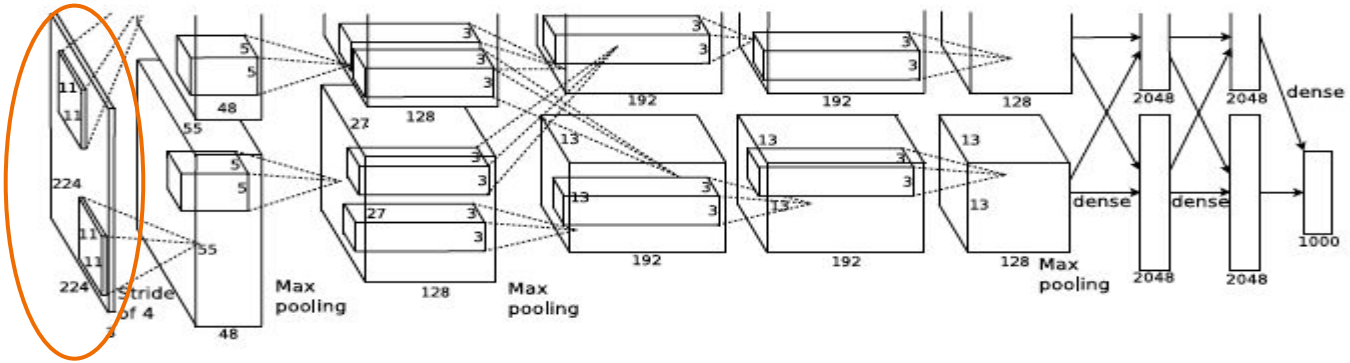
AlexNet (2012, Krizhevsky): Popularized CNNs - 1st to incorporate consecutive convolutional layers

GoogleNet / Inception (2014, Szegedy): Drastically reduced the # of parameters used (from 60 million to 4 million)

ResNet (2015, Kaiming He): Residual Network : famous for skip-connections and heavy use of batch-normalization; also removes some fully connected layers (at end of network)

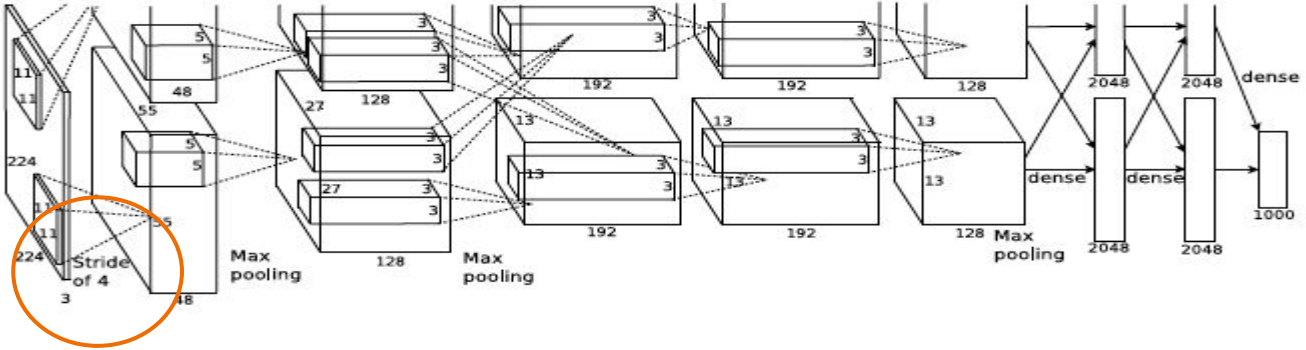
Convolutional Neural Nets : Architecture

1) **Input Layer: Raw pixel values of the image (ex: 224 x 224 x 3 (3 ~ color channels (RGB))**
2) Conv Layer
3) Pool Layer
4) ReLU Layer
5) FC (Fully Connected Layer)



Convolutional Neural Nets : Architecture

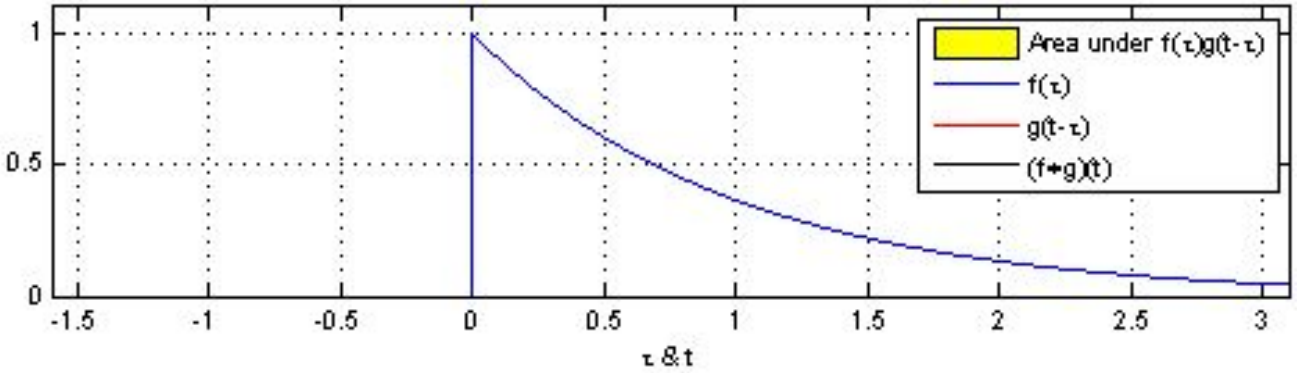
1) Input Layer: Raw pixel values of the image
2) **Conv Layer: Dot product between weights and the small region of input volume (ex: 11 x 11 x 3 filters)**
3) Pool Layer
4) ReLU Layer
5) FC (Fully Connected Layer)



Convolutional Neural Nets : Architecture

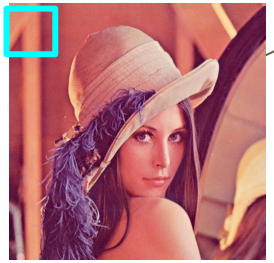
What is a Convolution?

$$f*g = \int f(t - \tau)g(\tau)d\tau$$



Convolutional Neural Nets : Architecture

What is a Convolution?



1	1	1	0
1	1	1	0
1	1	1	0

1	1	1
1	-8	1
1	1	1

→ 0

1	1	1	0
1	1	1	0
1	1	1	0

1	1	1
1	-8	1
1	1	1

→ -3

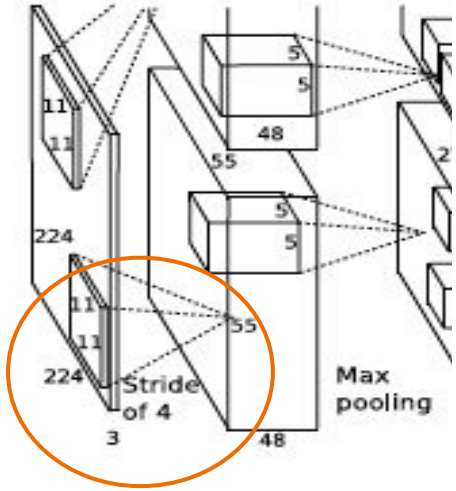
Convolutional Neural Nets : Architecture

What is a Convolution?

Convolutional Layer: (W-F + 2P)/S +1

- **W : Input Volume size**
- **F: Receptive Field size of the Conv Layer Neuron**
- **P: Zero- Padding**
- **S: Stride**

(224 - 11 +2(3))/4 + 1 = 55



Conv Layer Output ~ 55 x 55 x 96 (ie : 55^2 neurons in each layer)

Convolutional Neural Nets : Architecture

What is a Convolution?

Voila. We have 96 filters.

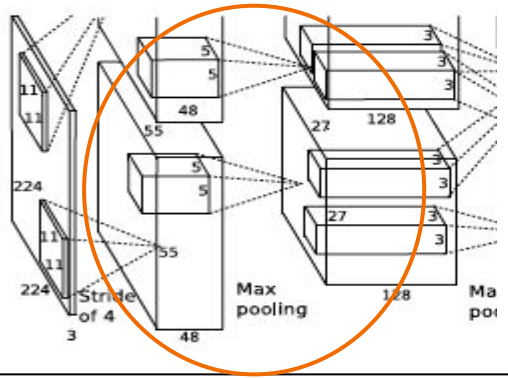
Convolutional Neural Nets : Architecture

1) Input Layer
2) Conv Layer
3) **Pooling Layer: Performs downsampling operation**
4) ReLU Layer
5) FC (Fully Connected Layer)

Our Eqn : O = (W- F)/S +1

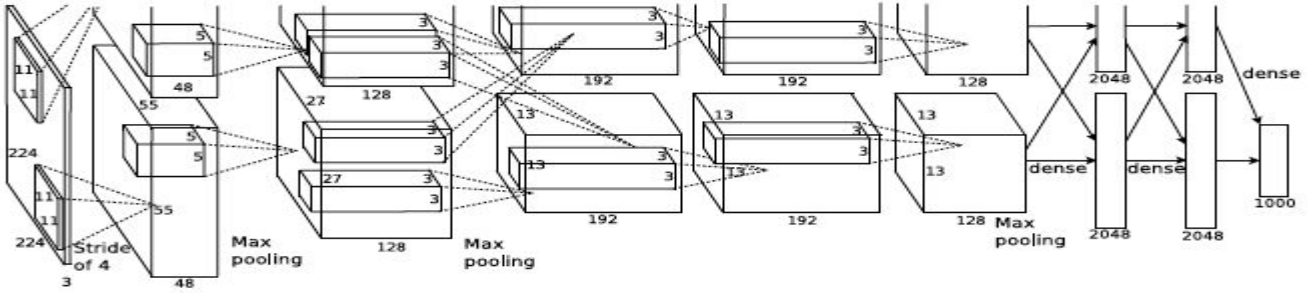
AlexNet: use 3 x 3 MaxPooling w/ stride = 2

O =(55-3)/2 + 1 = 27



Convolutional Neural Nets : Architecture

1) Input Layer: Raw pixel values of the image
2) Conv Layer:
3) Pool Layer:
4) **ReLU Layer: Apply an elementwise activation function**
   (ex : max(0,x) thresholding output dimension ~ same as input)
5) FC (Fully Connected Layer)



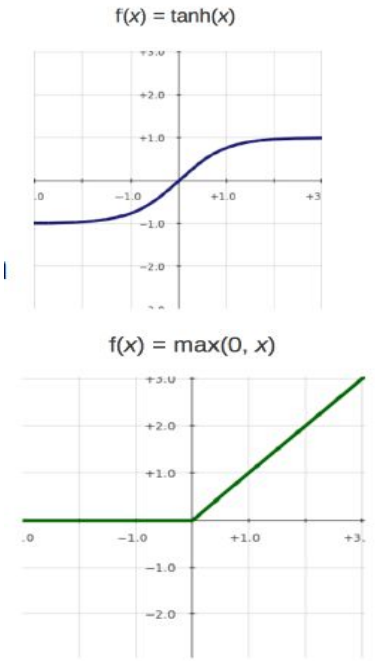
*The ReLU non-linearity is applied to the output of every convolutional and fully-connected layer.

Convolutional Neural Nets : Architecture

ReLU Layer:

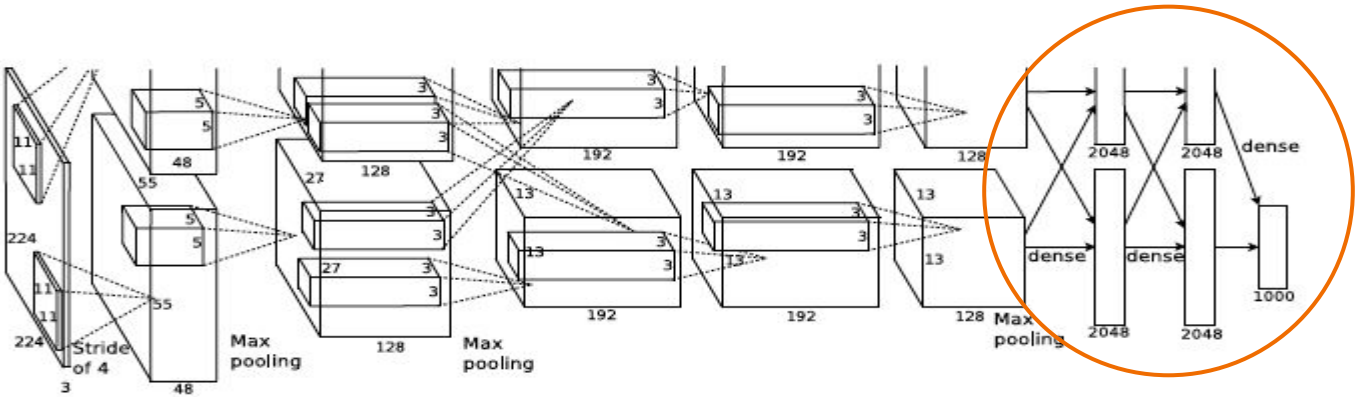
Tradionally:
f(x) = tanh(x) or fx= (1+e-x)^-1 (Very slow to train)

Now:
f(x) = max(0,x) (Faster to train)



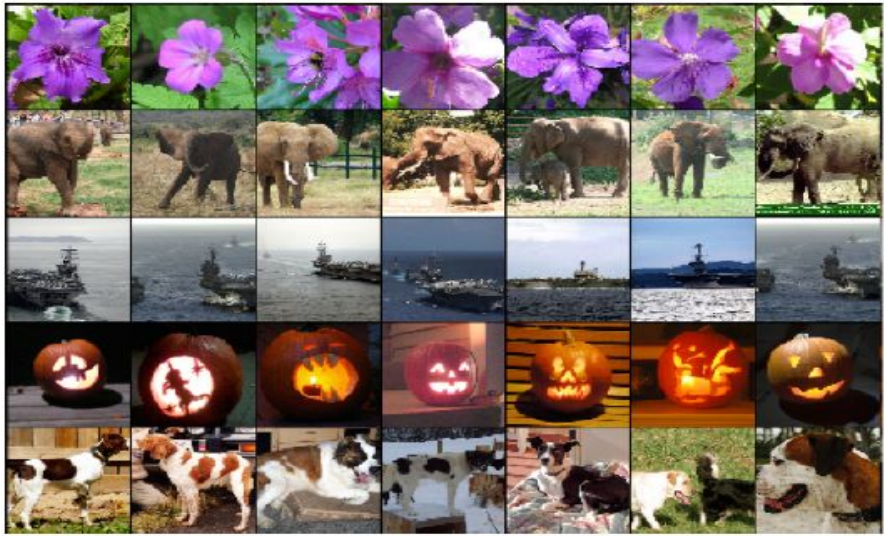
Convolutional Neural Nets : Architecture

1) Input Layer: Raw pixel values of the image
2) Conv Layer:
3) Pool Layer:
4) ReLU Layer:
5) **FC (Fully Connected) Layer : Each neuron will be connected to all activations of the previous volume. The output layer will compute class scores (ex: [1 x 1 x 1000])**



Convolutional Neural Nets : Architecture

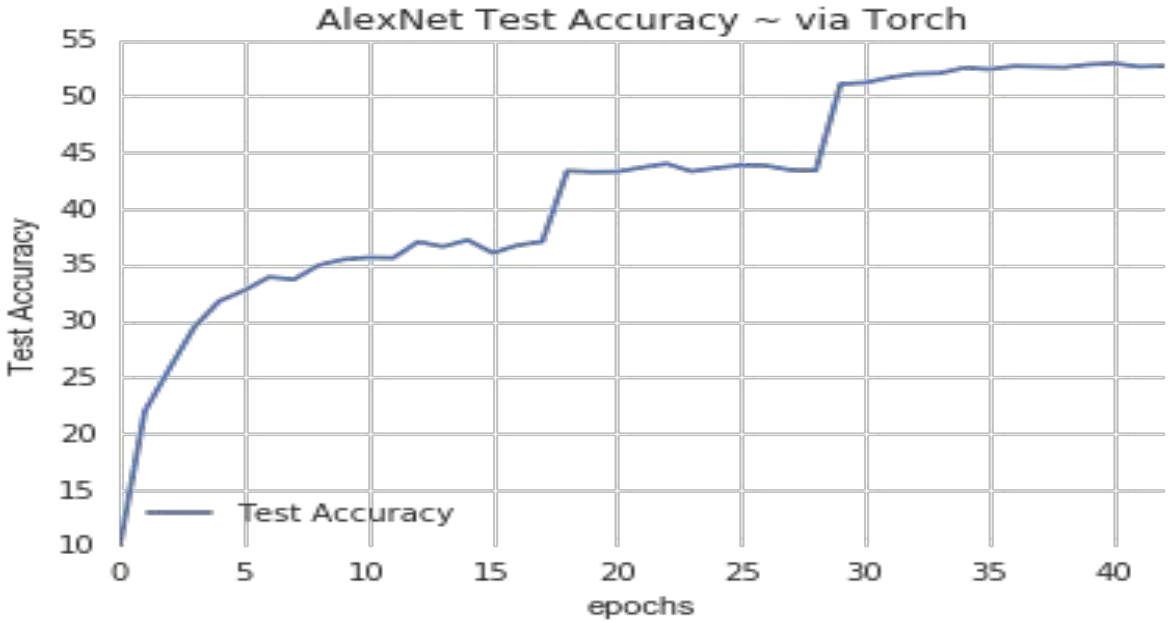
Output from the final 4096 fully connected layer :



Working with Behold.ai

How long does it take to train AlexNet to achieve 50% accuracy ?

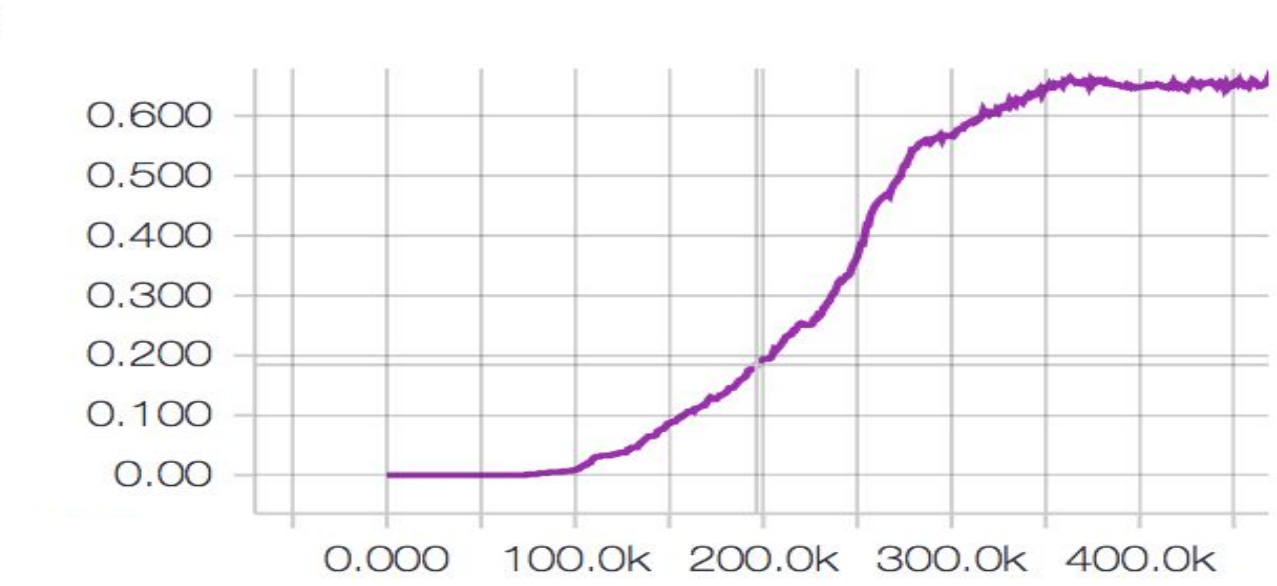
First: via Torch



Working with Behold.ai

How long does it take to train Inception-V3 to achieve 50% accuracy?

Then: via TensorFlow



Working with Behold.ai

Torch:

- Fast. Easy to integrate with GPUs
- Many modular pieces that are easy to combine https://github.com/soumith/imagenet-multiGPU.torch/blob/master/models/alexnet.lua
- Written in Lua

TensorFlow:

- Written in python & numpy
- Tensorboard for visualization
- Latest releases can be buggy
- Can be many x slower than Torch

https://console.aws.amazon.com/ec2/v2/home?region=us-east-1#LaunchInstanceWizard:

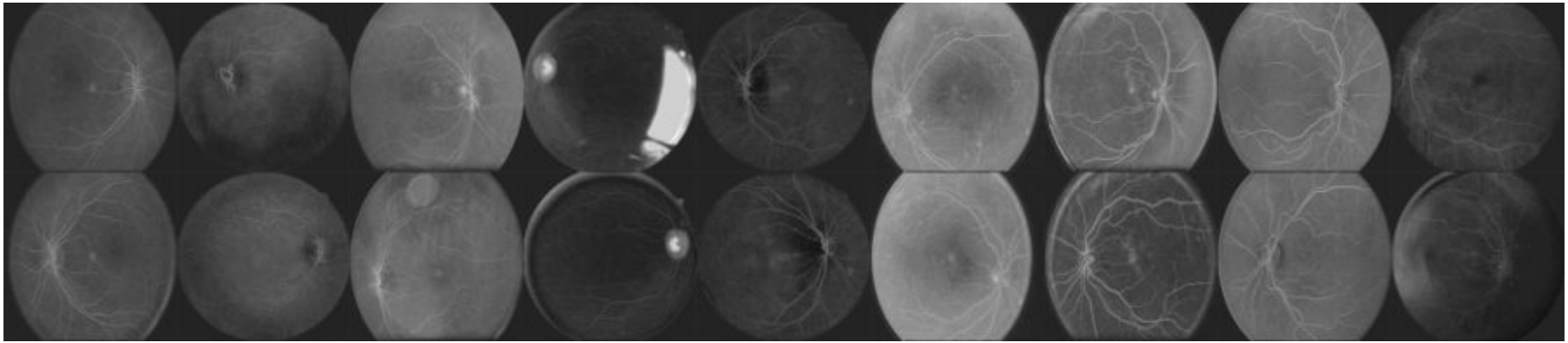
Working with Behold.ai

Can I leverage the AlexNet model and retrain it on a new dataset?

Train Retinopathy data via AlexNet on Torch

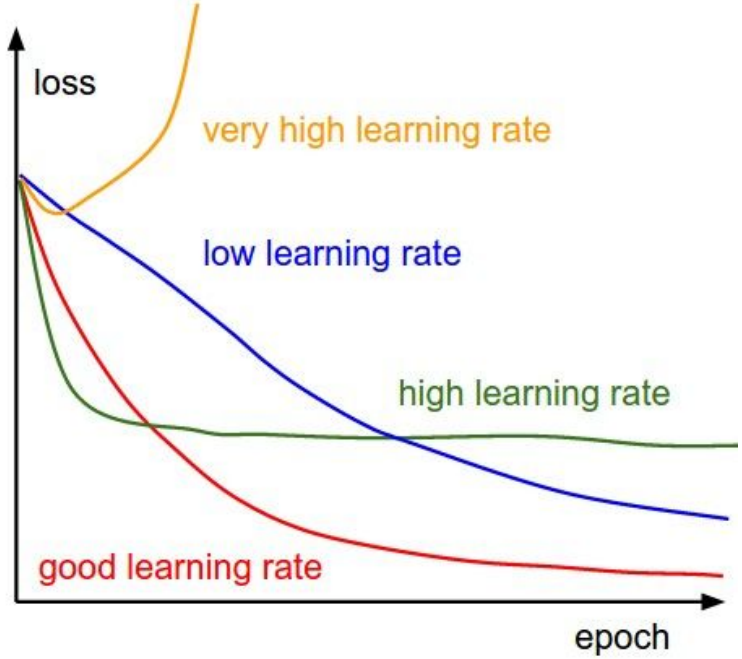
Kaggle Dataset:

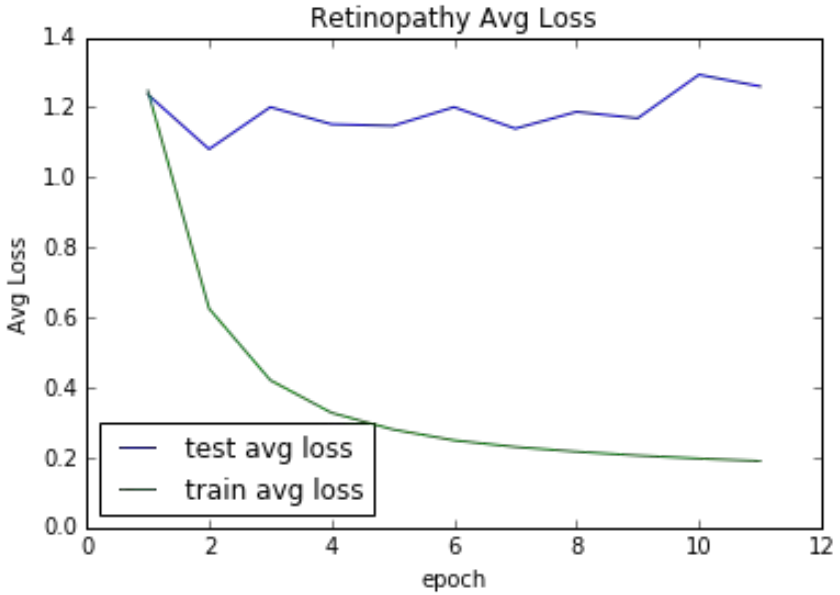
Diabetic Retinopathy Detection



Learning from the Learning Process

1) Loss functions

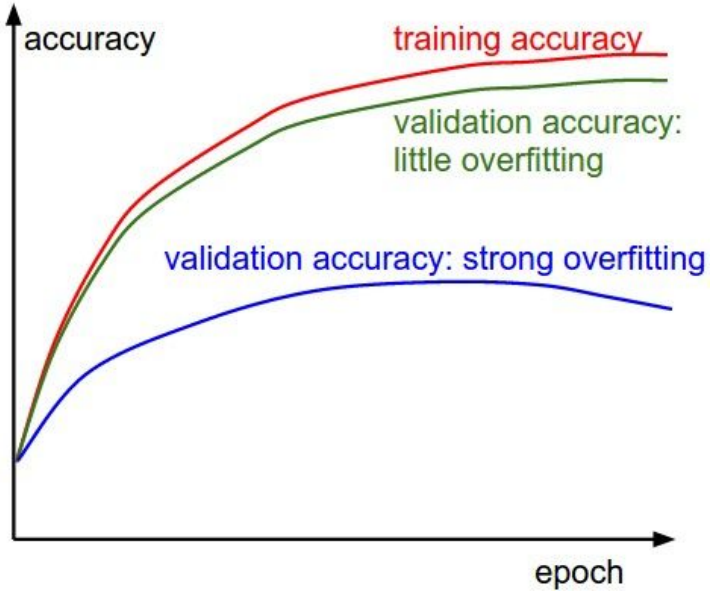


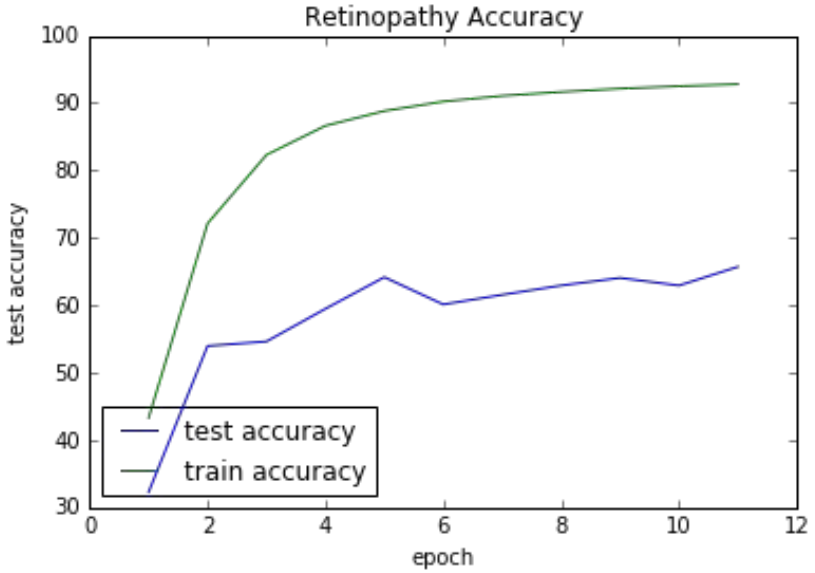


* Tip: Change the learning rate!

Learning from the Learning Process

2) Accuracy





* Tip: Increase L2 weight penalty , Increase Drop-Out, More Data (possibly with jitter) - -try batch norm ?

Learning from the Learning Process:

3) Weight Ratios

- update / weight ratio : should be roughly about 1e-3

(larger ~ learning rate may be too, too much lower ~ learning rate may be too low)

4) Activations & Gradient Distributions (per layer)

- An incorrect initialization can throw the model completely off

(Plot your activation & gradient histograms)

http://54.165.141.27:6006/#graphs

Learning from the Learning Process

5) First-layer Visualizations

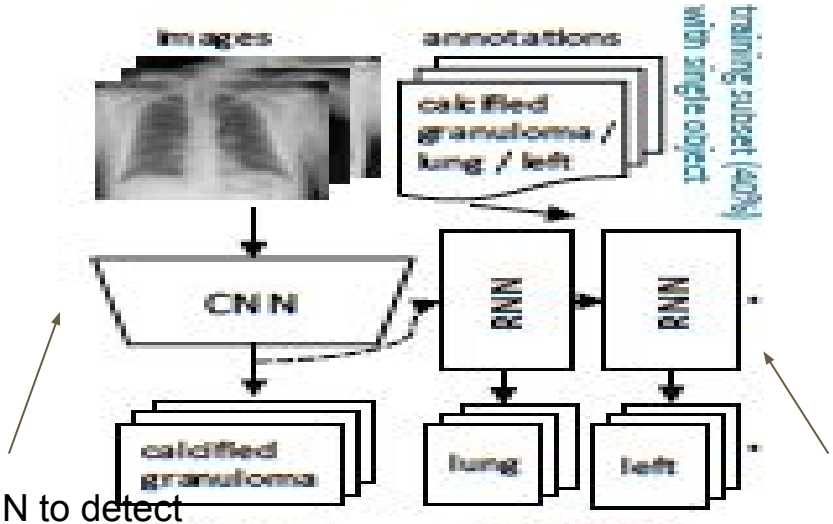
Visualized weights from the 1st layer of the network:

(smooth, diverse features indicate that training is going well)

Working with Behold.ai

Can we combine CNNs & with Recurrent Neural Nets to Decipher Image Annotation using Tensorflow?

Initial Training of CNN/RNN with single object labels:



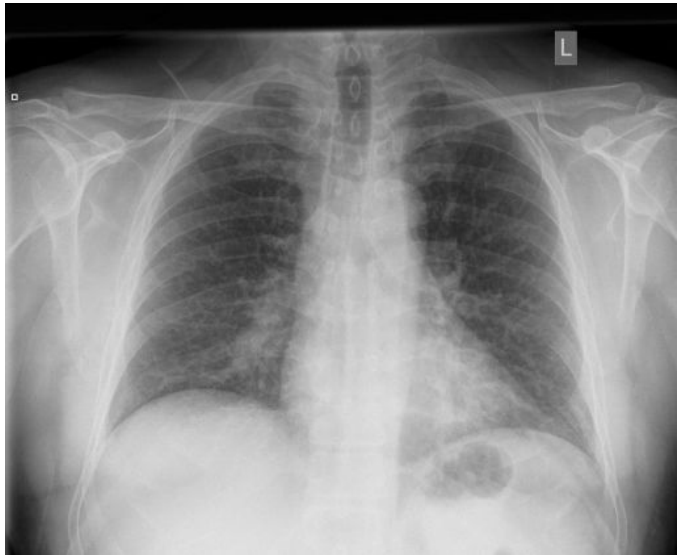
Train CNN to detect classes (15)

Train RNN to describe their contents

Working with Behold.ai

Can we combine CNNs & with Recurrent Neural Nets to Decipher Image Annotation using Tensorflow?

1) Train CNN to detect specific classes - Using Tensorflow

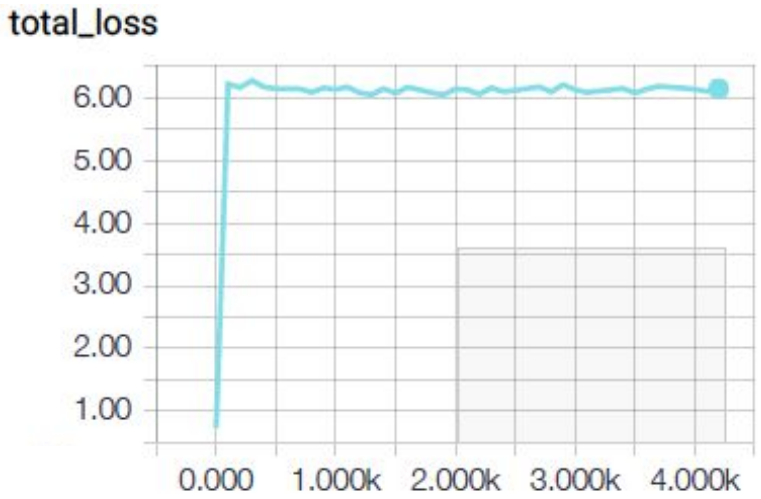


Opacity/lung/upper lobe/right

Working with Behold.ai

Can we combine CNNs & with Recurrent Neural Nets to Decipher Image Annotation using Tensorflow?

1) Train CNN to detect specific classes - Using Tensorflow's Inception V3

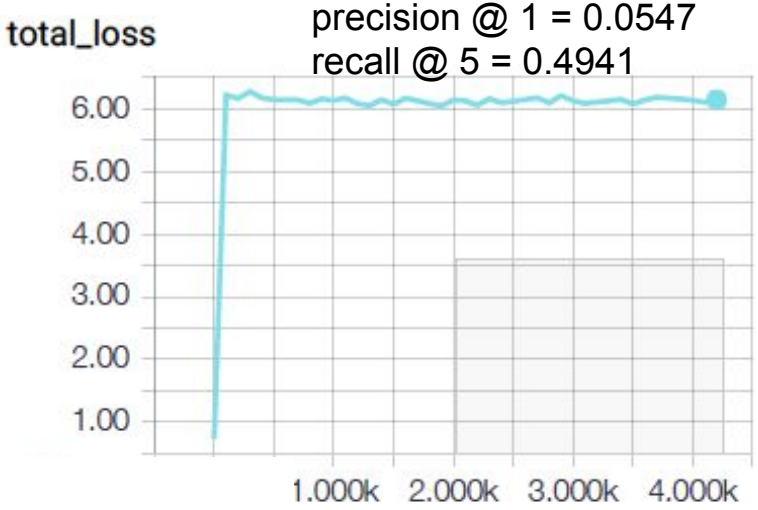


precision @ 1 = 0.0547
recall @ 5 = 0.4941

Working with Behold.ai

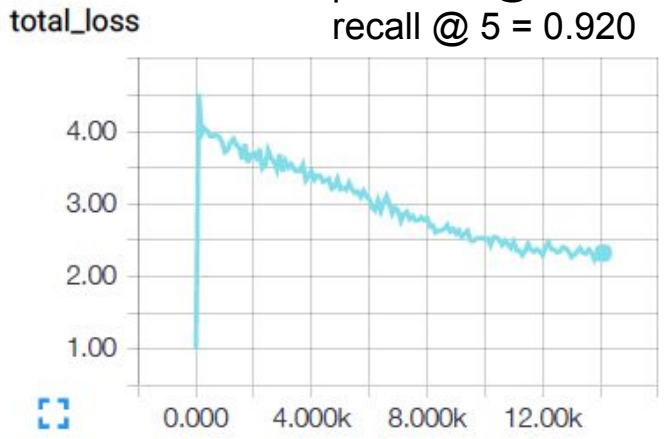
Can we combine CNNs & with Recurrent Neural Nets to Decipher Image Annotation using Tensorflow?

1) Train CNN to detect specific classes - Using Tensorflow's Inception V3



precision @ 1 = 0.0547
recall @ 5 = 0.4941

Train using Inception-V3 from scratch



precision @ 1 = 0.587
recall @ 5 = 0.920

Retrain using Inception-V3 from existing model

Working with Behold.ai

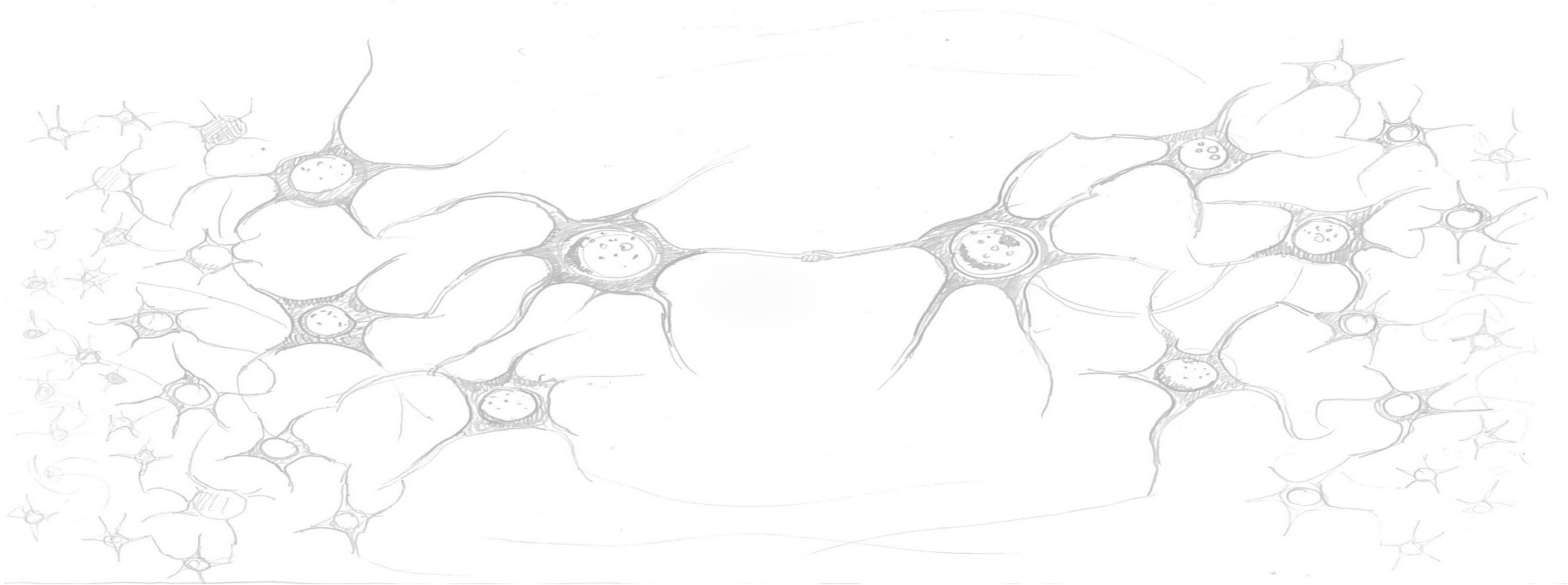
Can we combine CNNs & with Recurrent Neural Nets to Decipher Image Annotation using Tensorflow?

Why did that work so well ???

Next Steps:

- Combine the CNN Xray data with RNN to learn full annotated labels
- Use the ‘retrain’ method via Torch to retrain Kaggle Retinopathy dataset
- Leverage the ResNet model to train CNN Xray data via Torch

Thank you!



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