Autoencoders

Spring 2018

Review

- Last week:
  - Recurrent Neural Networks (RNNs)
  - Exploding/Vanishing Gradients
  - Gated RNNs: LSTMs

- Assignments (Canvas):
  - Project outline due next week
  - Prototype of final project system due next week

- Questions?

Today's Topics

- Autoencoders
- Fine-Tuning
- Software for Deep Learning
- Lab

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- Autoencoders
- Fine-Tuning
- Software for Deep Learning
- Lab

Recall: Types of Learning Tasks

- Unsupervised
  - No label given for training data

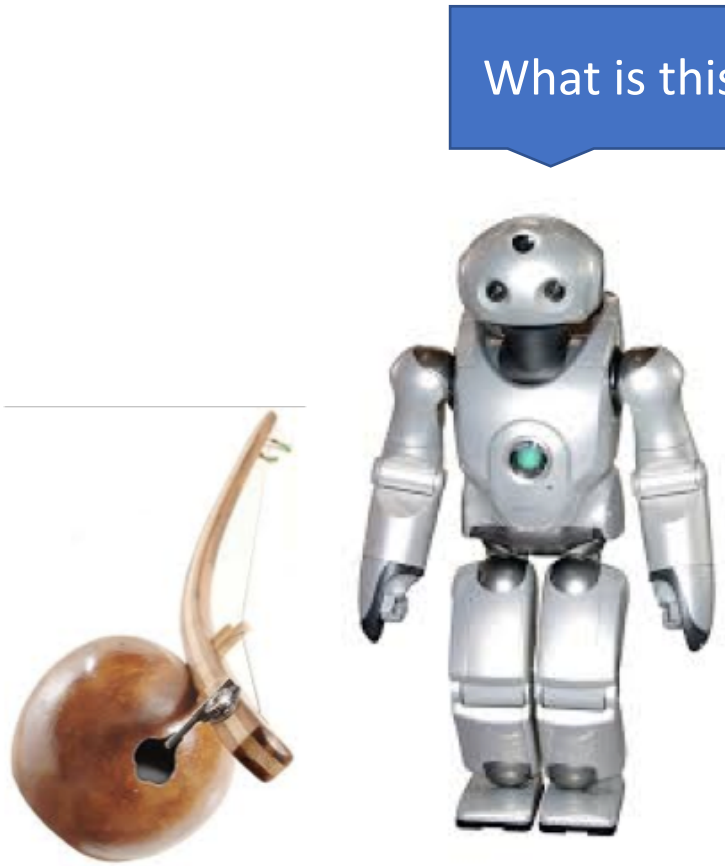
- Supervised
  - Label given for training data: e.g., “cat”

What is this?

Recall: Types of Learning Tasks

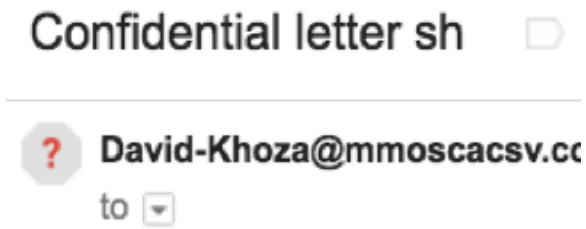
- Unsupervised
  - No label given for training data

- Supervised
  - Label given for training data: e.g., “berimbau”



Recall: Types of Learning Tasks

- Unsupervised
  - No label given for training data
- Supervised
  - Label given for training data: e.g., “yes”



Is this email spam?

Intuition: How Do Humans Learn?

- Supervision:
  - Idea: learn to group objects into one class because someone tells us to
- Experience:
  - Idea: learn to group objects into one class by seeing many of them

Unsupervised Learning with Neural Networks

How would you design an architecture if you are not given labels?

Autoencoder Architecture

- Learn to copy the input to the output

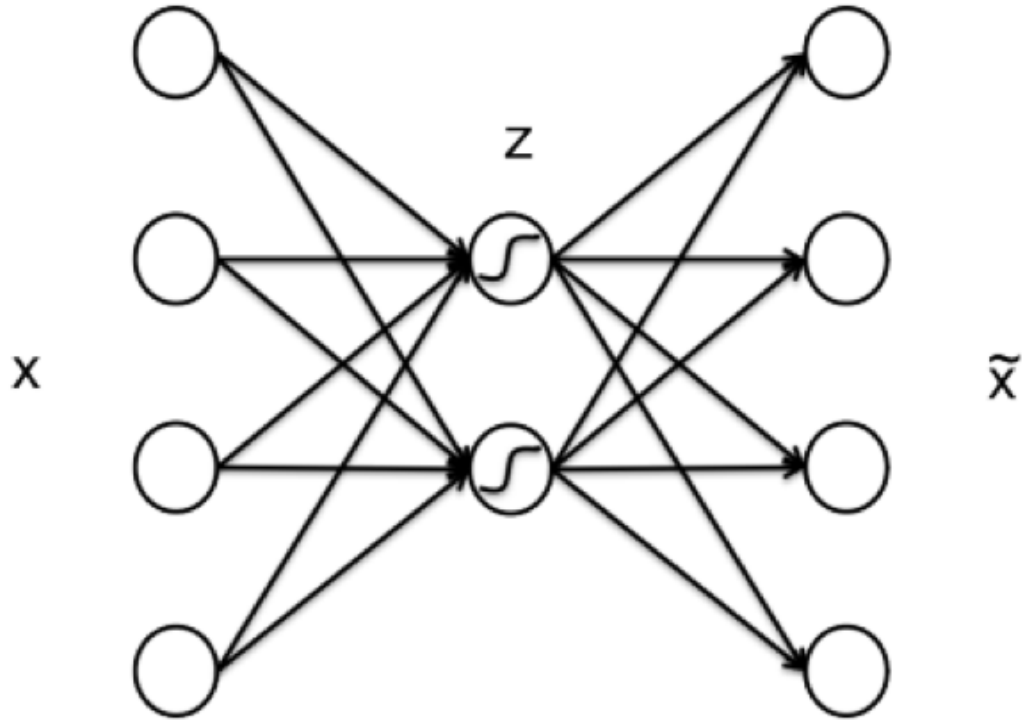


Figure Credit: https://lazyprogrammer.me/a-tutorial-on-autoencoders/

Autoencoder Architecture

- Consists of two parts:
  - **Encoder**: compresses inputs to an internal representation
  - **Decoder**: tries to reconstruct the input from the internal representation

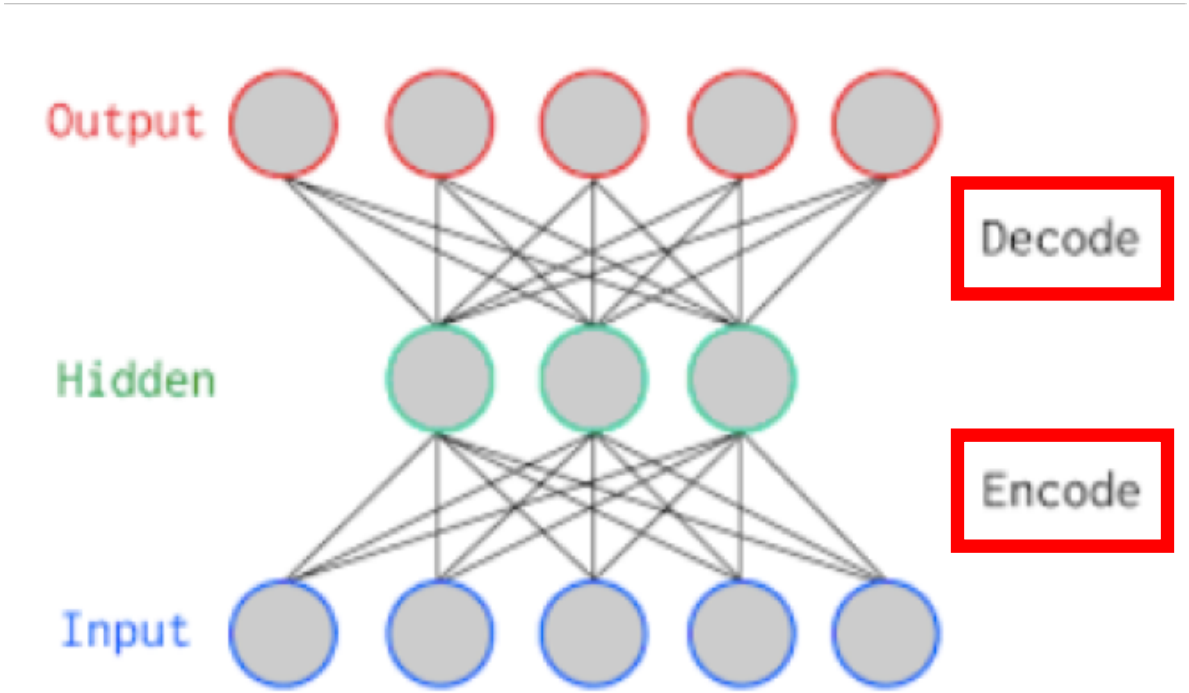
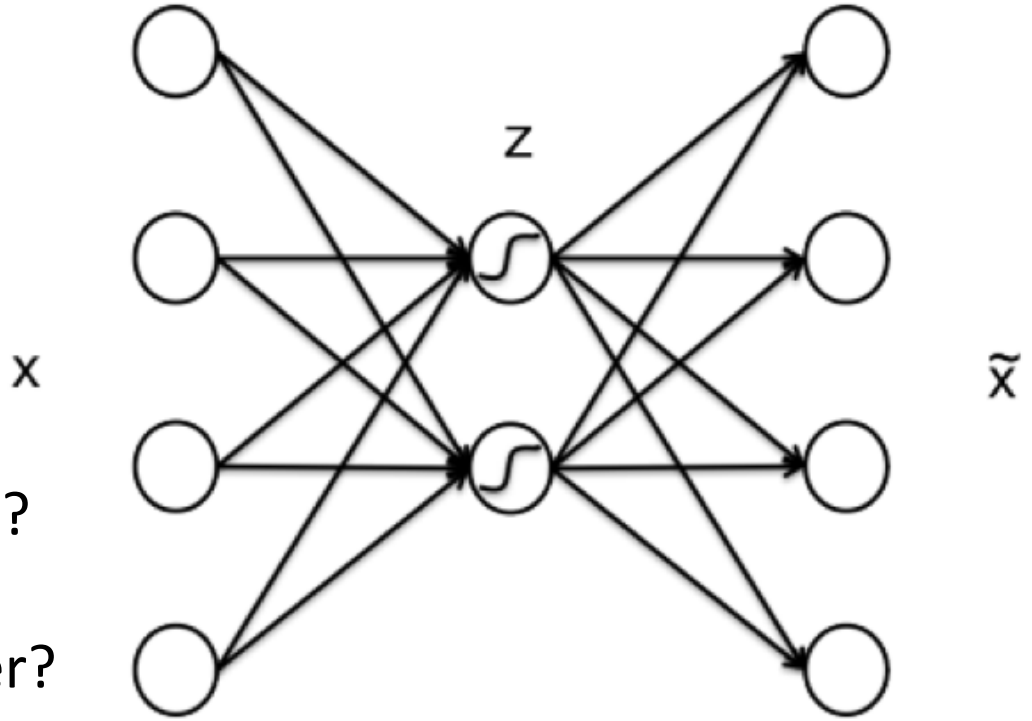


Figure Credit: https://www.datacamp.com/community/tutorials/autoencoder-keras-tutorial

Autoencoder Architecture

- Given this input 620 x 426 image (264,120 pixels):



  - What would a perfect autoencoder predict?
    - Itself
  - What number of nodes are in the final layer?
    - 264,120

Figure Credit: https://lazyprogrammer.me/a-tutorial-on-autoencoders/

Autoencoder Training

How do you train a neural network?

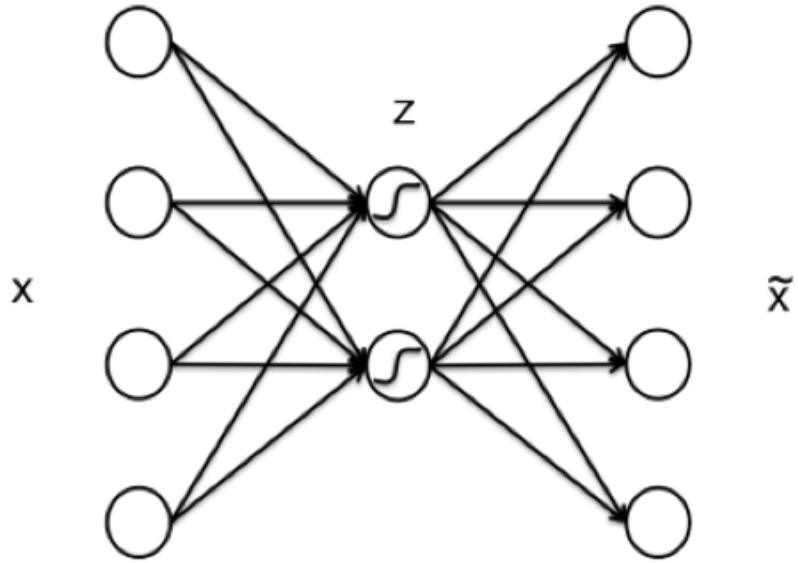
Autoencoder Training

Repeat until stopping criterion met:

1. **Forward pass**: propagate training data through network to make prediction
2. **Backward pass**: using predicted output, calculate error gradients backward
3. Update each weight using calculated gradients

Autoencoder

What are useful applications for autoencoders?



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Autoencoders: Dimensionality Reduction

- Intuition: which number sequence is easier to remember?
  - **A:** 30, 27, 22, 11, 6, 8, 7, 2
  - **B:** 30, 15, 46, 23, 70, 35, 106, 53, 160, 80, 40, 20, 10, 5
- **B:** need learn only two rules
  - If even, divide by 2
  - If odd, multiply by 3 and add 1

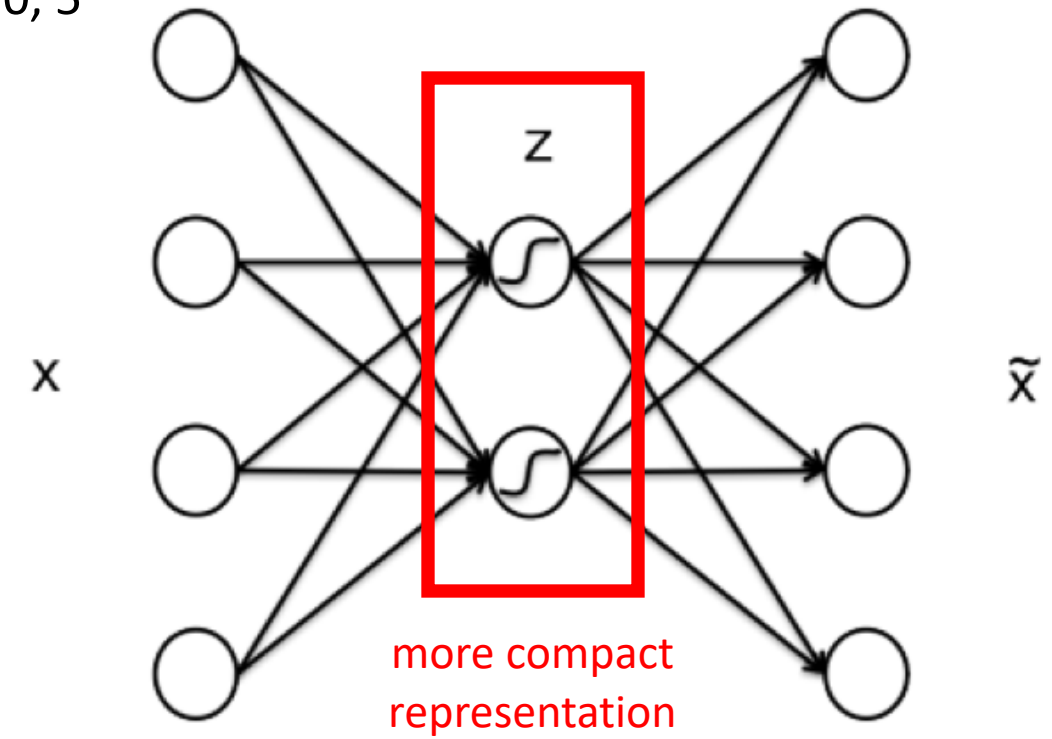
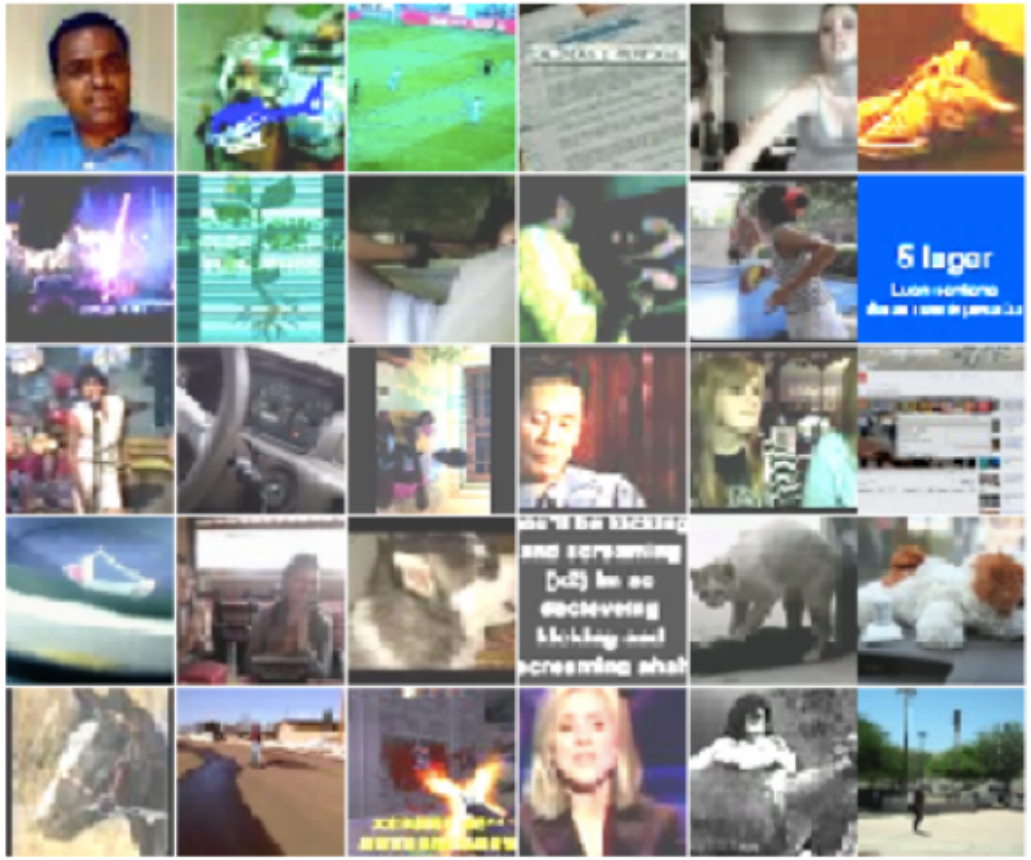


Figure Credit: https://lazyprogrammer.me/a-tutorial-on-autoencoders/

Autoencoders: Feature Extraction

- e.g., training data:
  - 1 image taken from 10 million YouTube videos
  - Each image is in color and 200x200 pixels

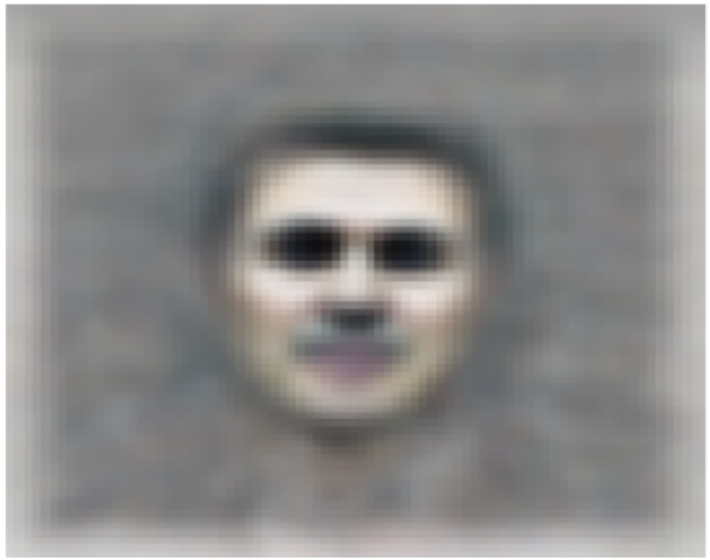


- What features do you think it learned?

Quoc V. Le et al., Building High-level FeaturesUsing Large Scale Unsupervised Learning; 2013.

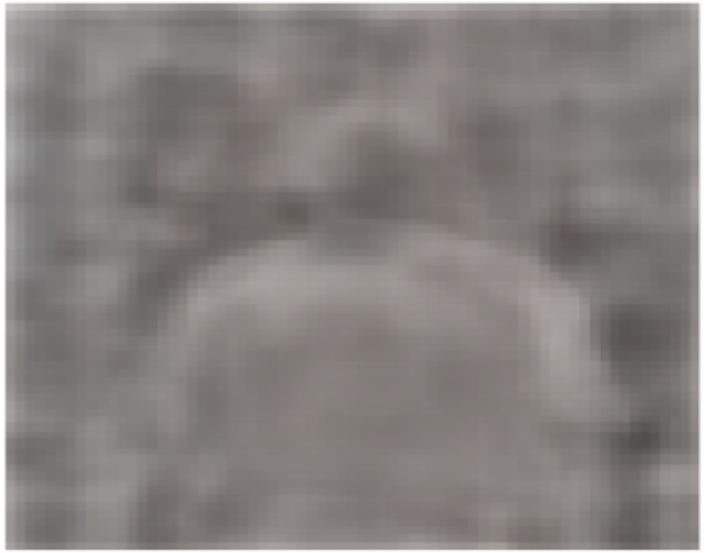
Autoencoders: Feature Extraction

- e.g., features learned include:



human face

cat face



human body

Quoc V. Le et al., Building High-level FeaturesUsing Large Scale Unsupervised Learning; 2013.

Autoencoders: Unsupervised Pretraining

- Why use unsupervised pretraining?
  - Little training data is available
  - Too costly and slow to collect labels for exclusive supervised training

- e.g., add one-versus-all logistic classifiers on top of the highest layer of pretrained autoencoder network (fine-tuning)

Quoc V. Le et al., Building High-level FeaturesUsing Large Scale Unsupervised Learning; 2013.

Autoencoders: Generative Models

Ian Goodfellow et al; Adversarial Autoencoders; 2016

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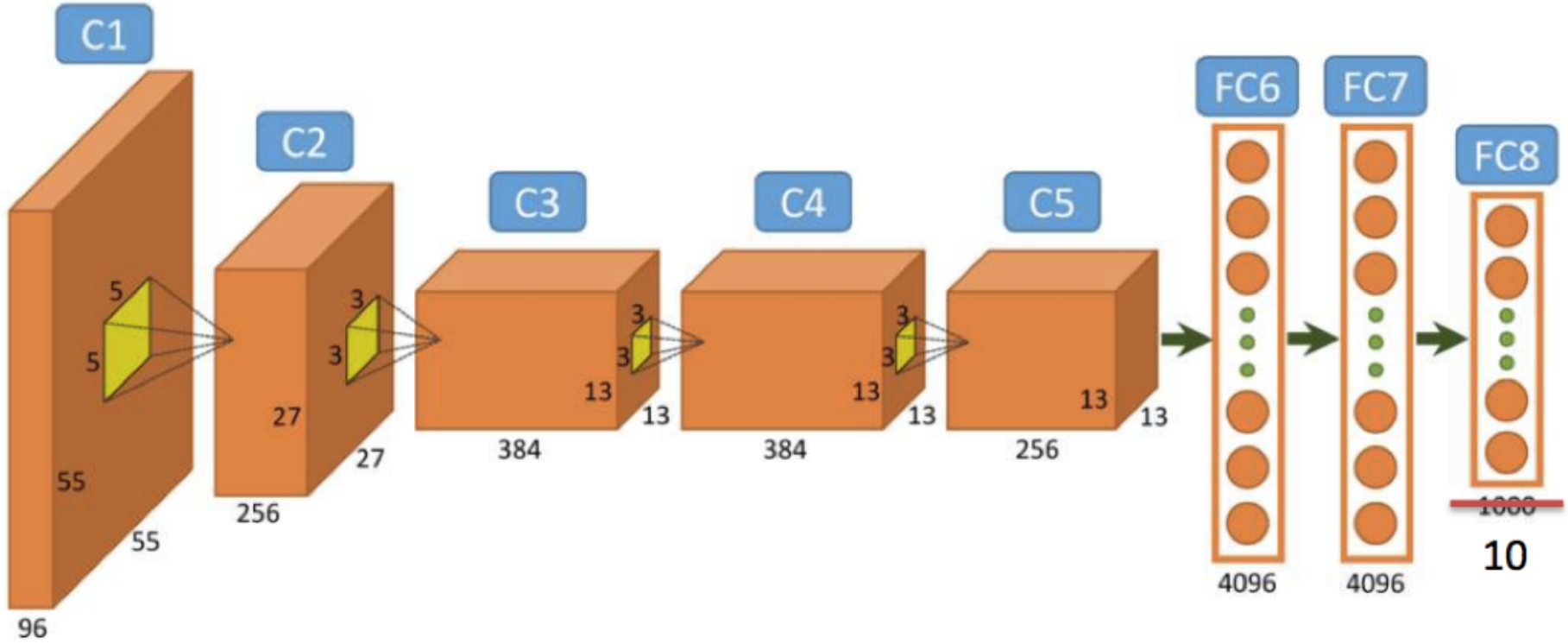
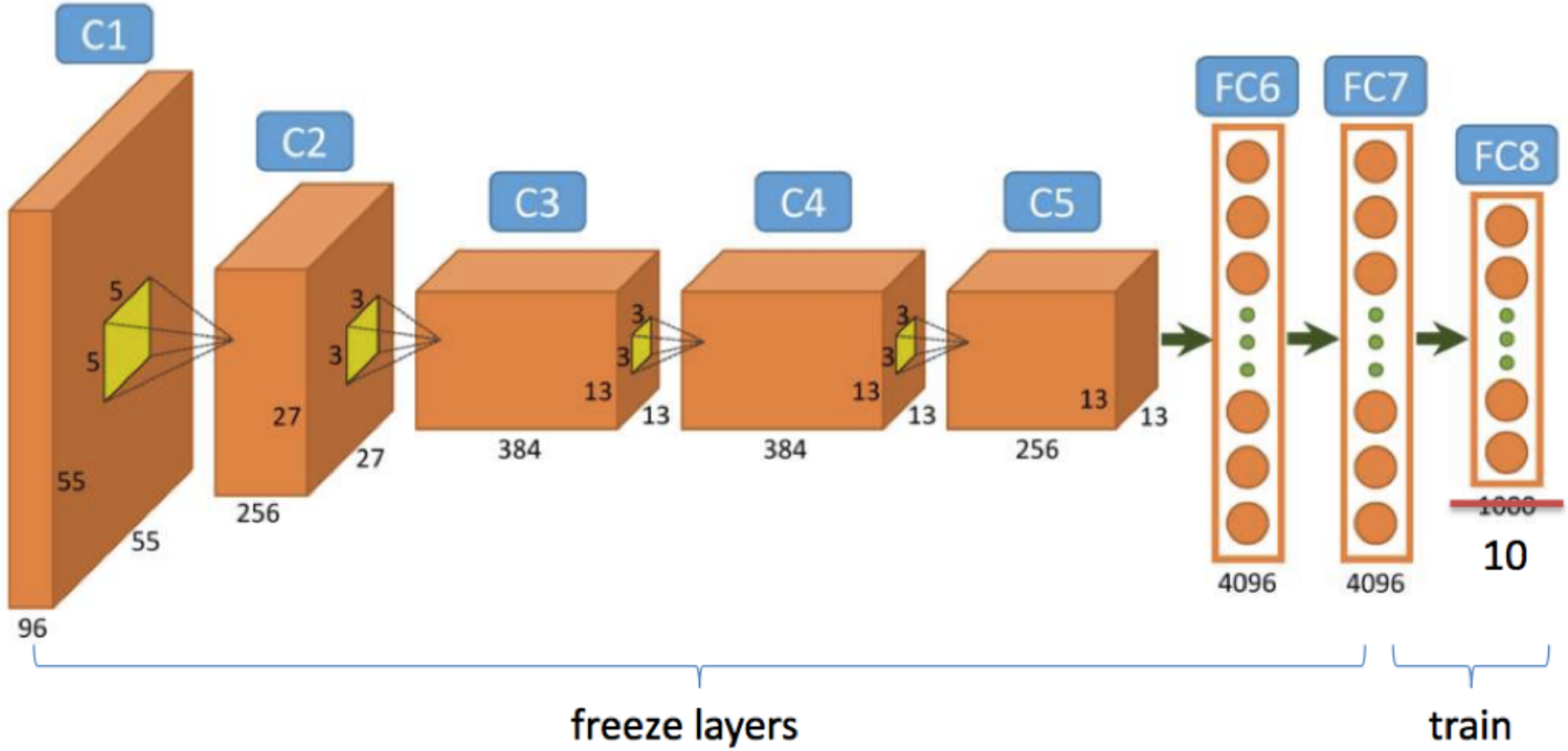
Fine-Tuning: Example 1



Slide Credit: https://www.slideshare.net/AndrKarpitenko/practical-deep-learning

Fine-Tuning: Example 1



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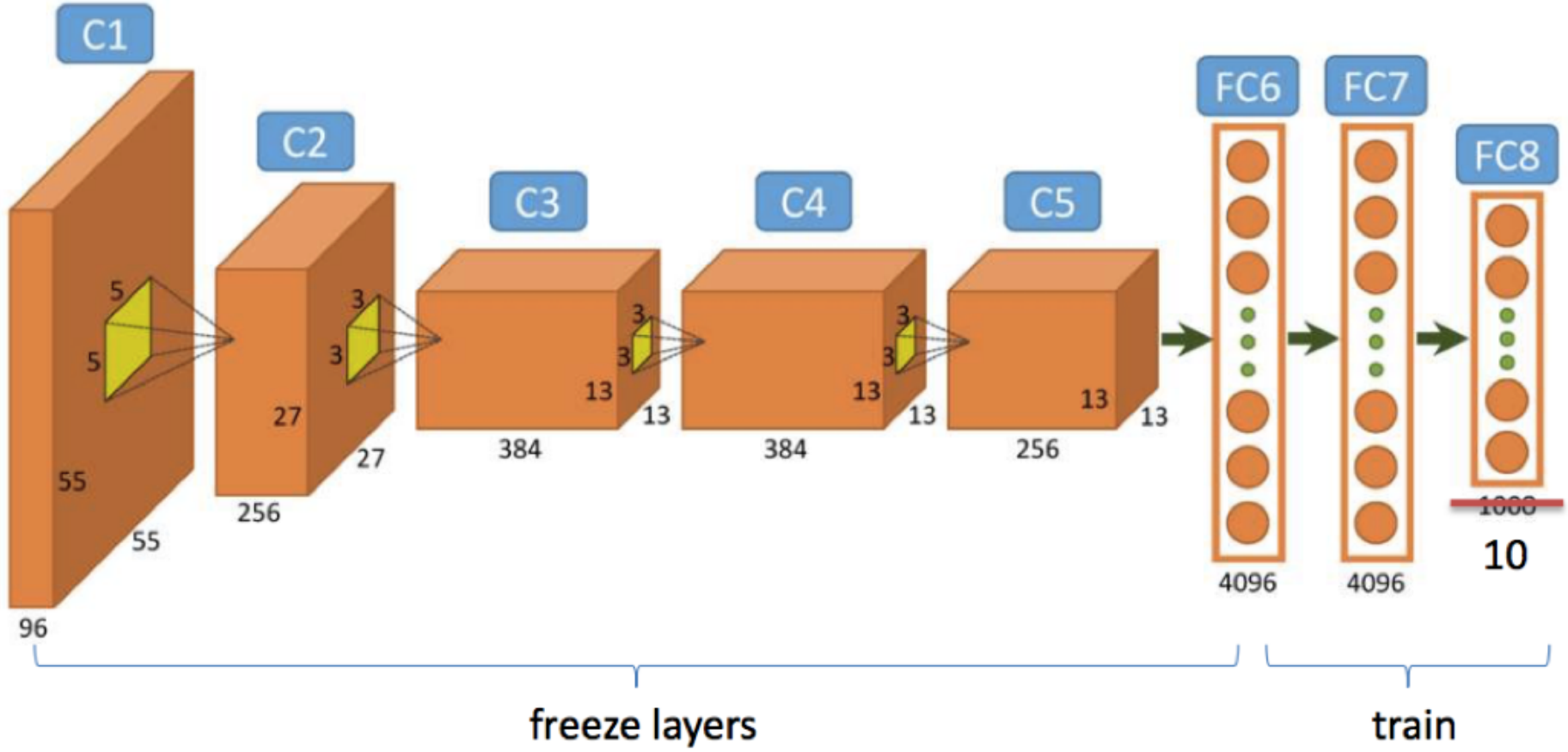

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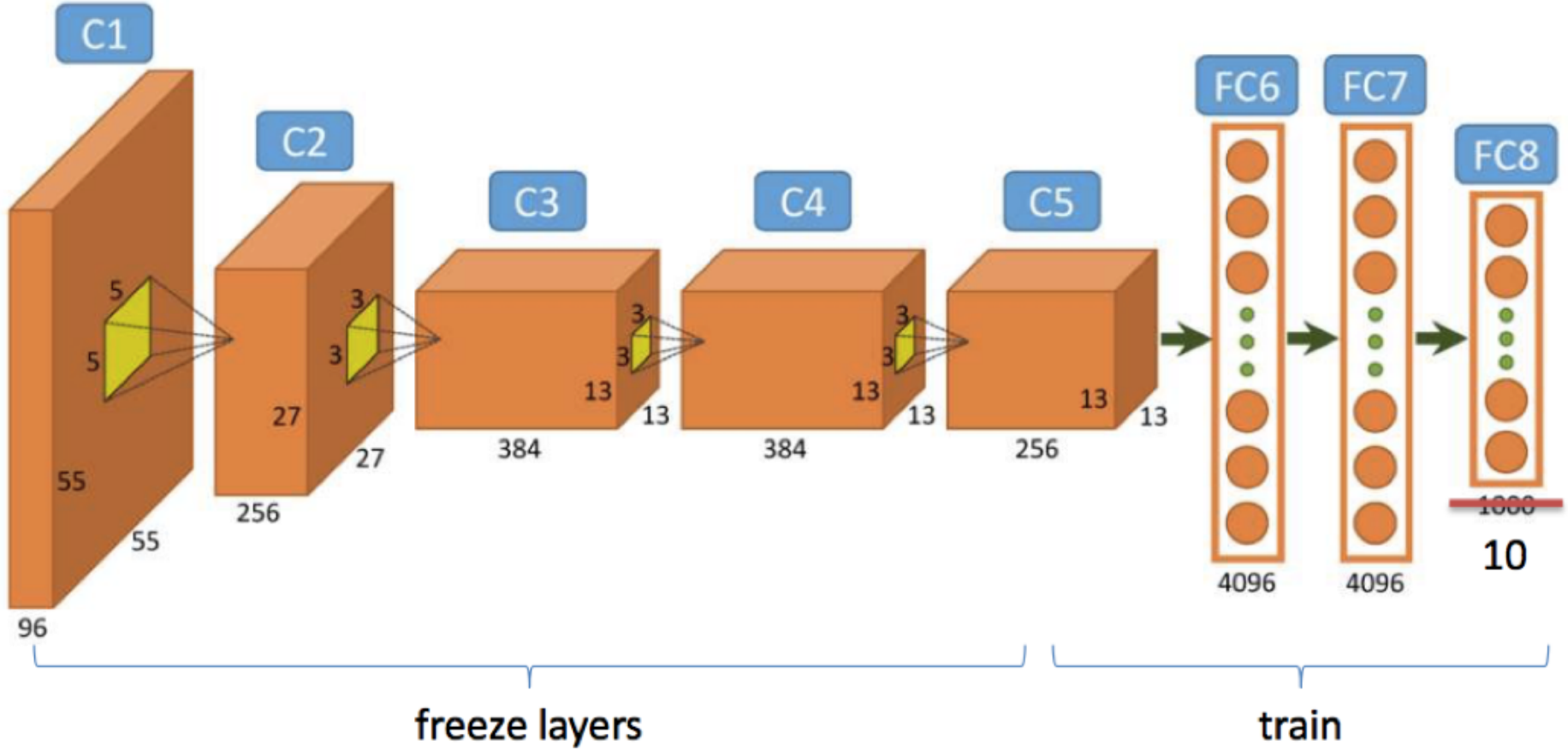

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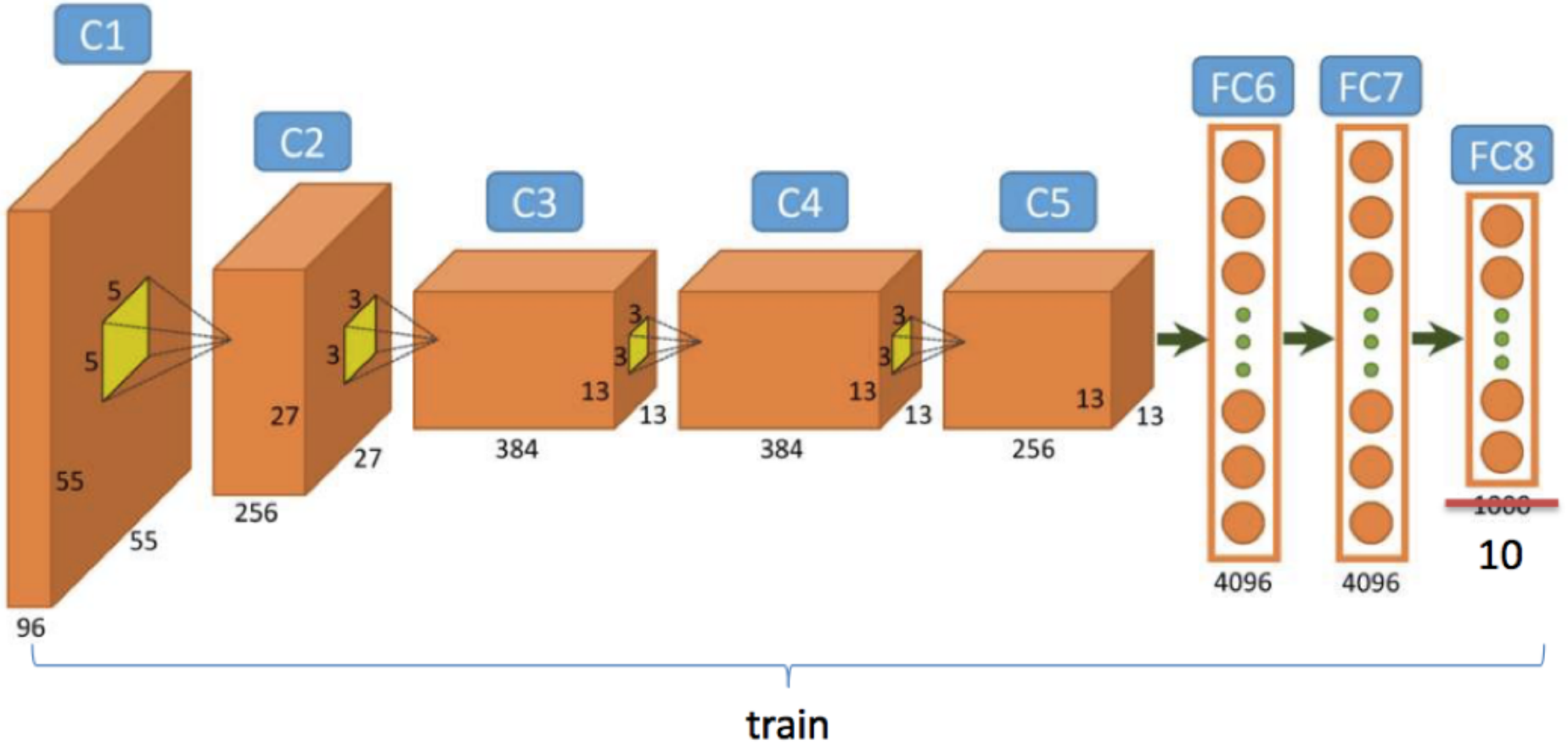

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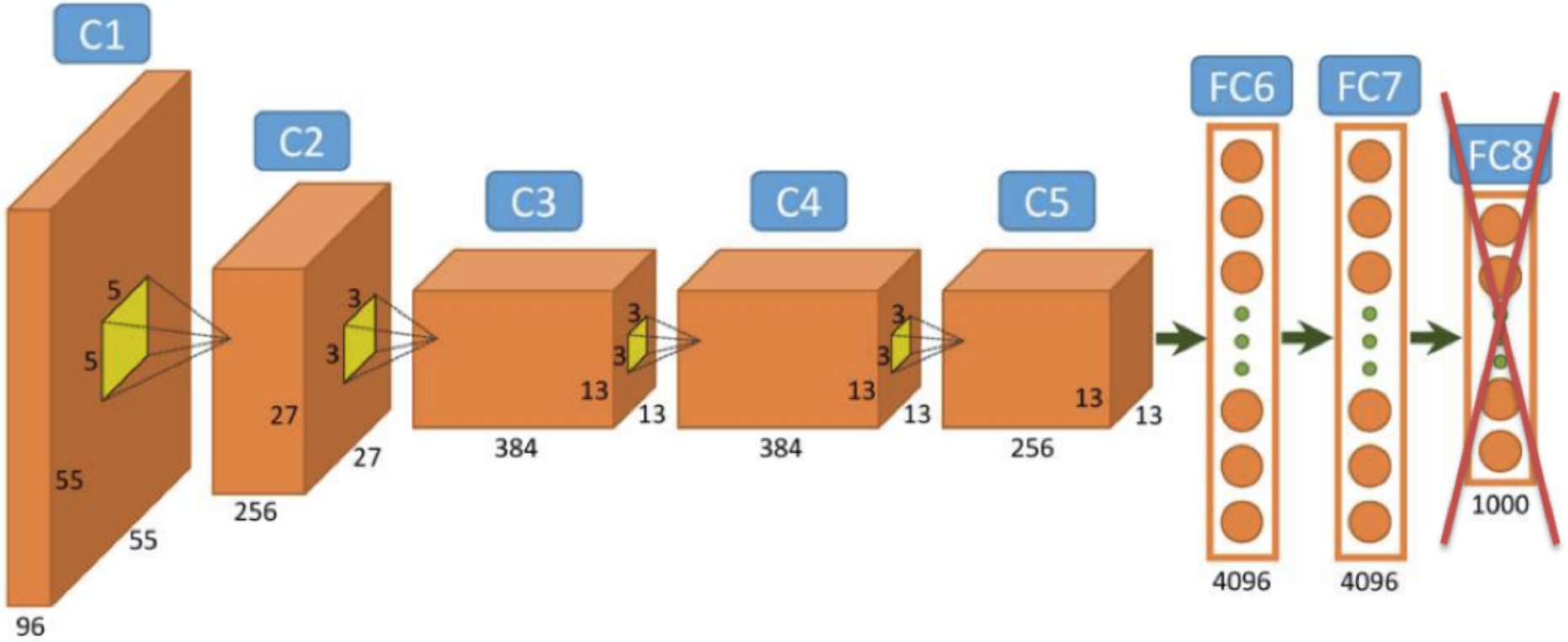
Fine-Tuning: Example 2



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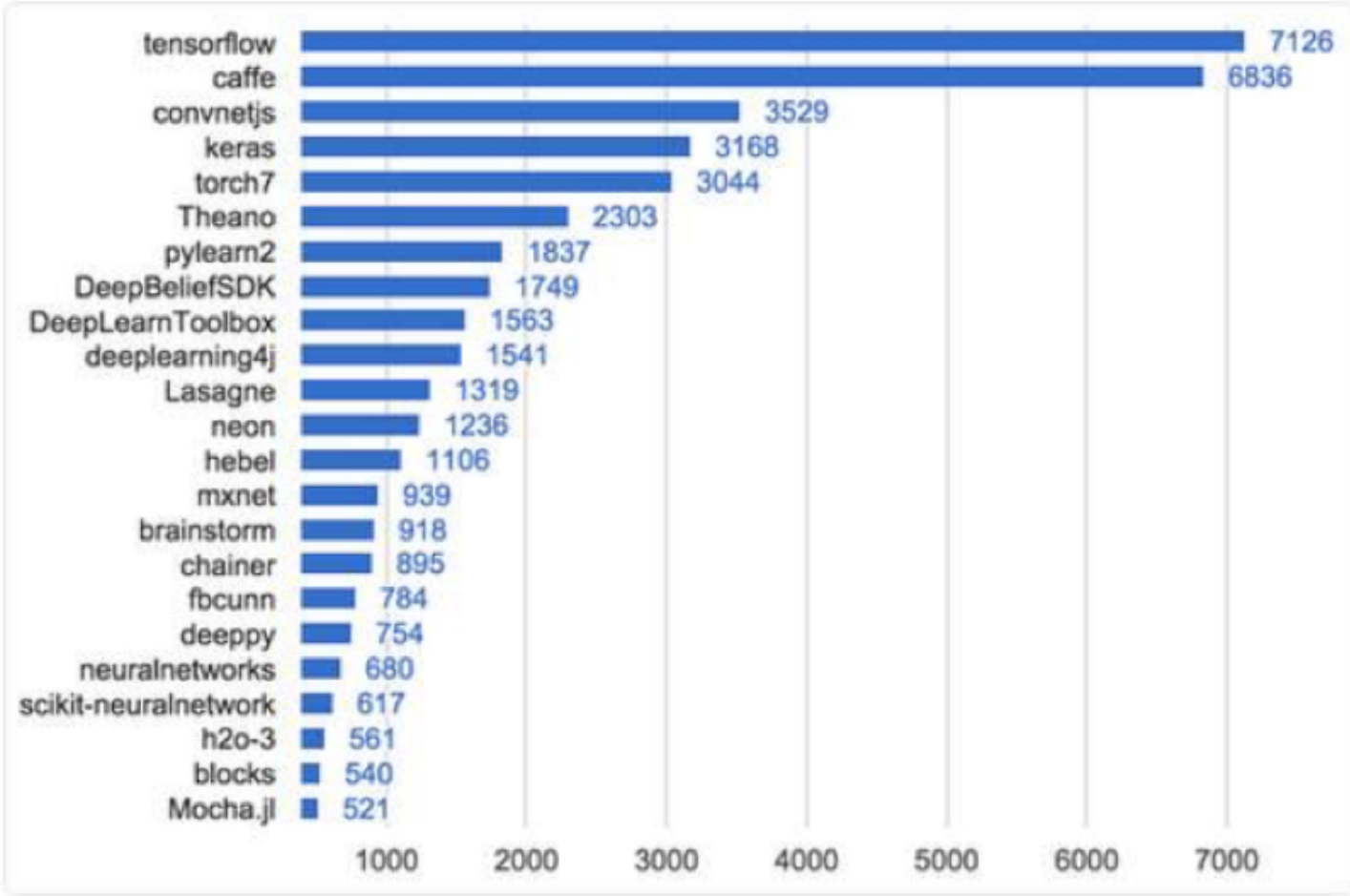
Software

Figure Credit: https://developer.nvidia.com/deep-learning-software

Software

2010-2014: a new deep learning toolkit is released every 47 days. 2015: every 22 days. tensorflow & caffe top github



RETWEETS 157 LIKES 159

1:05 AM - 11 Nov 2015

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Software

Software	Creator	Software license[a]	Open source	Platform	Written in	Interface	OpenMP support	OpenCL support	CUDA support	Automatic differentiation[1]	Has pretrained models	Recurrent nets	Convolutional nets
Caffe	Berkeley Vision and Learning Center	BSD license	Yes	Linux, macOS, Windows[2]	C++	Python, MATLAB	Yes	Under development[3]	Yes	Yes	Yes[4]	Yes	Yes
Deeplearning4j	Skymind engineering team; Deeplearning4j community; originally Adam Gibson	Apache 2.0	Yes	Linux, macOS, Windows, Android (Cross-platform)	C++, Java	Java, Scala, Clojure, Python (Keras), Kotlin	Yes	On roadmap[5]	Yes[6][7]	Computational Graph	Yes[8]	Yes	Yes
Dlib	Davis King	Boost Software License	Yes	Cross-Platform	C++	C++	Yes	No	Yes	Yes	Yes	No	Yes
Intel Data Analytics Acceleration Library	Intel	Apache License 2.0	Yes	Linux, macOS, Windows on Intel CPU[10]	C++, Python, Java	C++, Python, Java[10]	Yes	No	No	Yes	No		Yes
Intel Math Kernel Library	Intel	Proprietary	No	Linux, macOS, Windows on Intel CPU[11]		C[12]	Yes[13]	No	No	Yes	No	Yes[14]	Yes[14]
Keras	François Chollet	MIT license	Yes	Linux, macOS, Windows	Python	Python, R	Only if using Theano as backend	Under development for the Theano backend (and on roadmap for the TensorFlow backend)	Yes	Yes	Yes[15]	Yes	Yes

Figure Credit: https://en.wikipedia.org/wiki/Comparison_of_deep_learning_software

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- Hardware and Software for Deep Learning
- Lab