Training vision models with public transportation datasets

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Computer Vision
Convolutional Neural Networks
Object Detection
Image Segmentation

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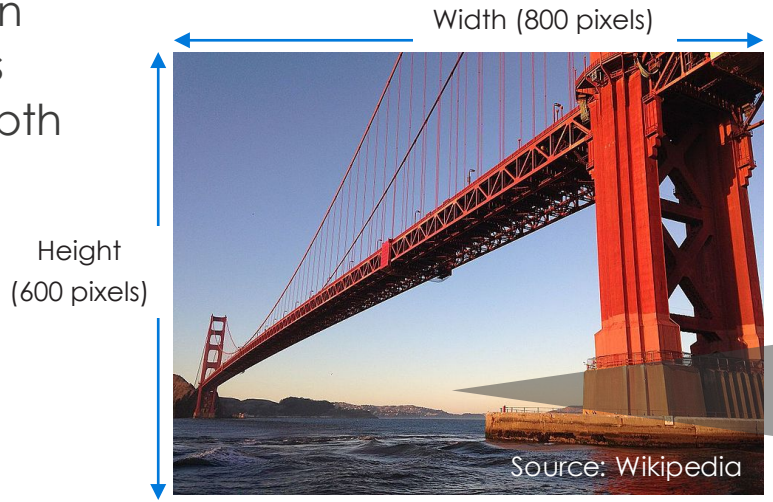
Agenda

- Computer Vision 101
- History of Computer Vision
- Deep Learning Basics
- Convolutional Neural Networks
- Image Classification Walk Through

Computer Vision 101

- Image Properties
  - Pixels
  - Dimension
  - Channels
  - Color Depth



8-bit Image

Color Depth	Channel Range
1-Bit	0-1
8-Bit	0-255
16-Bit	0-65,535
24-Bit	0-16,777,215

One Pixel

Channel	Red	Green	Blue
Value	0-255	0-255	0-255

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Computer Vision 101

Segmentation: Pixel-wise segments of objects in any image

Classification:
Label Item(s) in Image

Description:
Relationship between objects

Detection/Localization:
Bounding Boxes around objects

Goal: Build models that can perform visual tasks

Classification & Description

What is the man doing?

Submit

Predicted top-5 answers with confidence:

playing	99.126%
tennis	
tennis	0.553%
skateboarding	0.139%
serving	0.075%
jumping	0.033%

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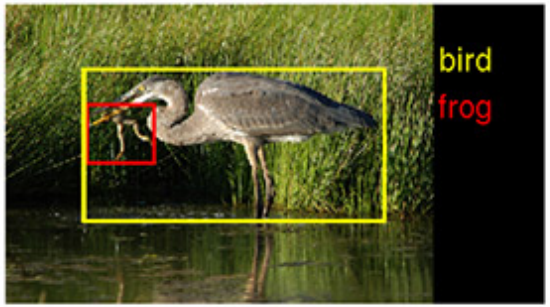
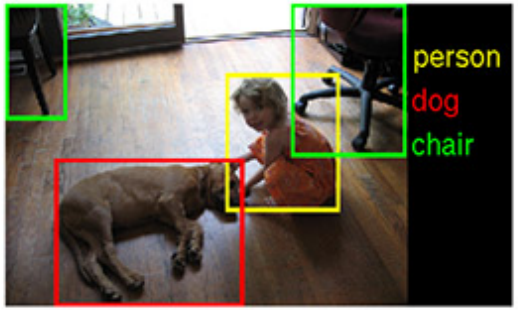
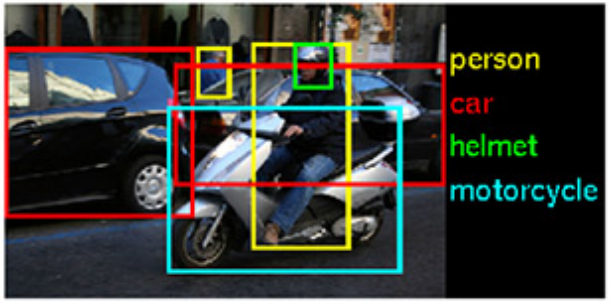
Localization







Source: Kaggle ImageNet Object Detection Challenge

Segmentation

Source: The Cityscapes Dataset - Semantic, instance-wise, dense pixel annotations of 30 classes

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History of Computer Vision

- Objectives
  - Extract generalized features (patterns) from images
  - Determine generalized descriptors for feature
  - Use generalized features to perform visual tasks based on descriptors
- What are features?
  - Edges
  - Shapes
  - Change in Colors/Intensity

Traditional Machine Learning → Deep Learning

- Featuring engineering challenges
  - Human scaling: Time consuming to create rules for each object
  - Computational scaling: Translating human curated features to algorithms that machines can perform at scale is tedious
- Feature Learning
  - Design computational models to learn features
- Feature Learning Challenges
  - Need large datasets with annotations
  - Model architectures become complex both to design and run

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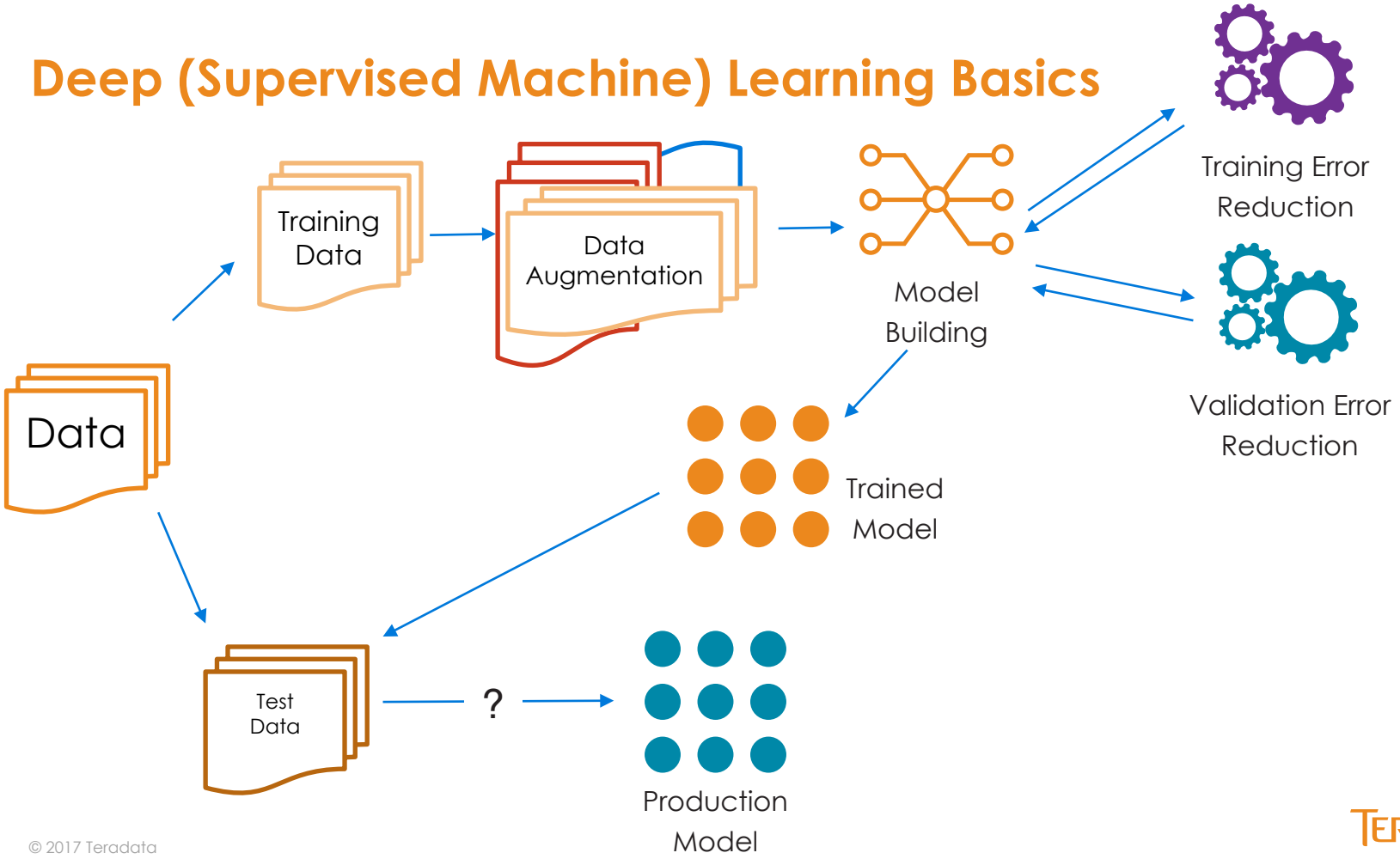
Deep (Supervised Machine) Learning Basics



Computer Vision Datasets: Video

- Extract Frames and Compose Video
  - FFMPEG
  - https://www.ffmpeg.org/

Extract `ffmpeg -i <video.file> image%03d.jpg`

Compose `ffmpeg -framerate 24 -i img%03d.jpg <output_video.file>`

Computer Vision Datasets: Images

- Data Augmentation in Keras
  - keras.preprocessing.image.ImageDataGenerator

```
featurewise_center
samplewise_center
featurewise_std_normalization
samplewise_std_normalization
zca_whitening
zca_epsilon
rotation_range
width_shift_range
height_shift_range
```

```
shear_range
zoom_range
channel_shift_range
fill_mode
cval
horizontal_flip
vertical_flip
rescale
```

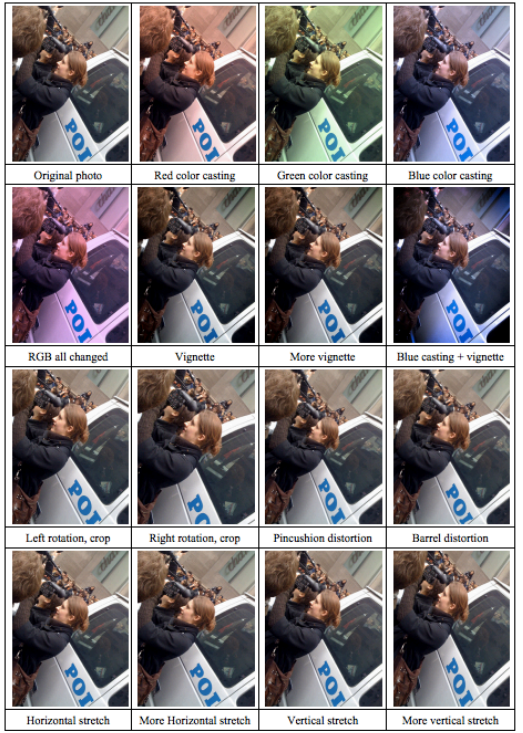


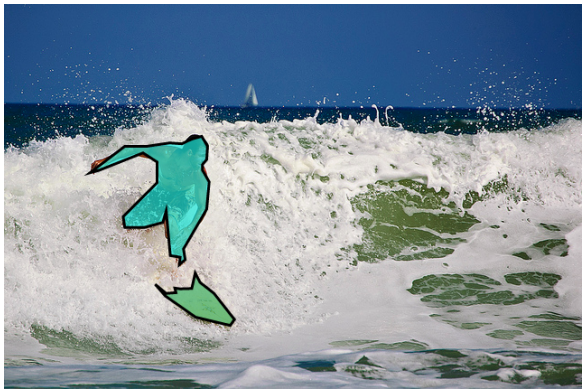
Image Source: Deep Image: Scaling up Image Recognition (Baidu) https://arxiv.org/abs/1501.02876

Computer Vision Datasets: Annotations

{"coco_url":"http://mscoco.org/images/405628",
"date_captured":"2013-11-21 00:26:09",
"file_name":"COCO_train2014_000000405628.jpg",
"flickr_url":"http://farm5.staticflickr.com/4130/5133418813_61f33c9633_z.jpg",
"height":426,
"id":405628,
"license":5,
"width":640}

{"area":7581.427150000003,
"bbox":[95.28,146.43,131.92,142.0],
"category_id":1,"id":188293,
"image_id":405628,
"iscrowd":0,
"segmentation":[[219.87,177.58,224.45,172.08,225.37,157.42,218.95,146.43,208.88,149.18,208.88,149.18,202.46,151.92,198.8,153.76,198.8,153.76,196.97,154.67,184.14,153.76,183.23,153.76,158.49,157.42,133.75,157.42,95.28,186.74,105.35,183.99,153.91,164.75,169.48,174.83,169.48,197.73,135.59,231.63,131.92,235.29,133.75,247.2,152.99,247.2,155.74,247.2,175.9,241.71,179.56,228.88,184.14,278.35,195.14,280.18,194.22,288.43,200.63,282.93,198.8,271.02,224.45,227.05,224.45,227.05,227.2,196.82,219.87,183.99]]},

http://cocodataset.org/#explore?id=405628



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Computer Vision Datasets: Annotations

	BOUNDING BOX	DOTS	POLYGON	SEMANTIC SEGMENTATION
COST	Least expensive	More expensive	More expensive	Most expensive
TIME COMMITMENT	Lowest	Medium	Medium	Highest
PRECISION	Good	Great	Great	Excellent
INSTANCE-BASED (OUTPUT CONTAINS DISCRETE OBJECTS)	Yes	Yes	Yes	No
POSSIBLE TO LABEL SEVERAL OBJECTS?	Yes	Yes	Yes	Yes
POSSIBLE TO LABEL SEVERAL CLASSES OF OBJECT IN A SINGLE JOB?	No	No	No	Yes
OUTPUT*	X,Y coordinate, width and length of each box	Series of x,y coordinates	Series of x,y coordinates, with shapes resolving	Coded RGB pixels as an image

Source: CrowdFlower WHAT WE LEARNED LABELING 1 MILLION IMAGES
A practical guide to image annotation for computer vision

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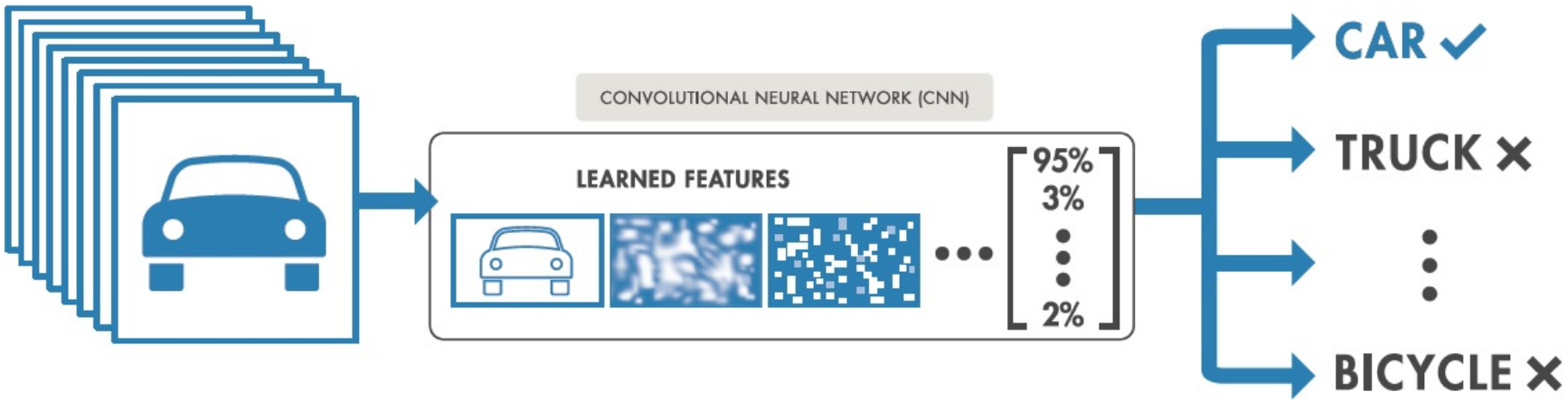
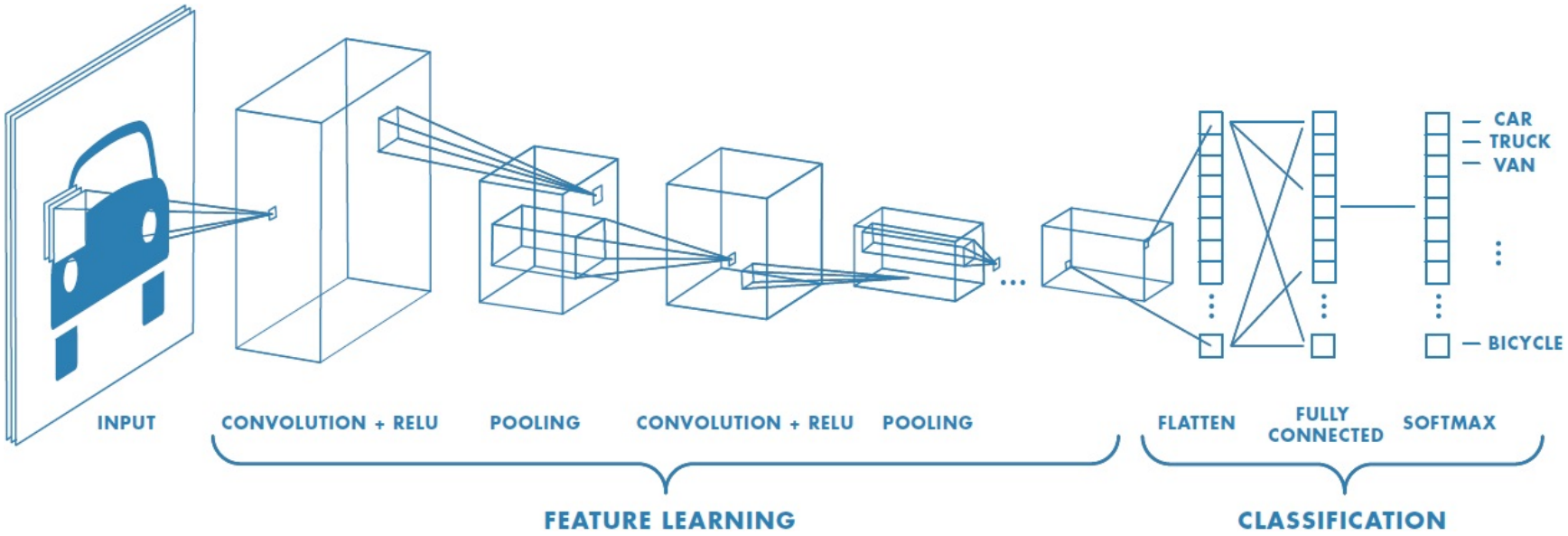
Convolutional Neural Networks



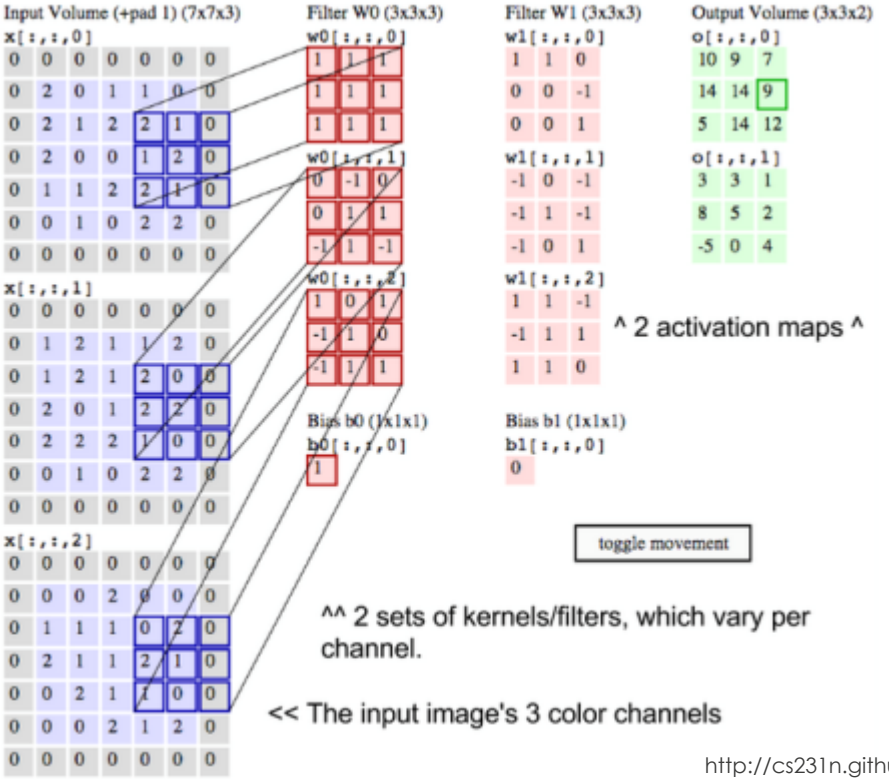
Source: Mathworks

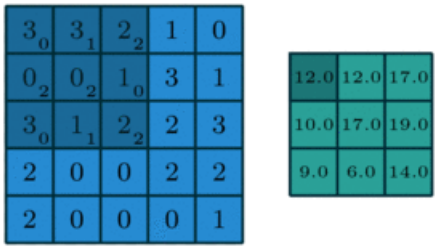
Convolutional Neural Networks



Source: Mathworks

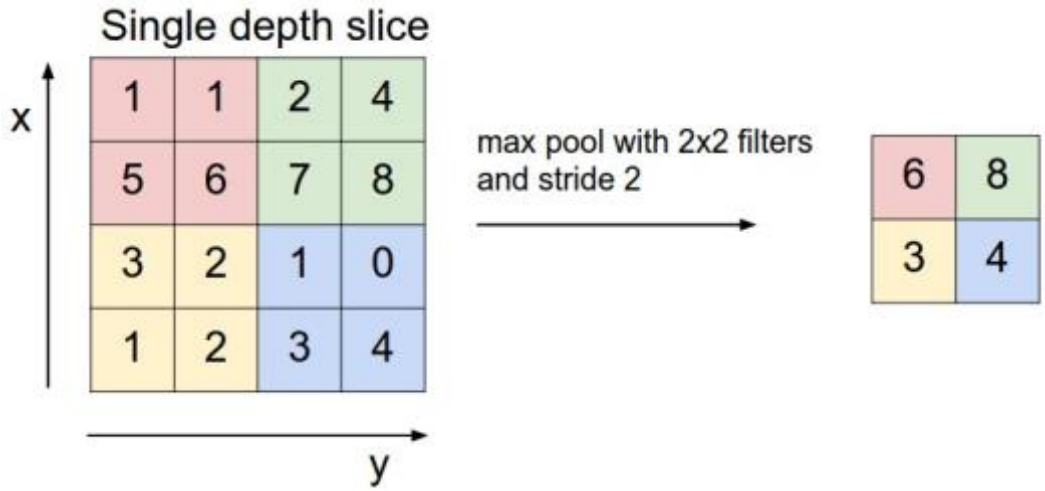
Convolution





http://cs231n.github.io/convolutional-networks/
https://m2dsupsdlclass.github.io/lectures-labs/slides/03_conv_nets/index.html
https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

Pooling



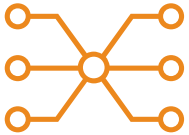
Source: Stanford University CS 231 Course:
http://cs231n.github.io/convolutional-networks/#pool

Fully Connected

- Traditional Machine Learning: Feature Engineering
- Deep Learning: Feature Learning
- Learned Features are fed to traditional classifier such as Multivariate Logistic Regression (Softmax)

Low Level Features

Flatten
10
24
2
3
…
…
…



Classifier

Class	Probability
A	0.01
B	0.07
C	0.13
D	0.60
E	0.03
F	0.05
G	0.11

Loss Reduction

Class	Probability	Truth	Loss/ Error
A	0.01	0	0
B	0.07	0	0
C	0.13	0	0
D	0.60	1	0.22
E	0.03	0	0
F	0.05	0	0
G	0.11	0	0

Cross Entropy Loss

One-Hot Encoded Vector of Class Label

Back Propagation

- Account for loss across the weights and biases in the network
- Use cost function provided by Back Propagation to optimize the weights and biases to reduce loss
- Variety of Stochastic Gradient Descent techniques used for optimization

Overview of Gradient Descent Techniques:
http://ruder.io/optimizing-gradient-descent/

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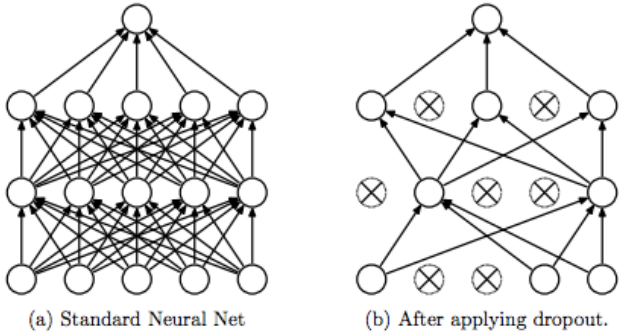
Generalization

Dropout

- Randomly remove learned nodes from network



(a) Standard Neural Net (b) After applying dropout.

Dropout: A Simple Way to Prevent Neural Networks from Overfitting
http://www.jmlr.org/papers/volume15/srivastava14a/srivastava14a.pdf

Batch Normalization

- During training input data shifts as weights and parameter adjust values
- To prevent internal covariate shift, normalize each batch by mean and variance

Batch Normalization: Accelerating Deep Network Training by Reducing Internal Covariate Shift
https://arxiv.org/abs/1502.03167

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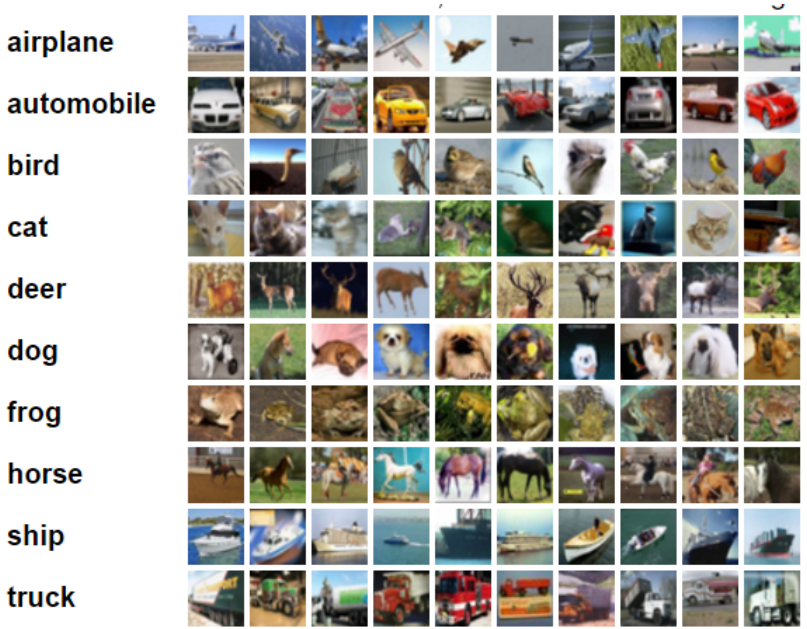
Deep Learning Software Quick-Start

- Get Anaconda Python Distribution
  - https://www.continuum.io/downloads
- Install Keras*
  - Open Anaconda Navigator
  - Go to Environments
  - Click on Channels, Click on Add, Add conda-forge and click on Update Channels
  - Search for TensorFlow and check the box in Name column
  - Search for Keras and check the box in Name column
  - Click Apply
- Launch Jupyter Notebook
  - Open Anaconda Navigator
  - From Home, click on Launch button for Jupyter Notebook

*your mileage may vary

CIFAR10 Image Classification

- Ten classes:
  - airplane, automobile, bird, cat, deer, dog, frog, horse, ship, and truck
- Dataset:
  - 60,000 32x32 colour images in 10 classes
  - 6000 images per class.
  - 50,000 training images
  - 10,000 test images



https://www.cs.toronto.edu/~kriz/cifar.html