CS50
Machine Learning
Week 7
Machine Learning

what society thinks I do  what my friends think I do  what my parents think I do

what other programmers think I do  what I think I do  what I really do

```python
>>> from sklearn import svm
```
Machine Learning?

- Search Engines
- Image Recognition
- Voice Recognition
- Natural Language Processing
Image Recognition

horse

car
Nineteen Eighty-Four
by George Orwell
(1984)

[...] BIG BROTHER IS WATCHING YOU, the caption said, while the dark eyes looked deep into Winston's own
[...]
Whodunit!

Image recognition

It was Colonel Mustard with the candlestick in the library.

horse car
Machine Learning algorithms

inputs → Training data → outputs
Machine Learning algorithms

Training data

horse
Image Classification
Handwritten digit classification

Training data

0

6
Nearest Neighbor Classifier

Labeled training set

Minimal distance

Test point
Nearest Neighbor Classifier

Labeled training set

Test point

Minimal distance
Nearest Neighbor Classifier

Labeled training set

Test point

Minimal distance
Flatland
by Edwin Abbott Abbott
(1884)
Flatland: The story describes a **two-dimensional world** occupied by geometric figures. The narrator is a square named **A Square** who guides the readers through some of the implications of life in two dimensions.

On New Year's Eve, A Square dreams about a visit to a **one-dimensional** world (Lineland) inhabited by "lustrous **points**", in which he attempts to convince the realm's monarch of a second dimension; but is unable to do so.

Following this vision, A Square is himself visited by a **three-dimensional** sphere named **A Sphere**, which he cannot comprehend until he sees Spaceland (a tridimensional world)

https://vimeo.com/8675372
Ready to go beyond Lineland, Flatland, and Spaceland?
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64 dimensional space
Nearest Neighbor Classifier

Labeled training set

Test point

dist( , )
\[ \text{dist}(\quad,\quad) = 31.98 \]
\[ \text{dist}( , ) = 45.97 \]

\[ \text{dist}( , ) = 45.97 \]
The digits dataset

Labeled training set
Python code
(Supervised Learning)
```python
np.sqrt(np.sum((x - y)**2))

x = [1, 1]
y = [3, 4]
x - y = [-2, -3]
(x - y)**2 = [4, 9]
np.sum((x - y)**2) = 13
np.sqrt(np.sum((x - y)**2)) = 3.60
```
With Nearest Neighbor Classifier

~ 97% Correct
The CIFAR-10 dataset

- airplane
- automobile
- bird
- cat
- deer
- dog
- frog
- horse
- ship
- truck

Labeled training set

www.kaggle.com

*http://www.cs.toronto.edu/~kriz/cifar.html*
With Nearest Neighbor Classifier

~ 30% Correct
Training set for category ‘0’:

Training set for category ‘horse’:
Challenges

Viewpoint variation

Scale variation

Deformation

Occlusion

Illumination conditions

Background clutter

Intra-class variation

*http://cs231n.github.io*
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Features

(6, 8, 10, 12, 14)
Deep Learning

Feature Representation

3rd layer “Objects”

2nd layer “Object parts”

1st layer “Edges”

Pixels

*http://www.slideshare.net/roelofp/220115dlmeetup
Tensorflow

Deep dream generator

https://www.tensorflow.org

http://deepdreamgenerator.com
The CIFAR-10 dataset

Labeled training set

*http://www.cs.toronto.edu/~kriz/cifar.html*
With Deep Learning...

~ 95% Correct
Is 95% enough?
Forward-facing camera
Image-processing software can detect lane stripes, signs, stoplights, road signs and other objects.
“Neither Autopilot nor the driver noticed the white side of the tractor trailer against a brightly lit sky, so the brake was not applied”
Challenges

Viewpoint variation

Scale variation

Deformation

Occlusion

Illumination conditions

Background clutter

Intra-class variation

*http://cs231n.github.io*
Text Clustering
Text clustering

IMDB synopses for:
- Robin Hood
- The Matrix
- The King's Speech
- Aladdin
- A Beautiful Mind
- Finding Nemo

k = 2

CLUSTER 1:
- A Beautiful Mind
- The Matrix
- The King's Speech

CLUSTER 2:
- Robin Hood
- Aladdin
- Finding Nemo

https://docs.google.com/spreadsheets/d/1udJ4nd9EKlX_awB90JCbKaStuYh6aVjh1X6j8iBUXIU/edit#gid=0
k = 2

Unlabeled data

K-means
Unlabeled data

K = 2

K-means
Told with animals for its cast, the story tells of Robin Hood (a fox) and Little John (a brown bear), who rob from the rich to give to the poor. [...]
Something simpler...

a) I love CS50. Staff is awesome, awesome, awesome!

b) I have a dog and a cat.

c) Best of CS50? Staff. And cakes. Ok, CS50 staff.

d) My dog keeps chasing my cat. Dogs!

k = 2

CLUSTER 1:
  a)  c)

CLUSTER 2:
  b)  d)
a) I love CS50. Staff is awesome, awesome, awesome!

b) I have a dog and a cat.

c) Best of CS50? Staff. And cakes. Ok, CS50 staff.

d) My dog keeps chasing my cat. Dogs!
I love CS50. Staff is awesome, awesome, awesome!
a) I love CS50. Staff is awesome, awesome, awesome!
b) I have a dog and a cat.
c) Best of CS50? Staff. And cakes. Ok, CS50 staff.
d) My dog keeps chasing my cat. Dogs!
I love CS50. Staff is awesome, awesome, awesome!

I have a dog and a cat.

Best of CS50? Staff. And cakes. Ok, CS50 staff.

My dog keeps chasing my cat. Dogs!

Frequency

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I love CS50. Staff is awesome, awesome, awesome!

12 dimensional space

(3/6, 0, 0, 0, 0, 1/6, 0, 0, 0, 1/6, 0, 1)
a) I love CS50. Staff is awesome, awesome, awesome!

b) I have a dog and a cat.

c) Best of CS50? Staff. And cakes. Ok, CS50 staff.

d) My dog keeps chasing my cat. Dogs!
Python code
(Unsupervised Learning)
Recap
Handwritten digit classification
Text clustering

IMDB synopses for:
- Robin Hood
- The Matrix
- The King's Speech
- Aladdin
- A Beautiful Mind
- Finding Nemo

k = 2

CLUSTER 1:
- A Beautiful Mind
- The Matrix
- The King's Speech

CLUSTER 2:
- Robin Hood
- Aladdin
- Finding Nemo

https://docs.google.com/spreadsheets/d/1udJ4nd9EKlX_awB90JCbKaStuYh6aVjh1X6j8iBUXIU/edit#gid=0
Machine Learning?

- Search Engines
- Image Recognition
- Voice Recognition
- Natural Language Processing
Machine Learning… so much more
“Commentators were convinced [AlphaGo] had made mistakes, but as it racked up wins, they were forced to concede that perhaps the machine [...] was using strategies its human masters had simply overlooked.”