Machine Learning

Jay Urbain, PhD

Credits: Tom Mitchell, Andrew Ng, Trevor Hastie, Robert Tibshirani, Google, nVidia

What is machine learning?

What is machine learning?

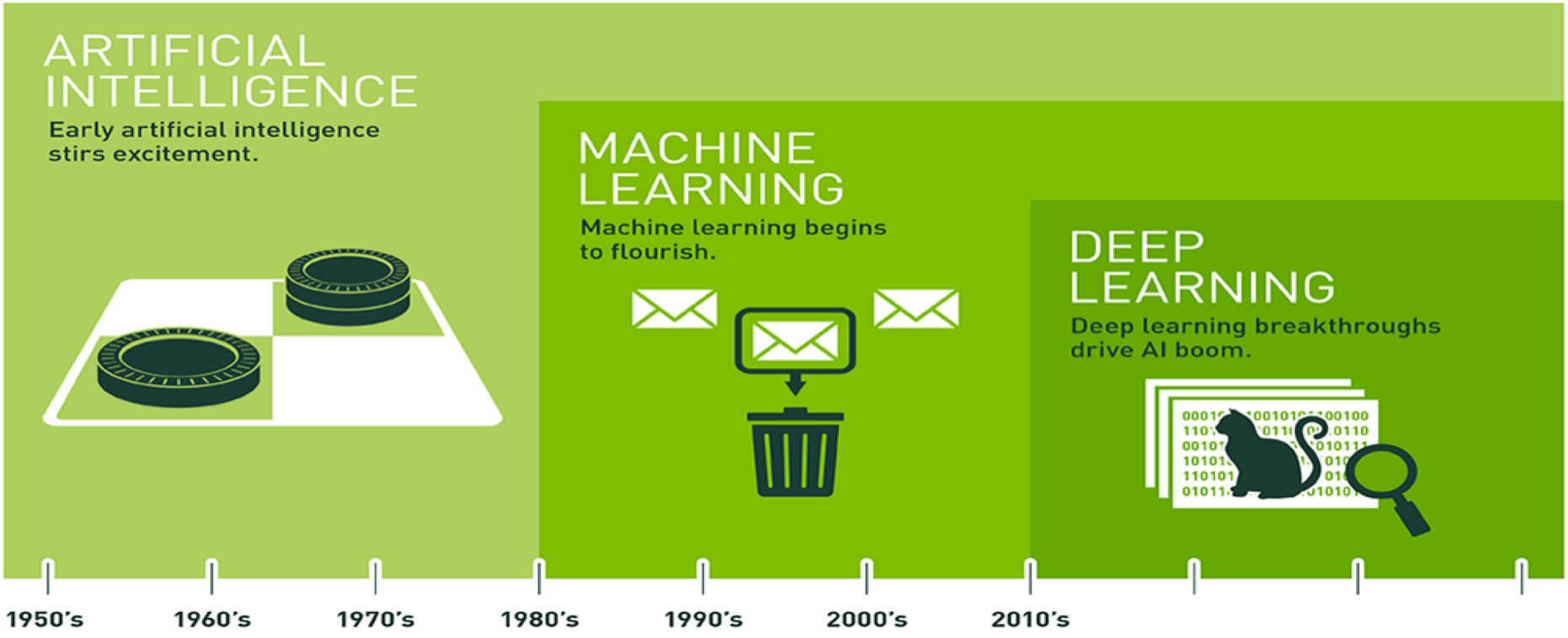
"A field of study that gives computers the ability to learn without being explicitly programmed." (1959)

Arthur Samuel, AI pioneer
Source: Stanford

Machine Learning (ML)

- Research and development of algorithms that can learn from and make predictions on data.
- ML algorithms build a model from example inputs in order to make data-driven predictions or decisions, rather than following static program instructions.

Accomplishing Complex Goals



Deep (Machine) Learning in Production

Speech Recognition

Recommender Systems

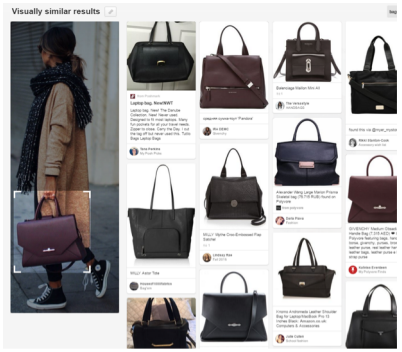
Autonomous Driving

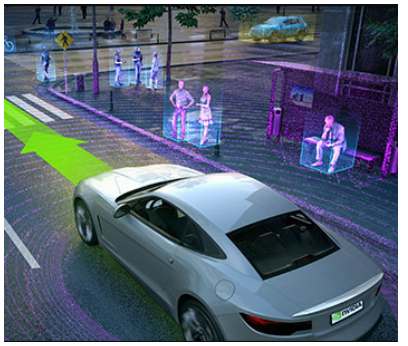
Real-time Object Recognition

Robotics

Real-time Language Translation

Many More…





EXAMPLE: FACIAL RECOGNITION: MACHINE LEARNING

Training set

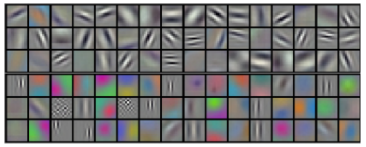
Face

Not Face

Face

Test

Face?



The core of machine learning deals with *representation* and *generalization*…

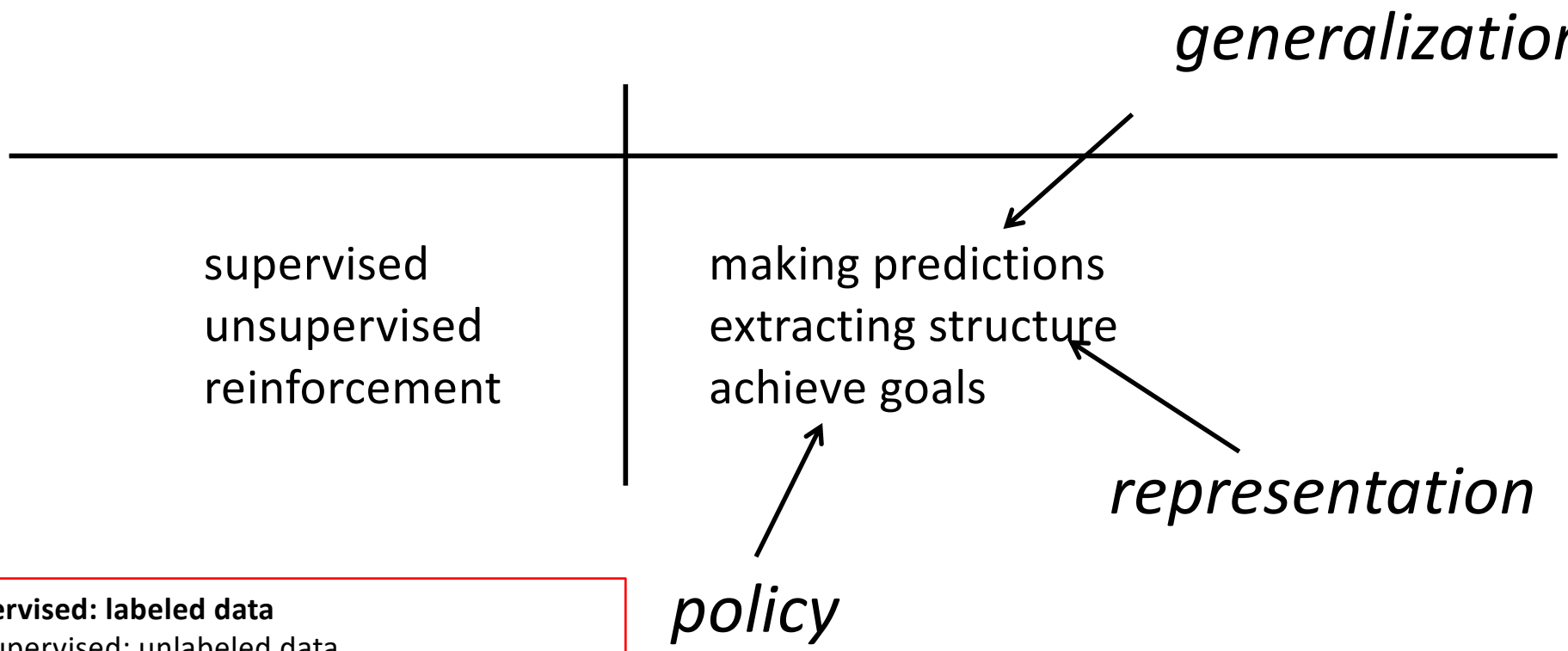
Machine Learning vs. Classical Algorithms

Machine Learning is a class of algorithms which are ***data-driven***. Unlike classical algorithms, it is the data that defines a "good" answer.

Example:

- A **Non-Machine Learning** algorithm might "define" a face as having a roundish structure, two eyes, hair, nose, etc. The algorithm then looks for these "hard-coded" features in test cases.
- A Machine Learning algorithm might only be given several pictures of faces and non-faces that are labeled as such. From the examples (called training set) it would "figure out" it's own definition (model) of a face.

Types of Machine Learning Problems



Supervised: labeled data
Unsupervised: unlabeled data
Reinforcement: goal, feedback

Machine Learning

- Grew out of work in AI and statistical modeling
- Cognitive neuroscience research
- Desire to add new capability for computers

Examples:

- Data mining / information retrieval
  - Large datasets from growth of automation/web.
  - E.g., Web click data, medical records, biology, sensor data
- Perceptive tasks:
  - Computer vision, NLP
- Self-customizing programs
  - E.g., Amazon, Netflix product recommendations
- Understanding human learning (brain, real AI).

Research challenge: general algorithm for learning?

https://www.wicab.com/

Oral electronic vision aid that provides electro-tactile stimulation to aid profoundly blind patients in orientation, mobility, and object recognition

Supervised Learning
Two stages: training, inference

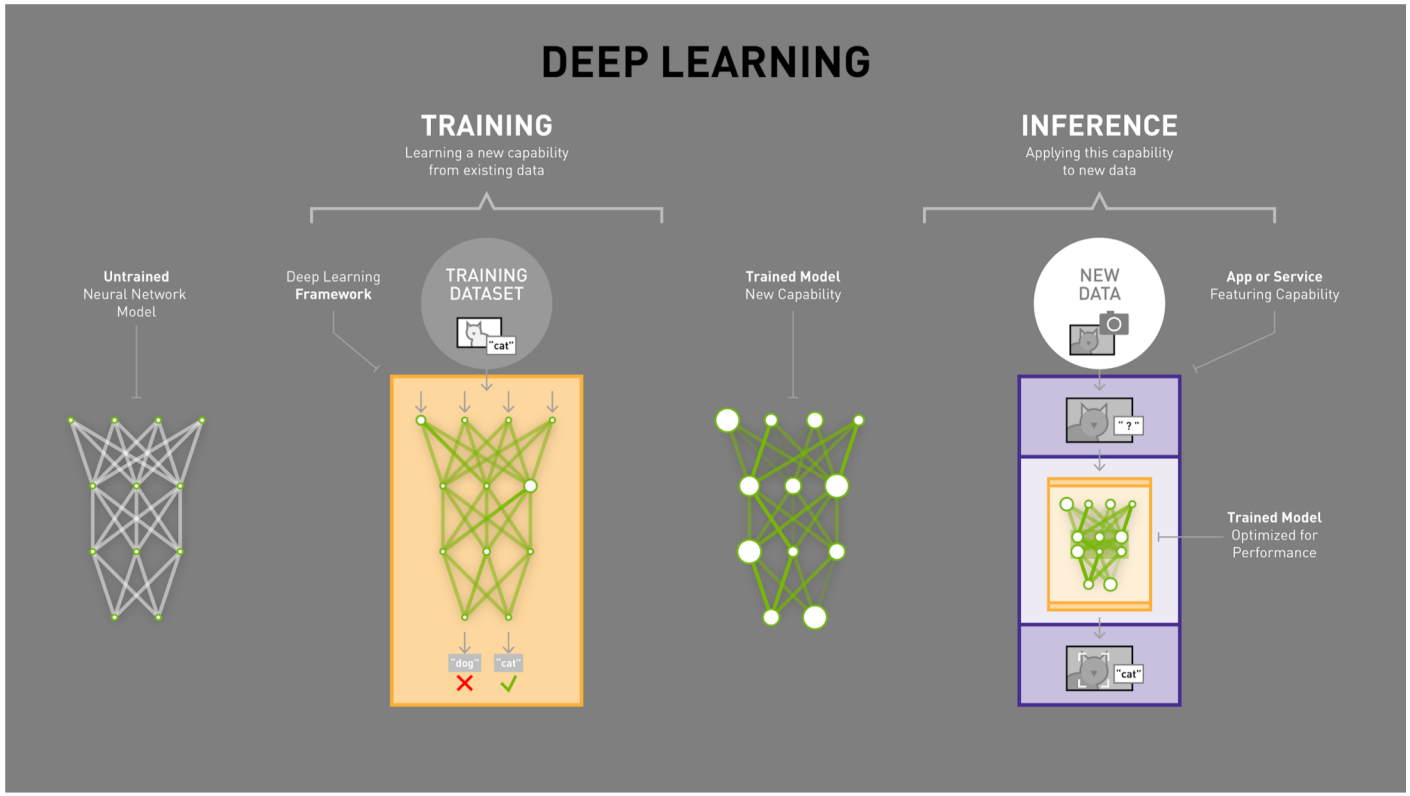


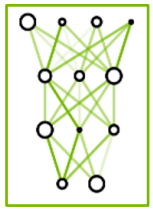
Image Captioning

To appreciate the complexity of this at a human level, take one minute to create your own caption for this image.

Images – Input and Output

Classifier data flow

100	37	59	87	55	29	13	44
62	79	54	62	23	93	93	26
50	57	93	17	67	53	60	75
3	54	70	37	17	20	69	7
86	42	2	55	90	45	74	77
59	39	100	52	10	8	20	37
61	2	62	92	83	18	12	82
11	7	87	20	5	13	4	34



Deep Neural Network

0.04	0	0.02	0.01	0.92	0.01
Kites	Harrier	Vulture	Hawk	Eagle	Buzzards

Eagle

Computer Vision

COMPUTER VISION TASKS

Image Classification

Image Classification + Localization

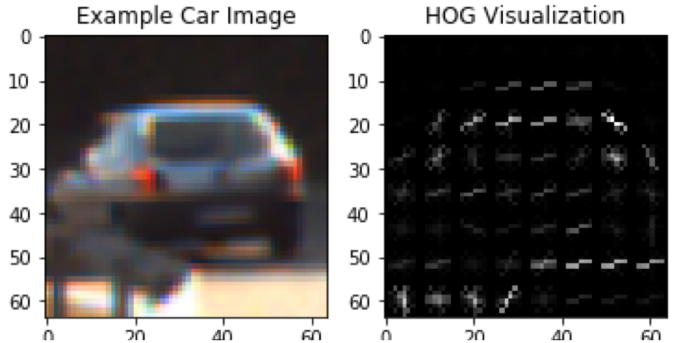
Object Detection

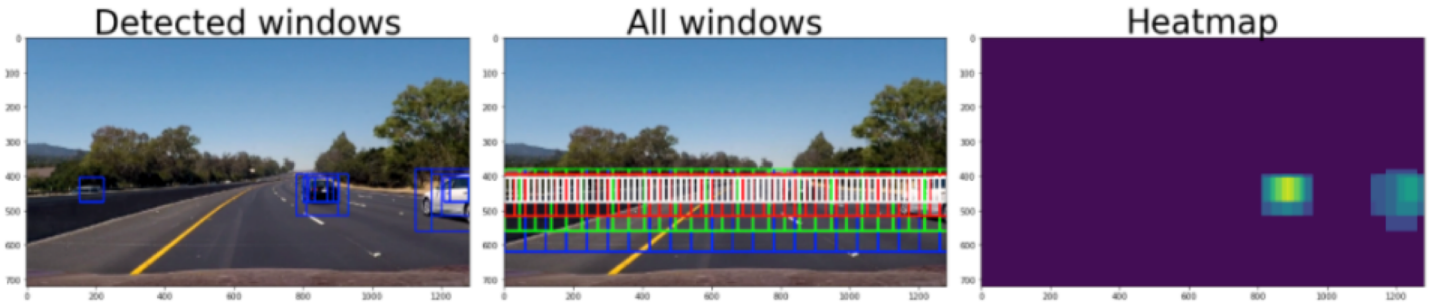
Image Segmentation

(inspired by a slide used in cs231n lecture from Stanford University)

Object Detection

Car Vehicle Detection – sliding window approach



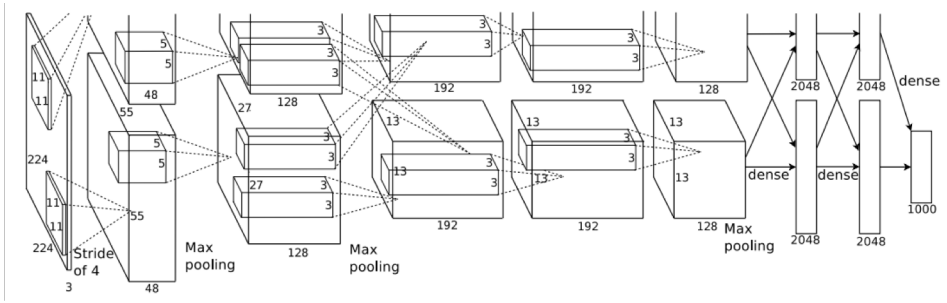


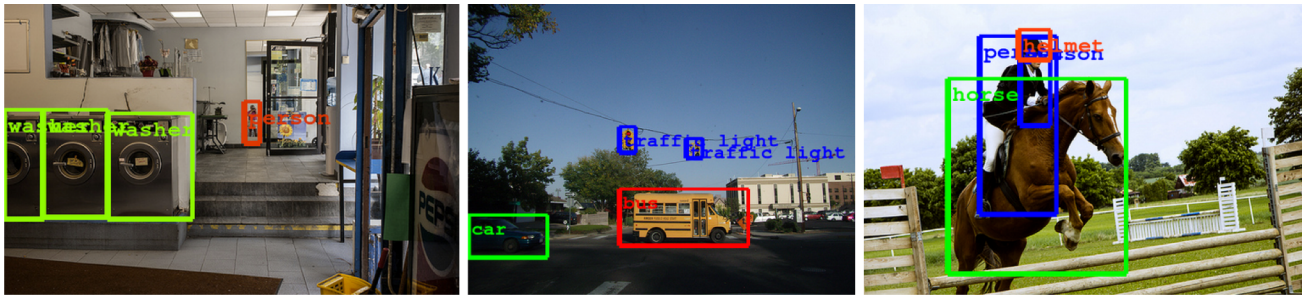
- Train car classifier on HOG image
- Convolve classifier across multiple image resolutions
- Generate heat map based window overlap
- Use non-maximal suppression to eliminate windows

Object Detection - Car Vehicle Detection

Image Classification: state of the art

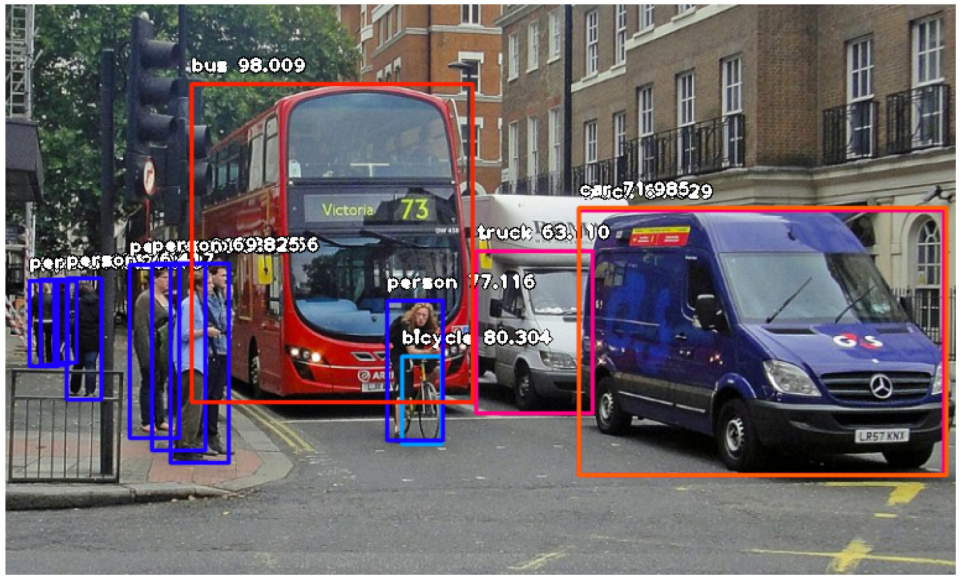
- Deep learning using convolution networks.
- Trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images using GPUs.
- http://www.cs.toronto.edu/~fritz/absps/imagenet.pdf

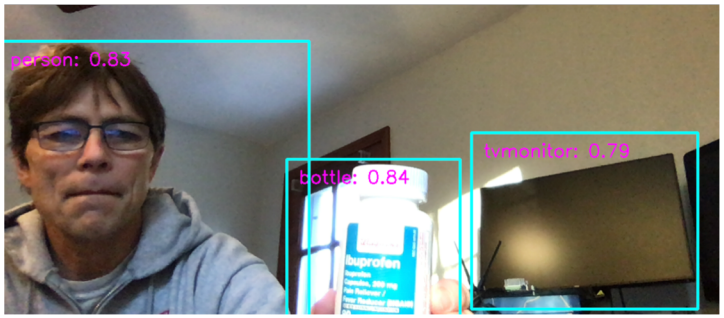




SSD - Object Detection
PyTorch Implementation

- cd /Users/jayurbain/Dropbox/cv_op_2018/pytorch-ssd
- python run_ssd_live_demo.py mb1-ssd models/mobilenet-v1-ssd-mp-0_675.pth models/voc-model-labels.txt





Pose Estimation

Pose estimation refers to detecting human figures in images and video.

Algorithm estimates where key body joints are.

Many potential uses:

- Natural human-computer interactions
- Driver attentiveness
- Augmented reality
- Animation using people
- Fitness
- Physical therapy

OpenPose

The architecture is designed to jointly learn part locations and their association via the same sequential process.

- conda activate tensorflow
- jupyter notebook
- keras_Realtime_Multi-Person_Pose_Estimation

Natural Language Processing

Machine Learning in the News

- Natural language processing
  - Voice recognition
  - Extract knowledge from text
  - Open domain question/answering
- Statistical modeling
  - Maximum likelihood given context
- Fusion
  - Integrate and rank results from multiple learning methods (search)
- Online Machine Learning
  - Watson becomes smarter as it tries to answer questions — and to learn as it gets them right or wrong.

http://www.aaai.org/Magazine/Watson/watson.php

"Building Watson: An Overview of the DeepQA Project," written by the IBM Watson Research Team, led by David Ferucci.

https://www.youtube.com/watch?v=WFR3lOm_xhE

Query Parse Results:

Query:
Diabetes related to CAD

Sentence parse (term, POS, noun phrase, proper noun phrase):
Diabetes NNP B-NP PNP
related VBD B-VP O
to TO B-PP O
CAD NNP B-NP PNP
. . O O

Information Retrieval,
Natural Language Processing

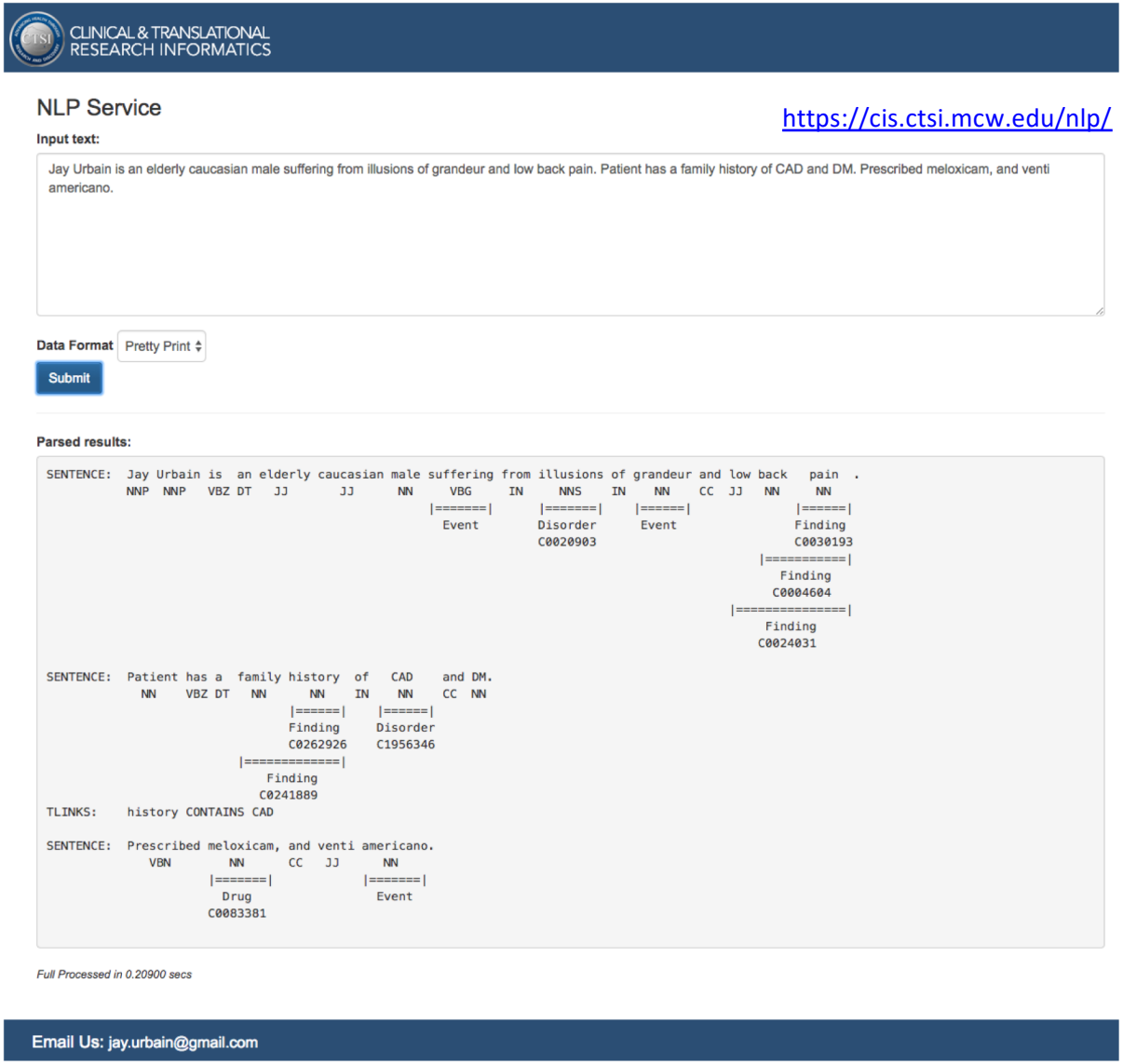
OpenNLP Entities:

Freebase Algorithm Entities:

PNP: Diabetes
id: /en/diabetes_mellitus, name: Diabetes mellitus, type: /medicine/disease, mappingType: MProblem
PNP: CAD
id: /en/coronary_heart_disease, name: Coronary artery disease, type: /medicine/disease, mappingType: MProblem

Reverb Relations: (entity1, relation, entity2)

Dependency relations: (entity1, depedency sequence 1, 2, ..., entity2)
diabetes; related_to; cad


CLINICAL & TRANSLATIONAL
RESEARCH INFORMATICS
NLP Service
https://cis.ctsi.mcw.edu/nlp/
Input text:
Jay Urbain is an elderly caucasian male suffering from illusions of grandeur and low back pain. Patient has a family history of CAD and DM. Prescribed meloxicam, and venti americano.
Data Format
Pretty Print
Submit
Parsed results:
SENTENCE: Jay Urbain is an elderly caucasian male suffering from illusions of grandeur and low back pain .
NNP NNP VBZ DT JJ JJ NN VBG IN NNS IN NN CC JJ NN NN
Event
Disorder
C0020903
Event
Finding
C0030193
Finding
C0004604
Finding
C0024031
SENTENCE: Patient has a family history of CAD and DM.
NN VBZ DT NN NN IN NN CC NN
Finding
C0262926
Disorder
C1956346
Finding
C0241889
TLINKS: history CONTAINS CAD
SENTENCE: Prescribed meloxicam, and venti americano.
VBN NN CC JJ NN
Drug
C0083381
Event
Full Processed in 0.20900 secs
Email Us: jay.urbain@gmail.com

Machine Reading for Question Answering

Experiments with deep encoder-decoder networks with memory and attention for question answering of medical records text. Select a question for the sample record, or supply a question. You may also provide your own passage of text from any source. Another passage sample from the WSJ is provided below. Modeled after the SQUAD data set. Training requires 50,000 to 400,000 training epochs using an AWS nVidia K80 or Tesla GPU instance. *Please note: this is a work in progress!*

Passage

COLONOSCOPY Procedure Note Date of Procedure: [1_21_2016] Primary Physician: [PERSON] [PERSON] [PERSON], MD Attending Physician: [PERSON] [PERSON], MD Fellow:None Indications: Colon cancer screening for family history of colon cancer Colon cancer screening for family history of polyps Previous COLONOSCOPY: Yes. Date: [8_16_2007] Medications Administered: Agents given by the anesthesia service during MAC Procedure Details: The patient was placed in the left lateral position and monitored continuously with ECG tracing, pulse oximetry monitoring and direct observations. Medications were administered incrementally over the course of the procedure to achieve an adequate level of moderate sedation. After anorectal examination was performed, the Olympus CF H180 was inserted into the rectum and advanced under direct vision to the terminal ileum. The procedure was considered not difficult. During withdrawal examination, the final quality of the prep was good. Bowel Prep Scale Right Colon: Grade 2 (minor amount of residual staining, small fragments of stool, and/or opaque liquid, but mucosa of colon segment is

Sample questions

How long should NSAIDs be avoided?
What is the Histopathologic Diagnosis?
Was the procedure difficult?
What were the indications for colon cancer screening?
How was the patient monitored?
What was retroflexed evaluation used for?
What are the indications of colon cancer?
What are the dietary recommendations?
How many polyps were found?
What was the transverse colon bowel prep scale?

Question

How long should NSAIDs be avoided?

Answer

14 days

Get Answer

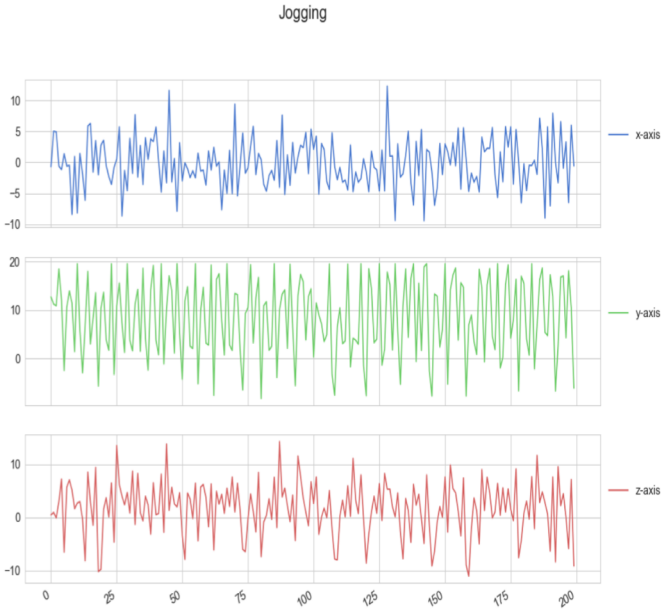
http://54.163.221.189:8080/

Sensor Data

Sequence classification: activity recognition

Temporal sensor analysis and activity tracking

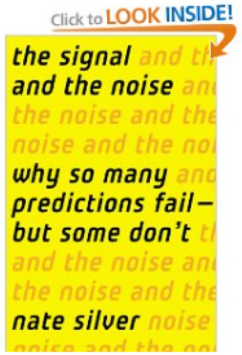
	user	activity	timestamp	x-axis	y-axis	z-axis
0	33	Jogging	49105962326000	-0.694638	12.680544	0.503953
1	33	Jogging	49106062271000	5.012288	11.264028	0.953424
2	33	Jogging	49106112167000	4.903325	10.882658	-0.081722
3	33	Jogging	49106222305000	-0.612916	18.496431	3.023717
4	33	Jogging	49106332290000	-1.184970	12.108489	7.205164



https://github.com/jayurbain/DeepSequenceLearningIntro

Learn Predictive Models from Data

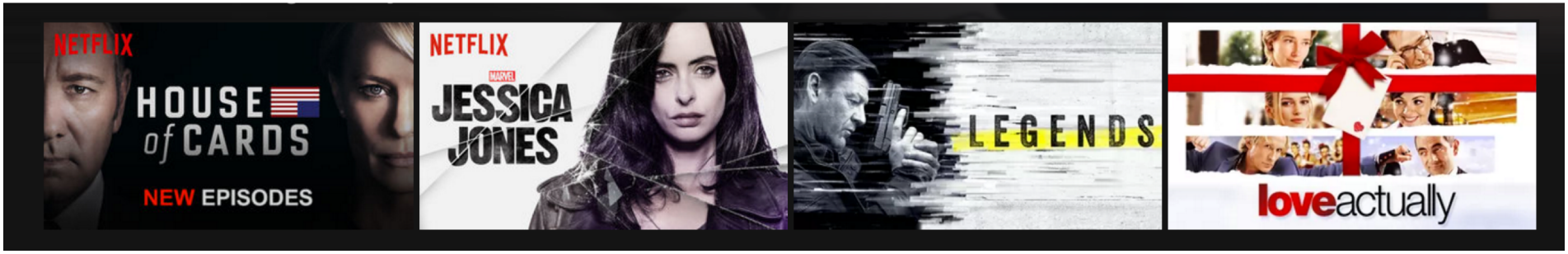
http://fivethirtyeight.com/features/how-the-fivethirtyeight-senate-forecast-model-works/



Recommender Systems

- Content filtering
- Collaborative filtering

http://www.netflixprize.com/



Reinforcement Learning

- http://heli.stanford.edu/
  - Autonomous Helicopter Aerobatics through Apprenticeship Learning, Pieter Abbeel, Adam Coates, and Andrew Y. Ng. IJRR, 2010.
  - Learning for Control from Multiple Demonstrations, Adam Coates, Pieter Abbeel, and Andrew Y. Ng. ICML, 2008.

https://www.youtube.com/watch?feature=player_embedded&v=VCdxqn0fcnE

Reinforcement Learning

https://deepmind.com/blog/alphago-zero-learning-scratch/

Fundamental Course Objectives

On the basis of the training data we would like to:

- Understand how and when to apply ML.
- Accurately predict unseen test cases.
- Understand which inputs affect the outcome, and how.
- Assess the quality of our predictions and inferences.

Philosophy

- It is important to understand the ideas behind the various techniques, in order to know how and when to use them.
- One has to understand the simpler methods first, in order to grasp the more sophisticated ones.
- It is important to accurately assess the performance of a method, to know how well or how badly it is working (simpler methods often perform as well as complex ones!)
- This is an exciting research area, having important applications in science, medicine, industry and finance.

STOP

"A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E."

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

Classifying emails as spam or not spam.

Watching you label emails as spam or not spam.

The number (or fraction) of emails correctly classified as spam/not spam.

None of the above—this is not a machine learning problem.

You're running a company, and you want to develop learning algorithms to address each of two problems.

Problem 1: You have a large inventory of identical items. You want to predict *how many* of these items will sell over the next 3 months.
Problem 2: You'd like software to examine individual customer accounts, and for each account decide if it has been hacked.

Should you treat these as classification or as regression problems?

Treat both as classification problems.

Treat problem 1 as a classification problem, problem 2 as a regression problem.

Treat problem 1 as a regression problem, problem 2 as a classification problem.

Treat both as regression problems.

Of the following examples, which would you address using an unsupervised learning algorithm? (Check all that apply.)

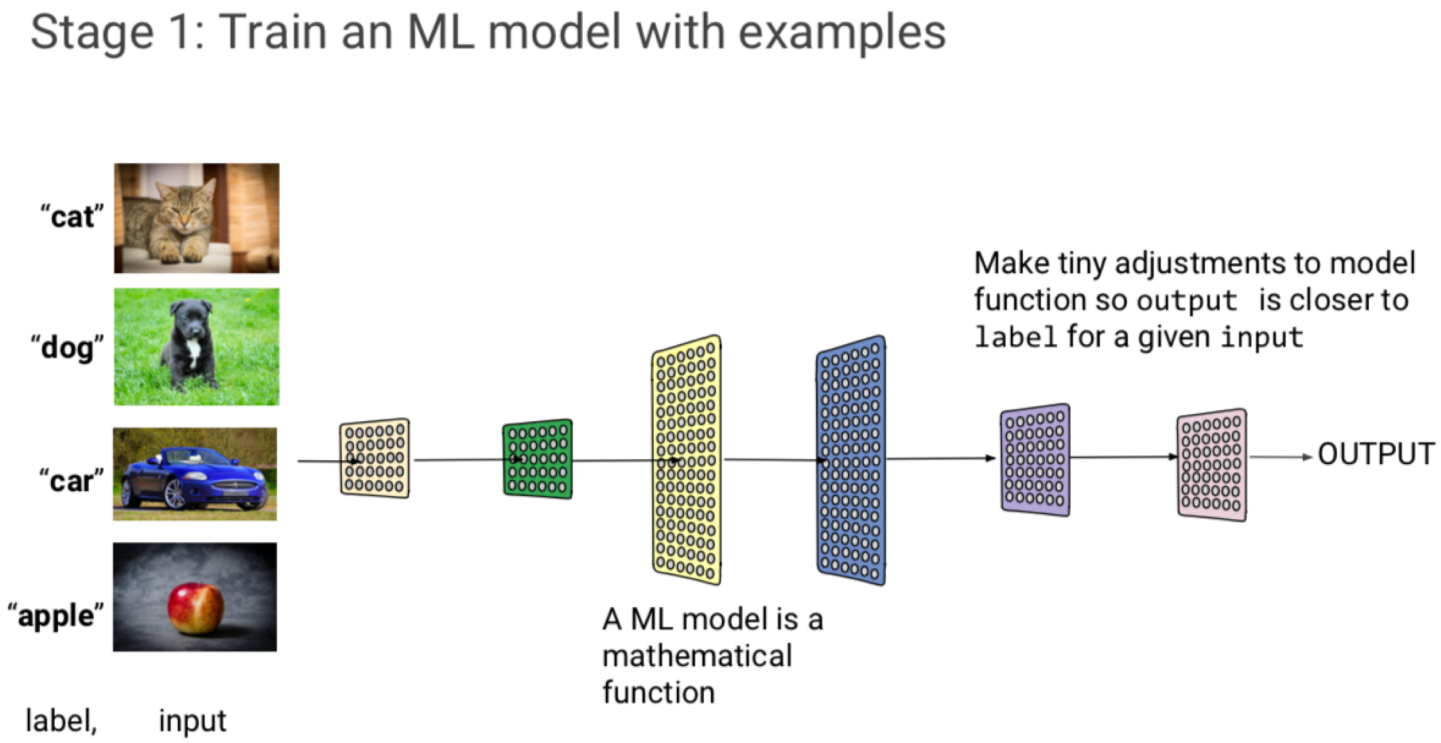
Given email labeled as spam/not spam, learn a spam filter.

Given a set of news articles found on the web, group them into sets of articles about the same story.

Given a database of customer data, automatically discover market segments and group customers into different market segments.

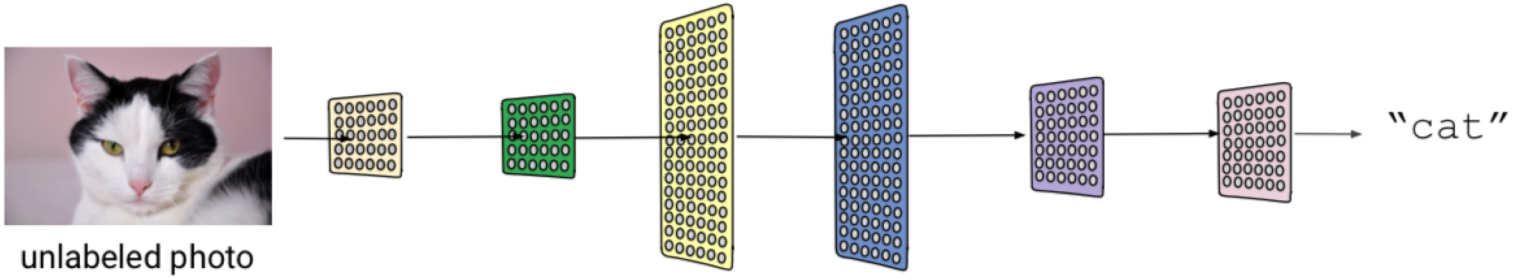
Given a dataset of patients diagnosed as either having diabetes or not, learn to classify new patients as having diabetes or not.

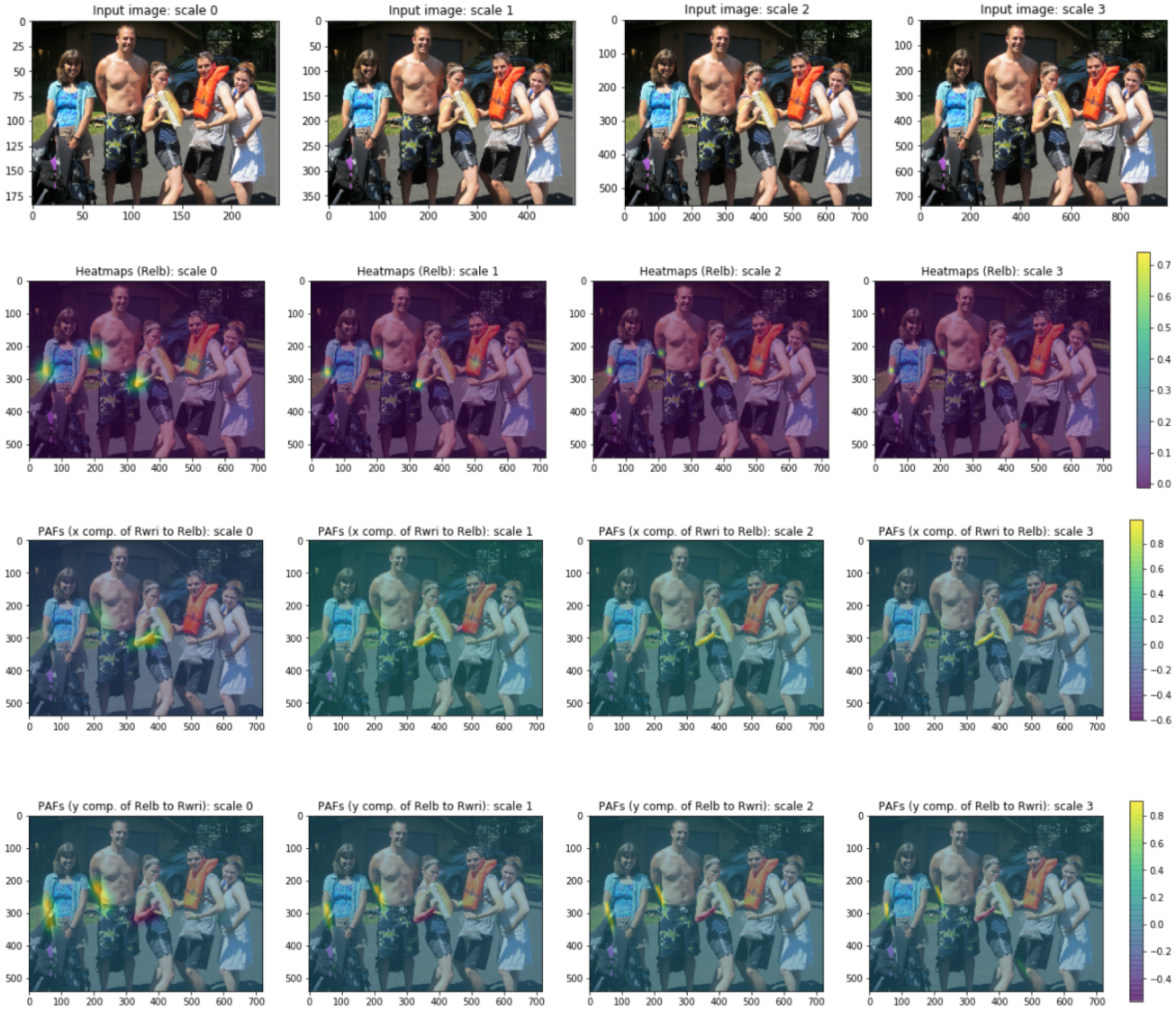
Supervised Machine Learning: 2 stages



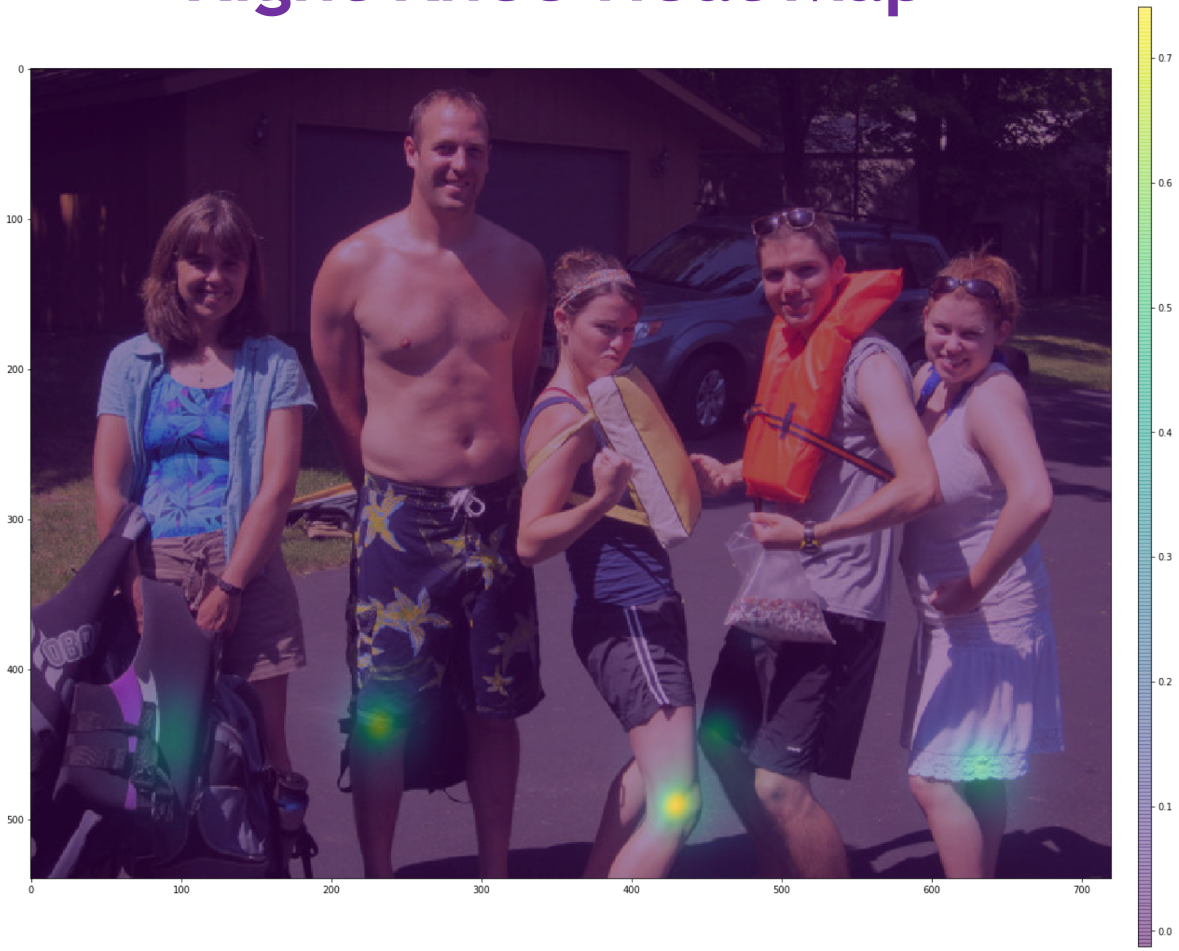
Supervised Machine Learning: 2 stages

Stage 2: Predict with a trained model



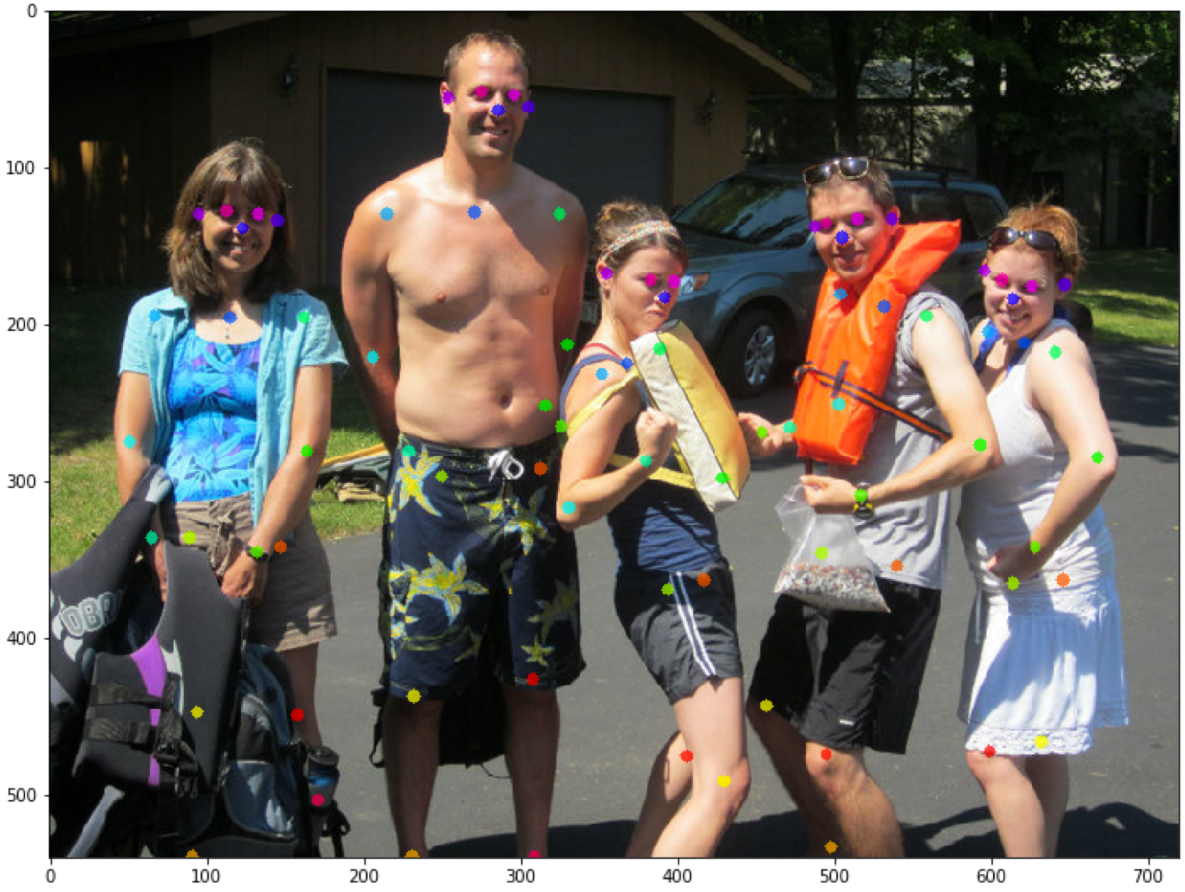

Input image: scale 0
Input image: scale 1
Input image: scale 2
Input image: scale 3
Heatmaps (Relb): scale 0
Heatmaps (Relb): scale 1
Heatmaps (Relb): scale 2
Heatmaps (Relb): scale 3
PAFs (x comp. of Rwri to Relb): scale 0
PAFs (x comp. of Rwri to Relb): scale 1
PAFs (x comp. of Rwri to Relb): scale 2
PAFs (x comp. of Rwri to Relb): scale 3
PAFs (y comp. of Relb to Rwri): scale 0
PAFs (y comp. of Relb to Rwri): scale 1
PAFs (y comp. of Relb to Rwri): scale 2
PAFs (y comp. of Relb to Rwri): scale 3

Right Knee Heat Map



Right forearm PAF

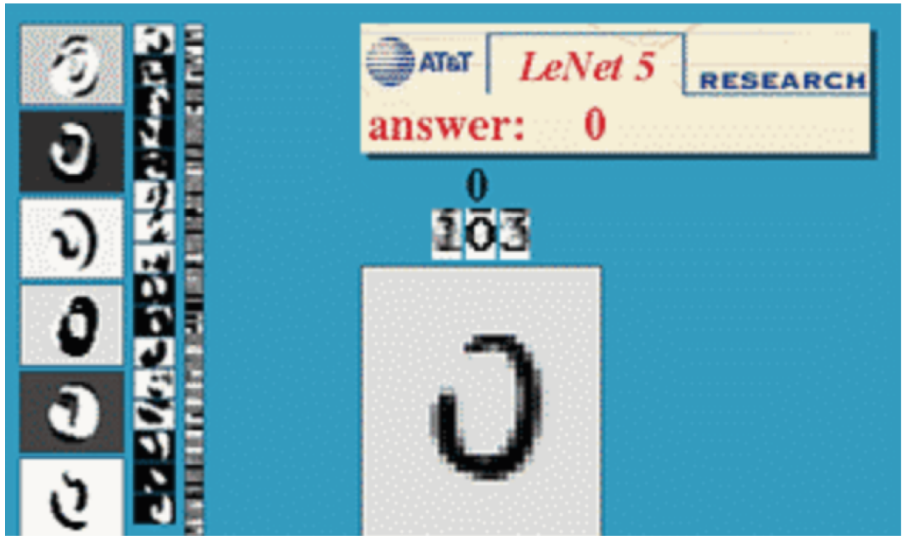
Keypoints



Skeleton from Keypoints

Image Classification

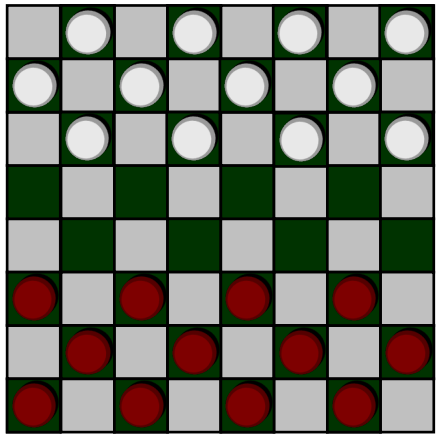
- Convolutional Neural Networks are are a special kind of multi-layer neural networks.
- Use back-propagation algorithm.
- Architecture of network designed to recognize visual patterns directly from pixel images with minimal preprocessing.
- Can recognize patterns with extreme variability (such as handwritten characters), and with robustness to distortions and simple geometric transformations.



http://yann.lecun.com/exdb/lenet/

Machine Learning definitions

- Arthur Samuel (1959). Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.
- Tom Mitchell (1998) Well-posed Learning Problem: A computer program is said to *learn from experience* E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.



"A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E."

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

Classifying emails as spam or not spam.

Watching you label emails as spam or not spam.

The number (or fraction) of emails correctly classified as spam/not spam.

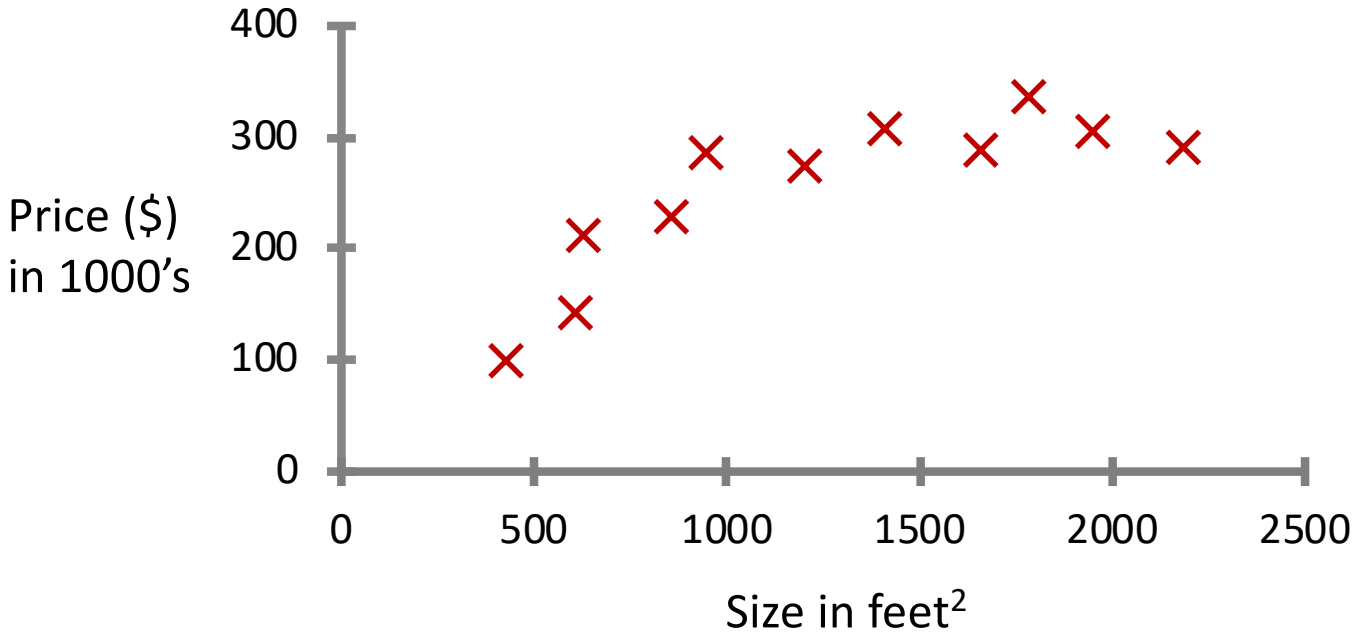
None of the above—this is not a machine learning problem.

Machine learning algorithms:

- Supervised learning
- Unsupervised learning
- Reinforcement learning
- Semi-supervised
- Etc.

Applying learning algorithms.

Housing price prediction. Regression.

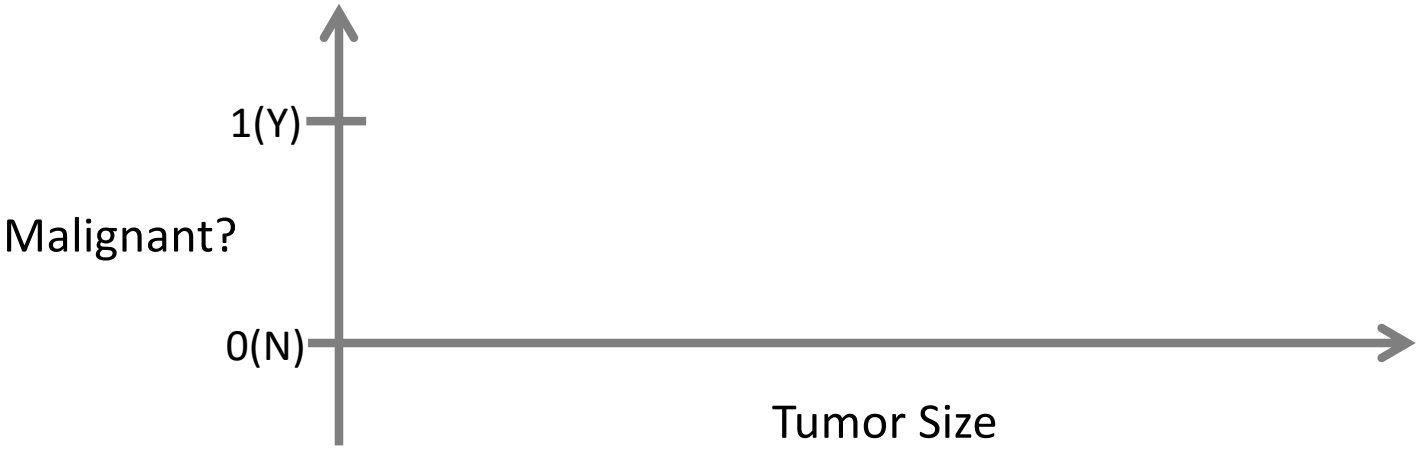


Supervised Learning

"right answers" given

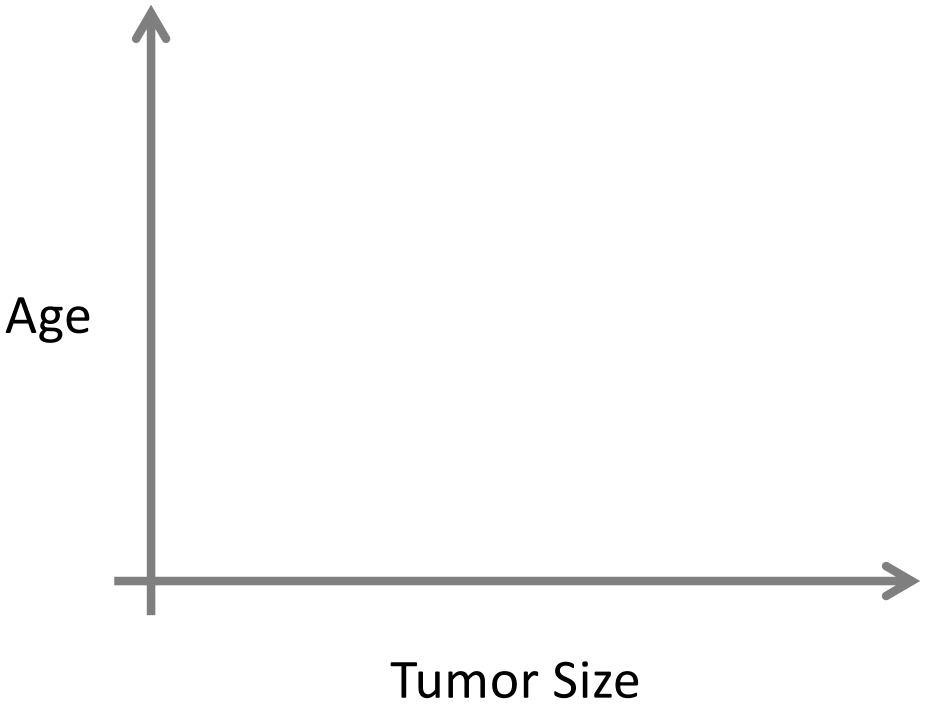
Regression: Predict continuous valued output (price)

Breast cancer (malignant, benign)



Classification

Discrete valued output (0 or 1)



- Clump Thickness
- Uniformity of Cell Size
- Uniformity of Cell Shape

…

You're running a company, and you want to develop learning algorithms to address each of two problems.

Problem 1: You have a large inventory of identical items. You want to predict *how many* of these items will sell over the next 3 months.
Problem 2: You'd like software to examine individual customer accounts, and for each account decide if it has been hacked.

Should you treat these as classification or as regression problems?

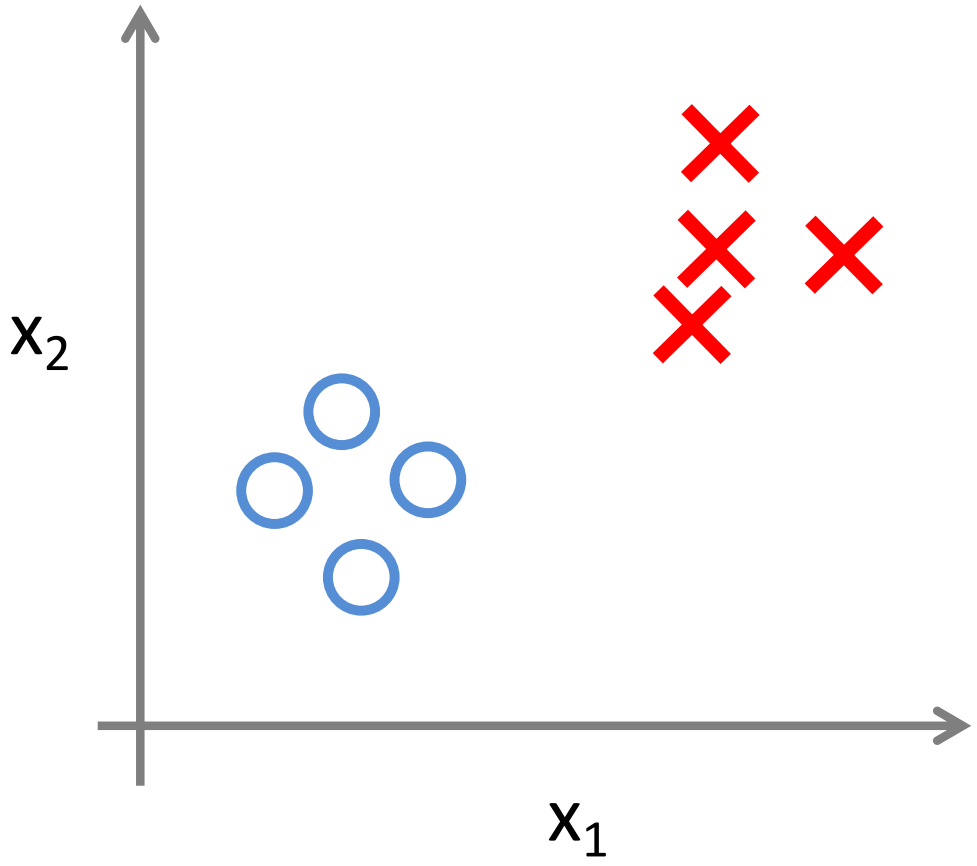
Treat both as classification problems.

Treat problem 1 as a classification problem, problem 2 as a regression problem.

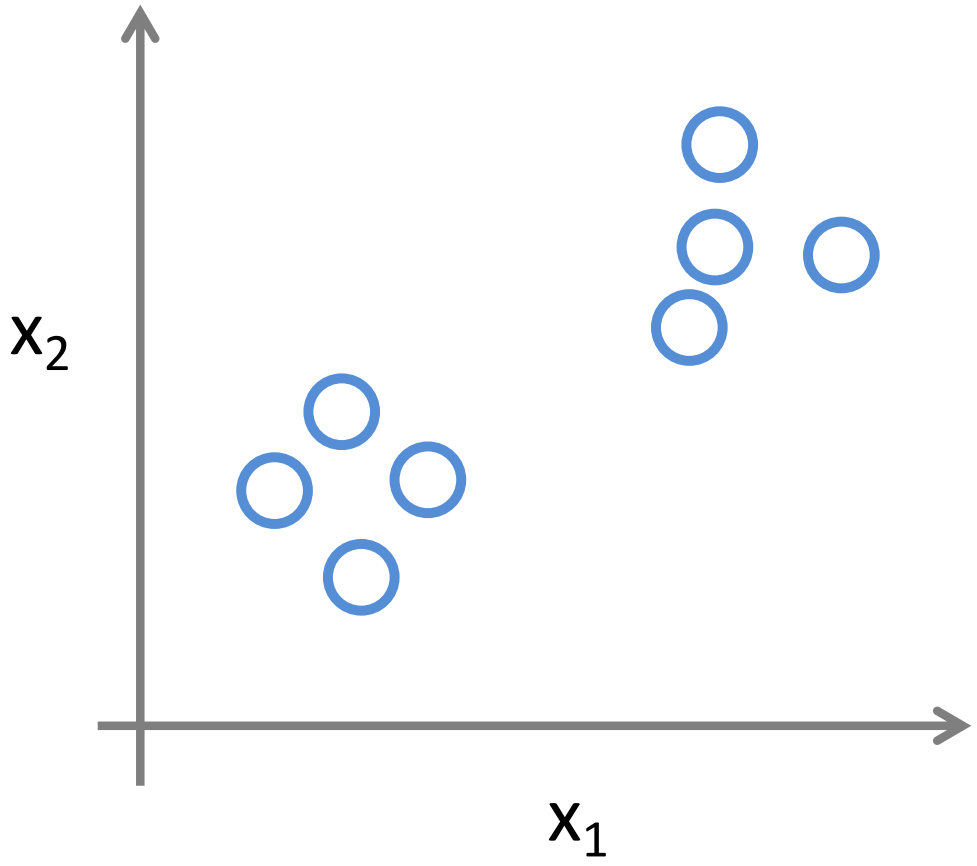
Treat problem 1 as a regression problem, problem 2 as a classification problem.

Treat both as regression problems.

Supervised Learning



Unsupervised Learning



Google

News

U.S. edition ▾ Modern ▾

Top Stories

- Nancy Reagan
- Peyton Manning
- Hillary Rodham Clinton
- Donald Trump
- Taliban
- Refugees
- Baghdad
- Marco Rubio
- Los Angeles Lakers
- European Union

Suggested for you

Milwaukee, Wisconsin

image casino video g...

android how to send ...

green bay packers ve...

Recommended

U.S.

Top Stories

Huffington ...

See realtime coverage

Nancy Reagan, First Lady Behind 'Just Say No' Campaign, Dead At 94

Huffington Post - 39 minutes ago

First lady Nancy Reagan and President Ronald Reagan greet the press outside the White House in May 1981. Former first lady Nancy Reagan died Sunday at the age of 94.

Opinion: Nancy Reagan served nation with grace: Your Say
USA TODAY

In Depth: Former First Lady Nancy Reagan Dies at 94 in California ABC News

Related Nancy Reagan » Ronald Reagan »

USA TODAY

CNN

Entertainment To...

Los Ange

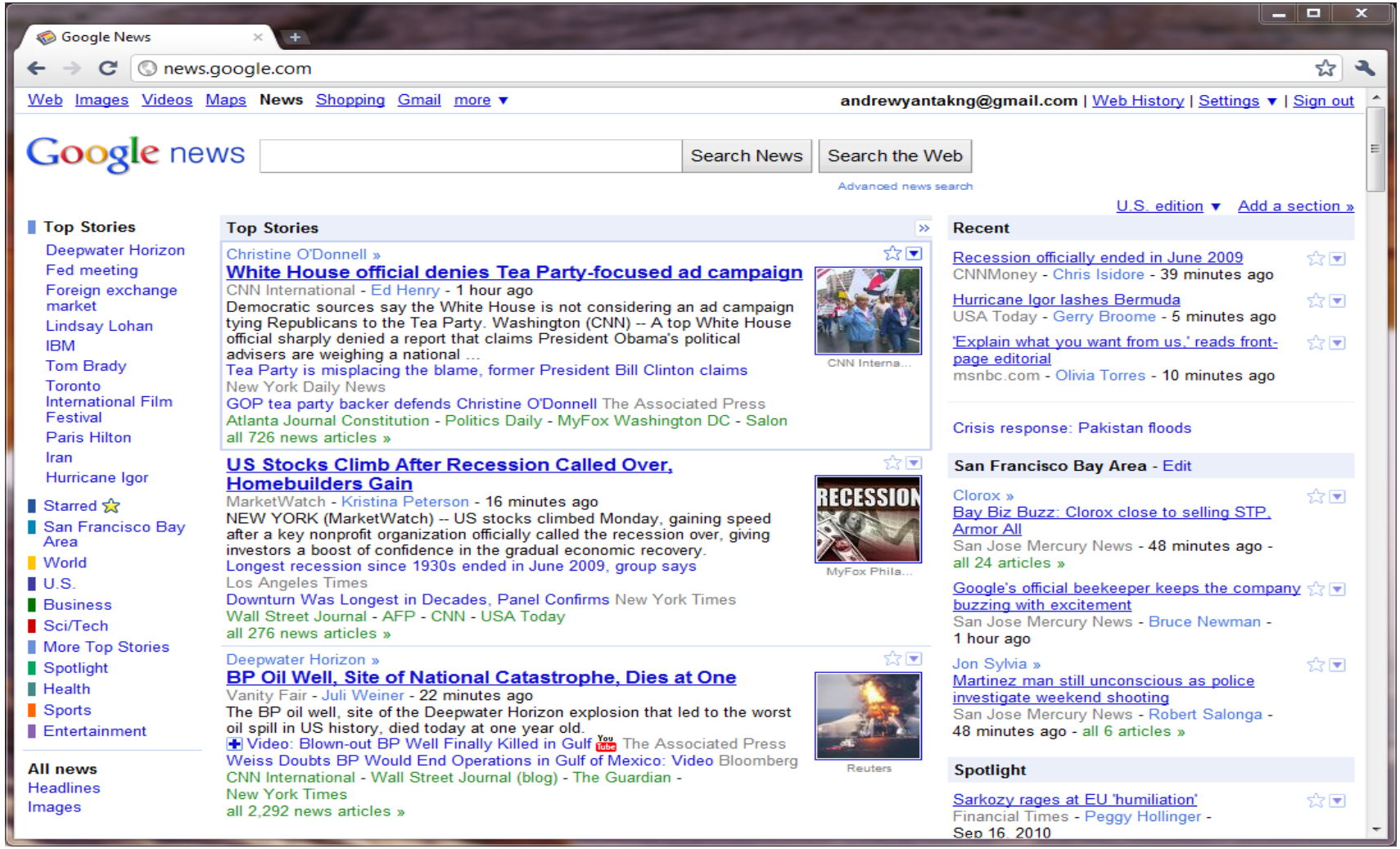
CNN

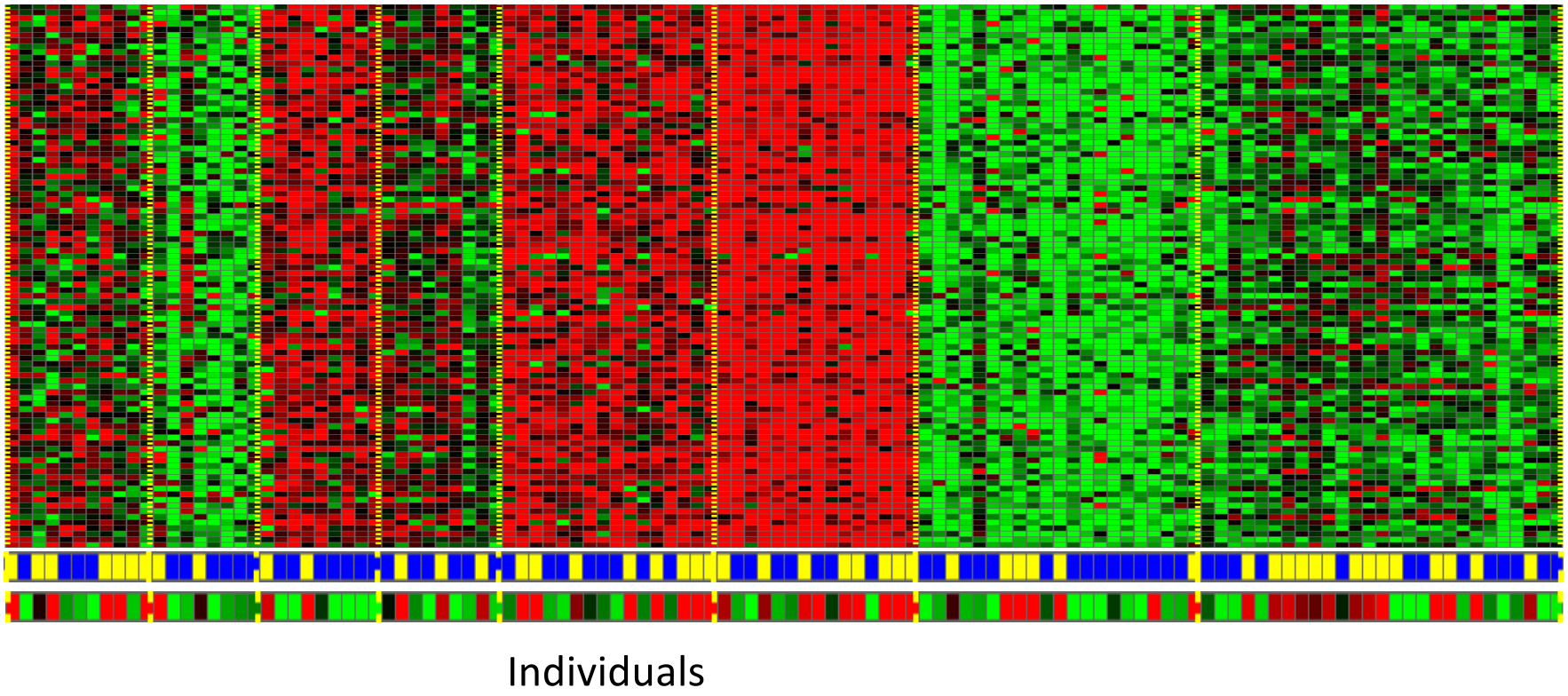
Clinton, Sanders to face off in Flint

CNN - 4 hours ago

(CNN) Hillary Clinton and Bernie Sanders go head-to-head Sunday in a CNN Democratic debate certain to focus on racial barriers and economic fairness but that will above all be defined by the toxic water crisis afflicting its host city, Flint,

tps://news.google.com/news/section?cf=all&hl=en&pz=1&ned=us&q=Nancy+Reagan&ict=clu_top


Google News
news.google.com
Web Images Videos Maps News Shopping Gmail more ▼
andrewyantakng@gmail.com | Web History | Settings ▼ | Sign out
Google news
Search News
Search the Web
Advanced news search
U.S. edition ▼ Add a section »
Top Stories
Deepwater Horizon
Fed meeting
Foreign exchange market
Lindsay Lohan
IBM
Tom Brady
Toronto International Film Festival
Paris Hilton
Iran
Hurricane Igor
Starred
San Francisco Bay Area
World
U.S.
Business
Sci/Tech
More Top Stories
Spotlight
Health
Sports
Entertainment
All news
Headlines
Images
Top Stories
Christine O'Donnell »
White House official denies Tea Party-focused ad campaign
CNN International - Ed Henry - 1 hour ago
Democratic sources say the White House is not considering an ad campaign tying Republicans to the Tea Party. Washington (CNN) -- A top White House official sharply denied a report that claims President Obama's political advisers are weighing a national ...
Tea Party is misplacing the blame, former President Bill Clinton claims New York Daily News
GOP tea party backer defends Christine O'Donnell The Associated Press
Atlanta Journal Constitution - Politics Daily - MyFox Washington DC - Salon
all 726 news articles »
CNN Interna...
US Stocks Climb After Recession Called Over, Homebuilders Gain
MarketWatch - Kristina Peterson - 16 minutes ago
NEW YORK (MarketWatch) -- US stocks climbed Monday, gaining speed after a key nonprofit organization officially called the recession over, giving investors a boost of confidence in the gradual economic recovery.
Longest recession since 1930s ended in June 2009, group says Los Angeles Times
Downturn Was Longest in Decades, Panel Confirms New York Times
Wall Street Journal - AFP - CNN - USA Today
all 276 news articles »
RECESSION
MyFox Phila...
Deepwater Horizon »
BP Oil Well, Site of National Catastrophe, Dies at One
Vanity Fair - Juli Weiner - 22 minutes ago
The BP oil well, site of the Deepwater Horizon explosion that led to the worst oil spill in US history, died today at one year old.
Video: Blown-out BP Well Finally Killed in Gulf The Associated Press
Weiss Doubts BP Would End Operations in Gulf of Mexico: Video Bloomberg
CNN International - Wall Street Journal (blog) - The Guardian - New York Times
all 2,292 news articles »
Reuters
Recent
Recession officially ended in June 2009
CNNMoney - Chris Isidore - 39 minutes ago
Hurricane Igor lashes Bermuda
USA Today - Gerry Broome - 5 minutes ago
'Explain what you want from us,' reads front-page editorial
msnbc.com - Olivia Torres - 10 minutes ago
Crisis response: Pakistan floods
San Francisco Bay Area - Edit
Clorox »
Bay Biz Buzz: Clorox close to selling STP, Armor All
San Jose Mercury News - 48 minutes ago - all 24 articles »
Google's official beekeeper keeps the company buzzing with excitement
San Jose Mercury News - Bruce Newman - 1 hour ago
Jon Sylvia »
Martinez man still unconscious as police investigate weekend shooting
San Jose Mercury News - Robert Salonga - 48 minutes ago - all 6 articles »
Spotlight
Sarkozy rages at EU 'humiliation'
Financial Times - Peggy Hollinger - Sep 16, 2010



[Source: Daphne Koller]

Of the following examples, which would you address using an unsupervised learning algorithm? (Check all that apply.)

Given email labeled as spam/not spam, learn a spam filter.

Given a set of news articles found on the web, group them into sets of articles about the same story.

Given a database of customer data, automatically discover market segments and group customers into different market segments.

Given a dataset of patients diagnosed as either having diabetes or not, learn to classify new patients as having diabetes or not.

Fundamental Course Objectives

On the basis of the training data we would like to:

- Accurately predict unseen test cases.
- Understand which inputs affect the outcome, and how.
- Assess the quality of our predictions and inferences.

Philosophy

- It is important to understand the ideas behind the various techniques, in order to know how and when to use them.
- One has to understand the simpler methods first, in order to grasp the more sophisticated ones.
- It is important to accurately assess the performance of a method, to know how well or how badly it is working (simpler methods often perform as well as complex ones!)
- This is an exciting research area, having important applications in science, medicine, industry and finance.