Machine Learning

Shahid Mahmood Awan, PhD

University of Management and Technology, Lahore

Profile: Shahid Mahmood Awan

- Ph.D. in Machine Learning (Computer Science).
- Assistant Professor at University of Management and Technology, Lahore.
- 14 years of Research, Software Development, and Teaching Experience in Data Science / Machine Learning.
- Advisor to Machine Learning projects and theses.
- **Research Areas:** Machine Learning, Deep Learning, Neural Networks, Data Analytics, Natural Language Processing, Smart Environments

Recent Projects

- **Indoor Positioning System using WIFI hotspots/ Smart Buildings using Estimote Beacons:** An indoor positioning system for GPS-Deprived large buildings. This application can interact with Wifi-routers, RFID readers, and Bluetooth Beacons to assist indoor navigation, targeted marketing, tracking and locating users, and payless exit in shopping malls.

- **Activity Recognition in Smart Homes using Machine Learning.** An activity recognition system for Smart Homes using Artificial Intelligence (AI) techniques. The activities of daily living and human behaviours are captured using different sensors installed in a smart home environment. The Machine Learning techniques are incorporated to classify and predict the activities being performed. It may be used for patient monitoring, to assist disable persons, or it may report any alarming conditions.

- **IoT based Smart Home:** This project aimed at developing a Home Automation system for Disabled Persons. The Home Appliances can be controlled through a mobile phone application using different communication channels (Bluetooth, WiFi). Further different sensors have been used to record the activities and hence artificial intelligence techniques are used to monitor and report any alarming situation.

- **Smart Irrigation System:** The purpose of smart irrigation system is to monitor the environment and soil conditions of crops and household plants through different sensors. Further, this intelligent decision making application can control the soil moisture based on current and forecasted weather conditions. It can enhance the irrigation efficiency by saving time, water, and labour cost.

- **Medical Diagnostic ChatBot**: A data driven Artificial Intelligence based system that get symptoms and ask relevant questions from users and based on the information gained, it can diagnose the diseases and help reach relevant doctors online.

- **Intelligent Health Assistant** : This application addresses the basic needs of patients for record keeping, making appointments, track their turn, paying doctor bills, search for hospitals and pharmacies. It can also track the drug dosage and remind for upcoming visits. Doctors and Hospitals can post any health seminars, free medical camps and any discount offers. It also ranks the medical facilities and doctors by mining public opinion.

- **Suspicious activity recognition through video streams:** An intelligent video surveillance using image processing, computer vision, and machine learning techniques is being developed which can monitor the human activities in real-time and categorize them as usual and unusual activities; and can generate an alert.

- **Medical Imaging: Heart Disease Diagnosis, Retinopathy, Breast Cancer Classification**

Recent Projects

- **Cricket Match Commentary Generation using Deep Learning:** Automatic scene segmentation and labelling paves the way towards the complete scene understanding. To get automated description of the scenes in any cricket related video. We build a pipeline with various modules applying deep learning on cricket related tasks. We first segment a cricket match into various scenes including shots, batsmen getting ready, bowlers getting ready, crowd chanting etc. We then classify each scene and generate a caption for it using Long Short Term Memory Neural Networks (LSTMs).

- **YouTube Video Categorization using Deep Learning:** A very useful application of deep learning neural networks to classify YouTube videos either child safe or not. This application won the 1st place at Hackathon held at ITU, Lahore, in Jan'18.

- **Sketch Recognition using Deep Learning:** A convolutional neural network based application to recognize sketch and match them with real life objects.

- **Text Summarization for Urdu Documents:** A Text Summarization tool for Urdu Documents. Data Preparation includes Tokenization, Lemmatization, Stemming, and removal of stop words. This work also covers results comparison with existing techniques.

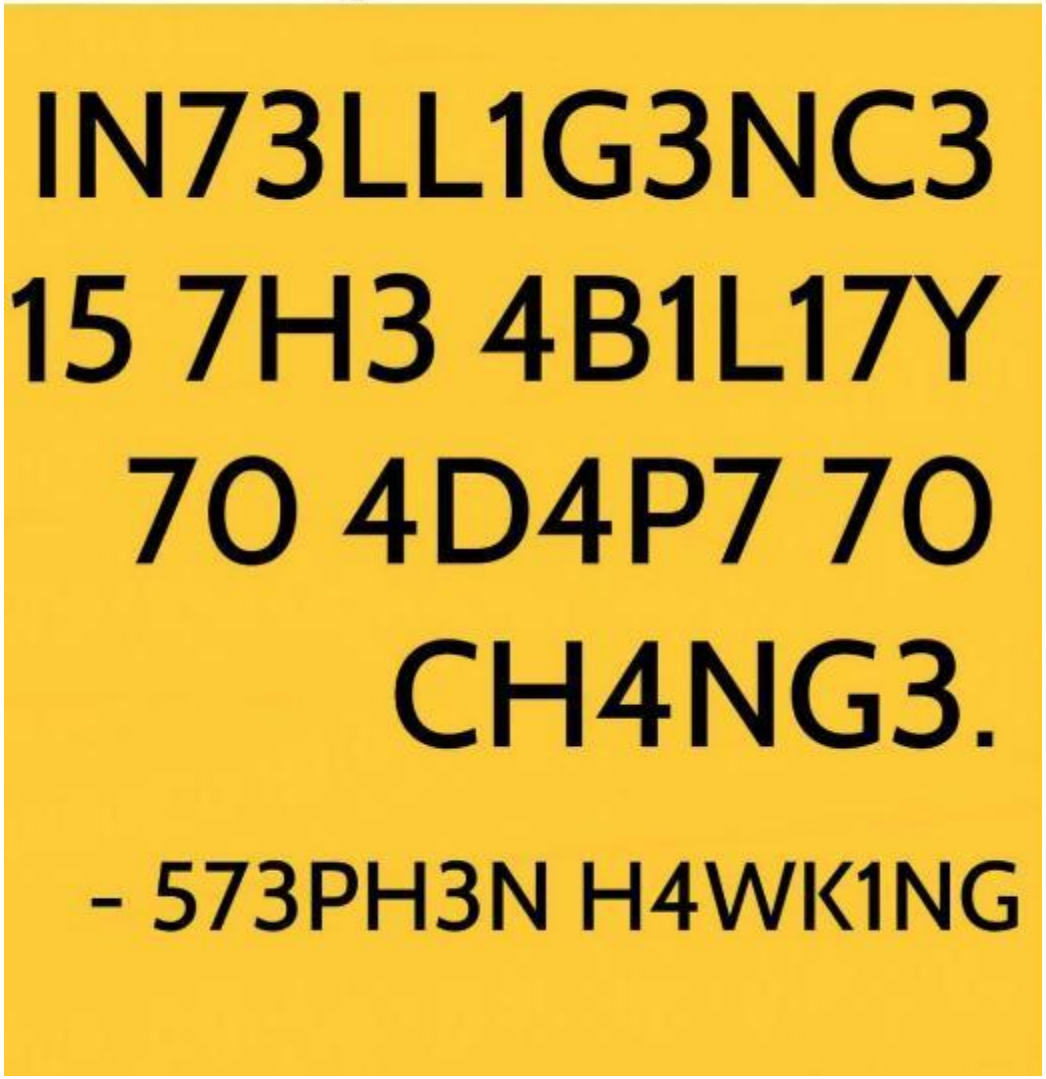
- **Fake News Detection using Deep Learning:** Detection of Fake News has gained much focus due to severity of the issue. This work covers the usage of machine learning techniques to classify as Fake or Real. Further, an analysis on appropriate feature extraction techniques help improve accuracy of classification.

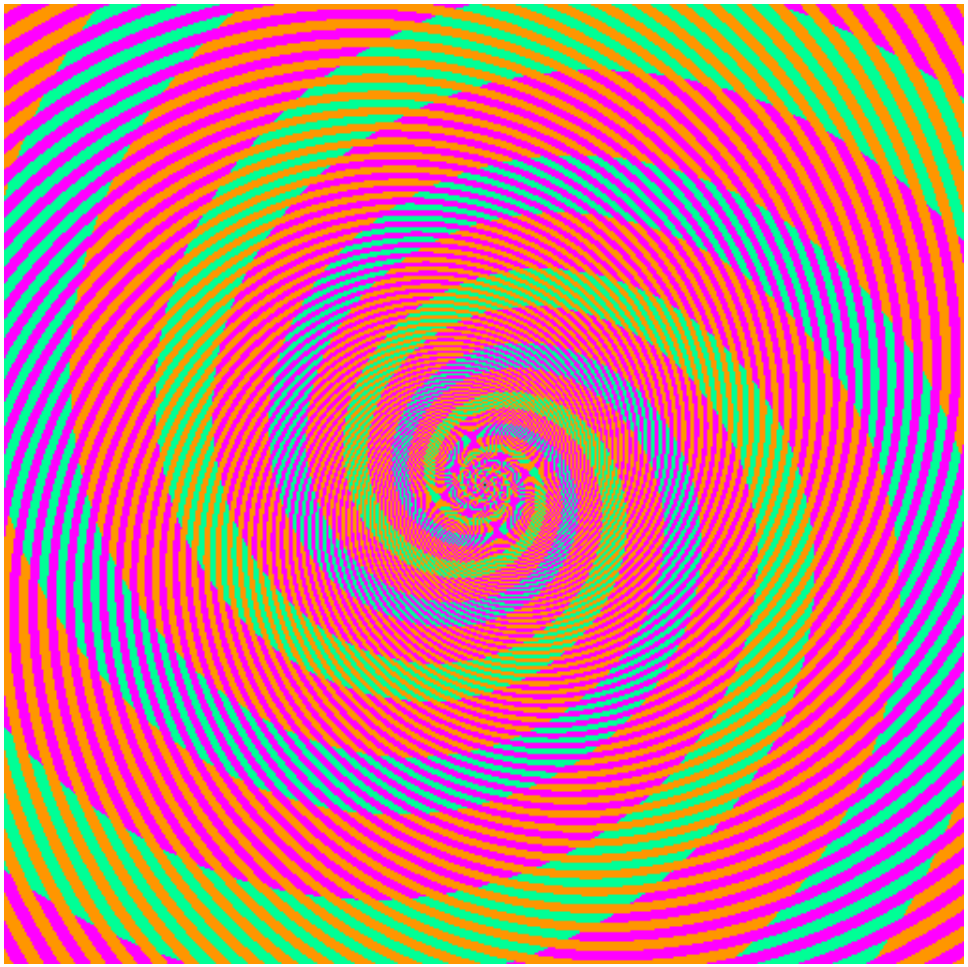
- **Urdu Text Generation:** We aim at producing the Urdu Poetry and Text using Machine Learning and Deep Learning Techniques. This is a very challenging task due to unavailability of basic resources for Urdu language. We have formed collaborations with researchers of others universities so that a basic natural language processing toolkit for Urdu can be released.

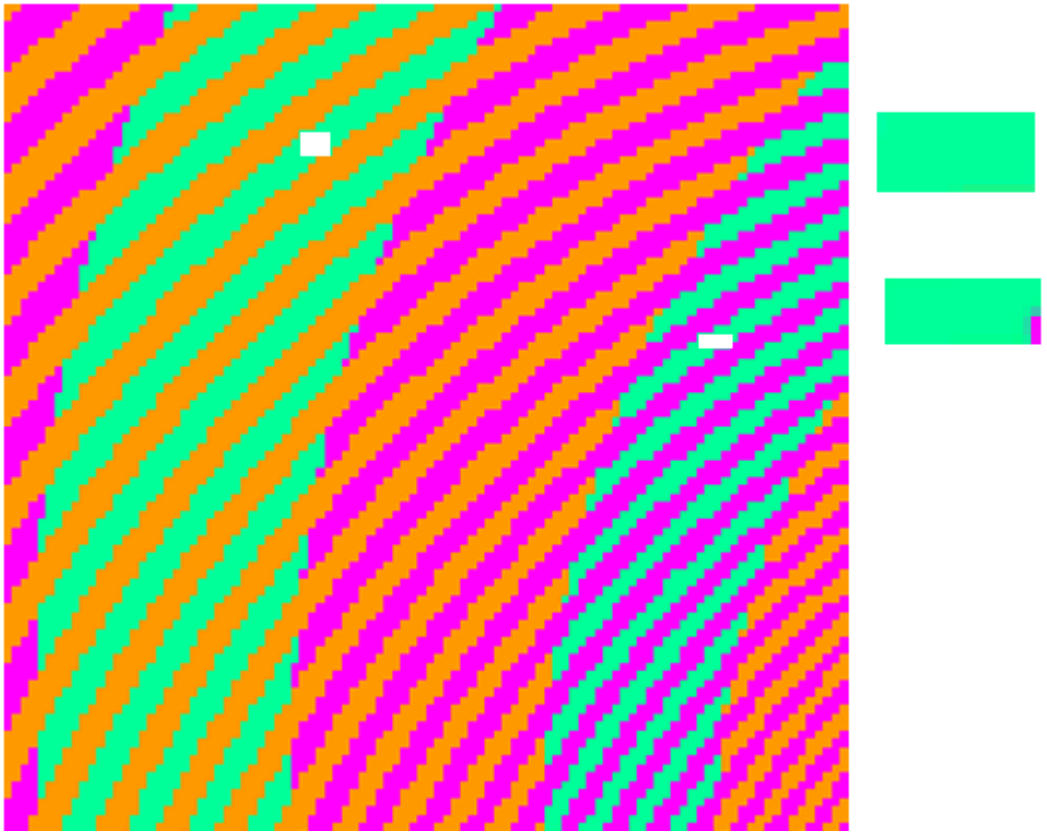
- **Human Fall Detection, Human Pose Detection:** This work focuses on solving the Human Pose Detection and Human Fall Detection using deep learning neural network. This work is especially important for patient monitoring, to assist elderly or disable persons.

- **Sentiment Analysis for Political Opinion Mining:** This sentiment analysis mobile and web application uses sophisticated machine learning techniques to get a close guess of public opinion. It uses social media data as well as internet articles and blogs for this purpose. This system provides word level, phrase level, sentence level, and context level sentiment analysis of the given text. It can also analyze for anger, hate, depression, humor, sarcasm in the text.

Can you read it?



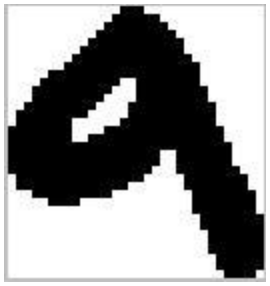




The blue and green colors are actually the same

http://blogs.discovermagazine.com/badastronomy/2009/06/24/the-blue-and-the-green/

Can you recognize this?



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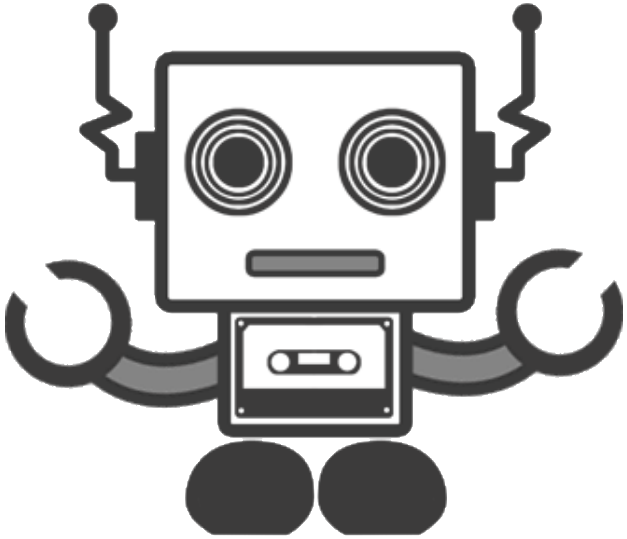
Recognize the Fruit…

What is Learning?

What is Machine Learning?

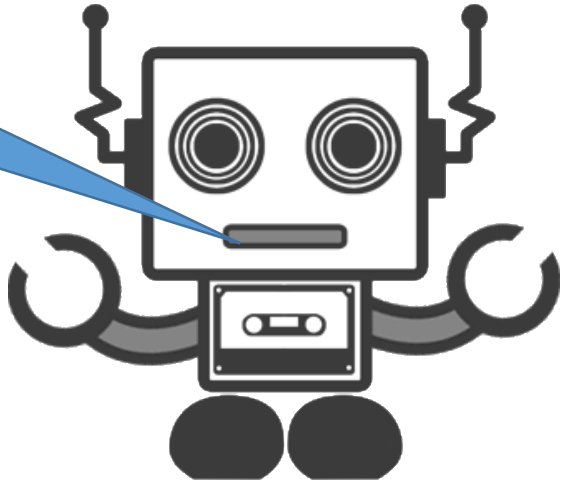
How do we learn?



What can machines do?

What is Machine Learning?

Can we make them learn from Experience?



Experience = Data

Model that fits the data

Follow Instructions

Learn from Experience

Make a mental model out of observed data and the re-tune it after seeing more and more data?

What is Machine Learning?

Traditional Programming

Machine Learning

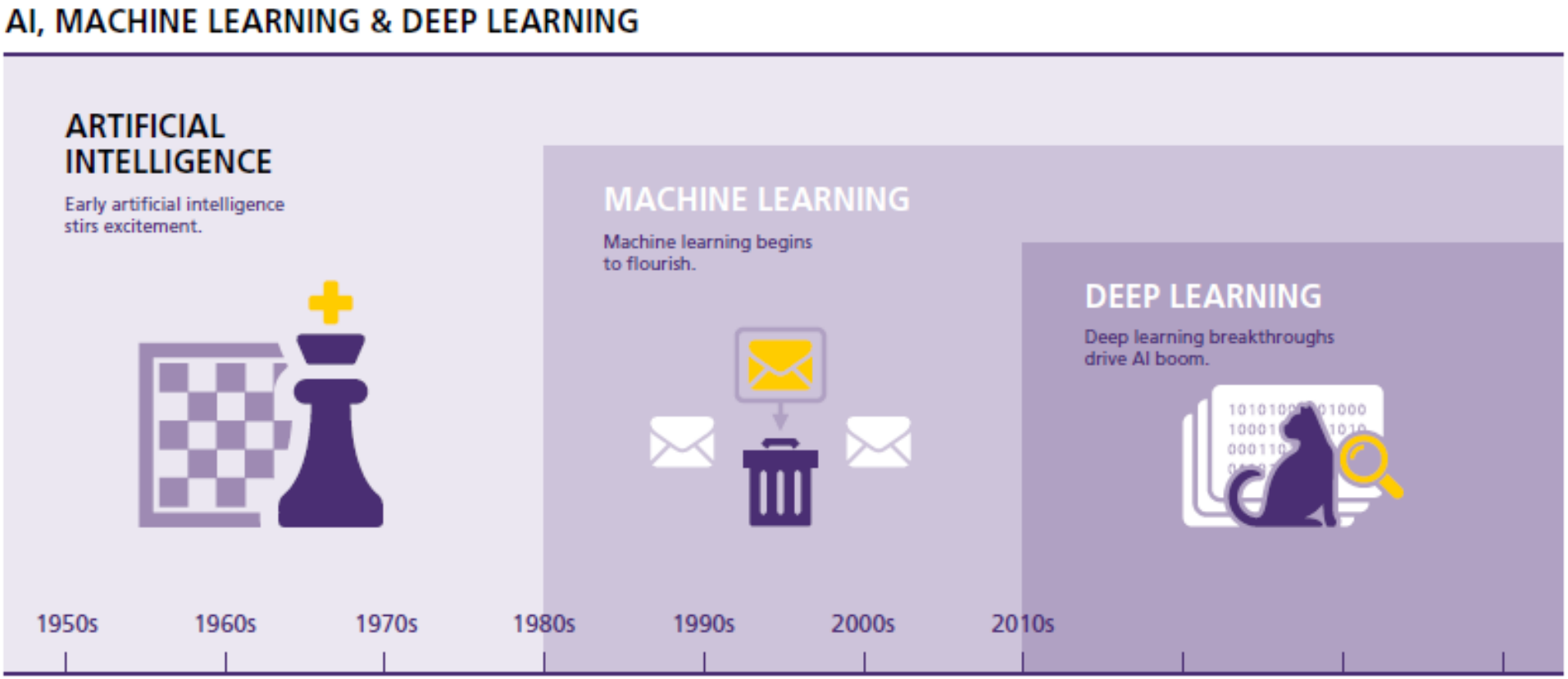


Figure 3: A visual representation of AI, machine learning, and deep learning; **Source:** Nvidia

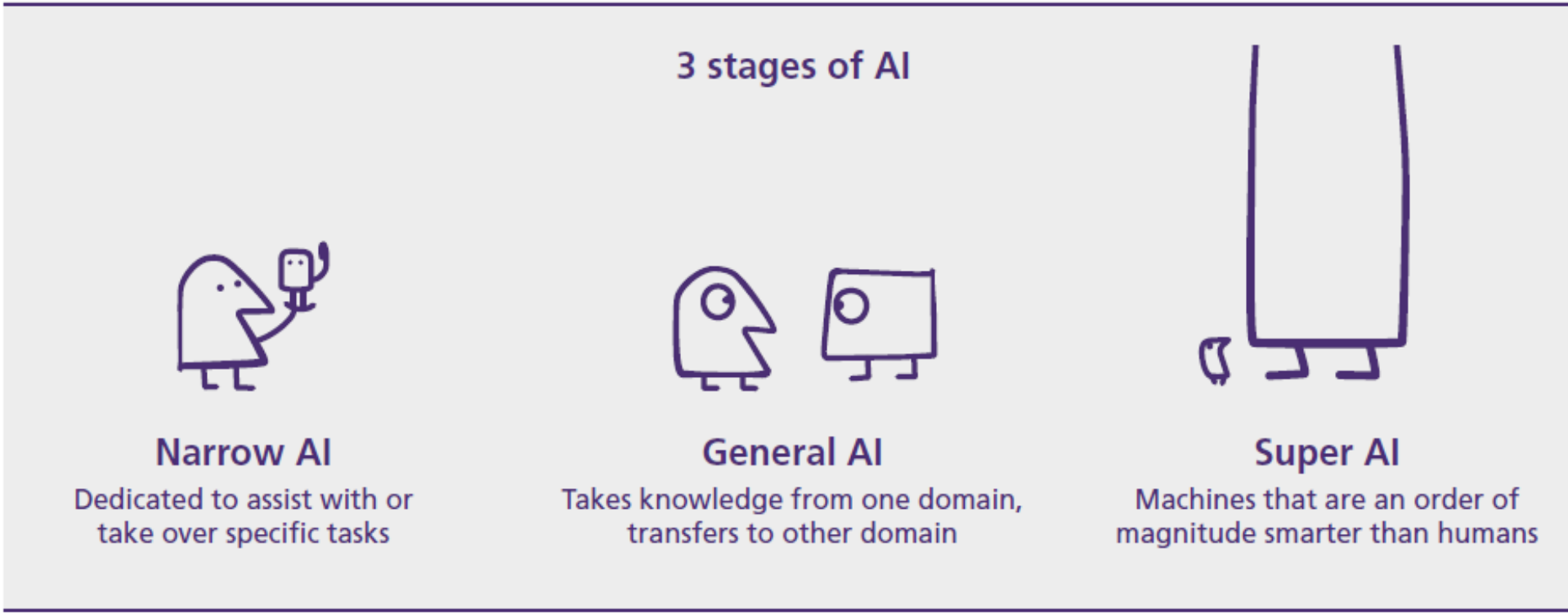


Figure 19: A comical but representative theoretical depiction of the three stages of AI; **Source:** van der Linde, N.

Full AI Learning Cycle

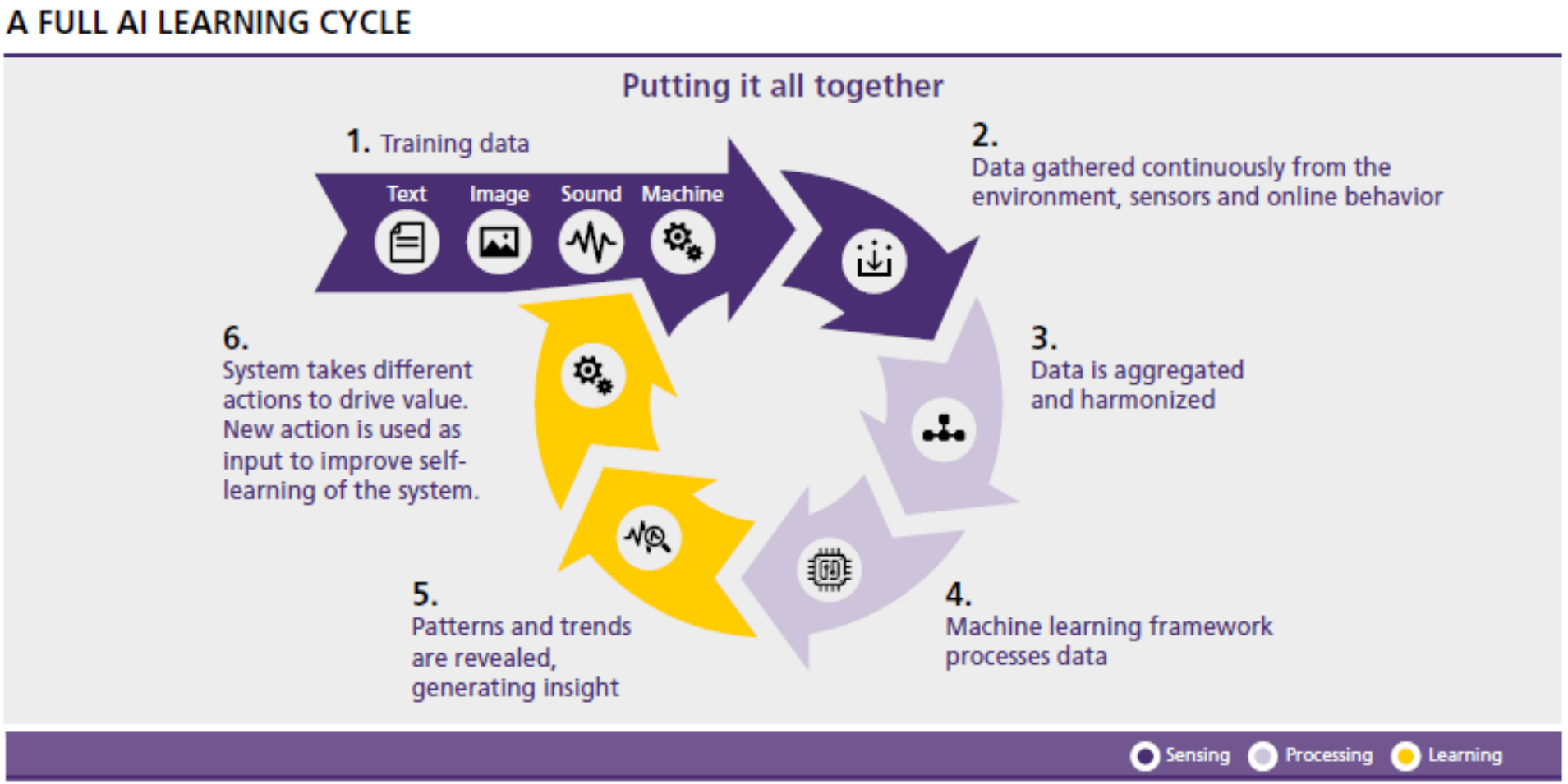
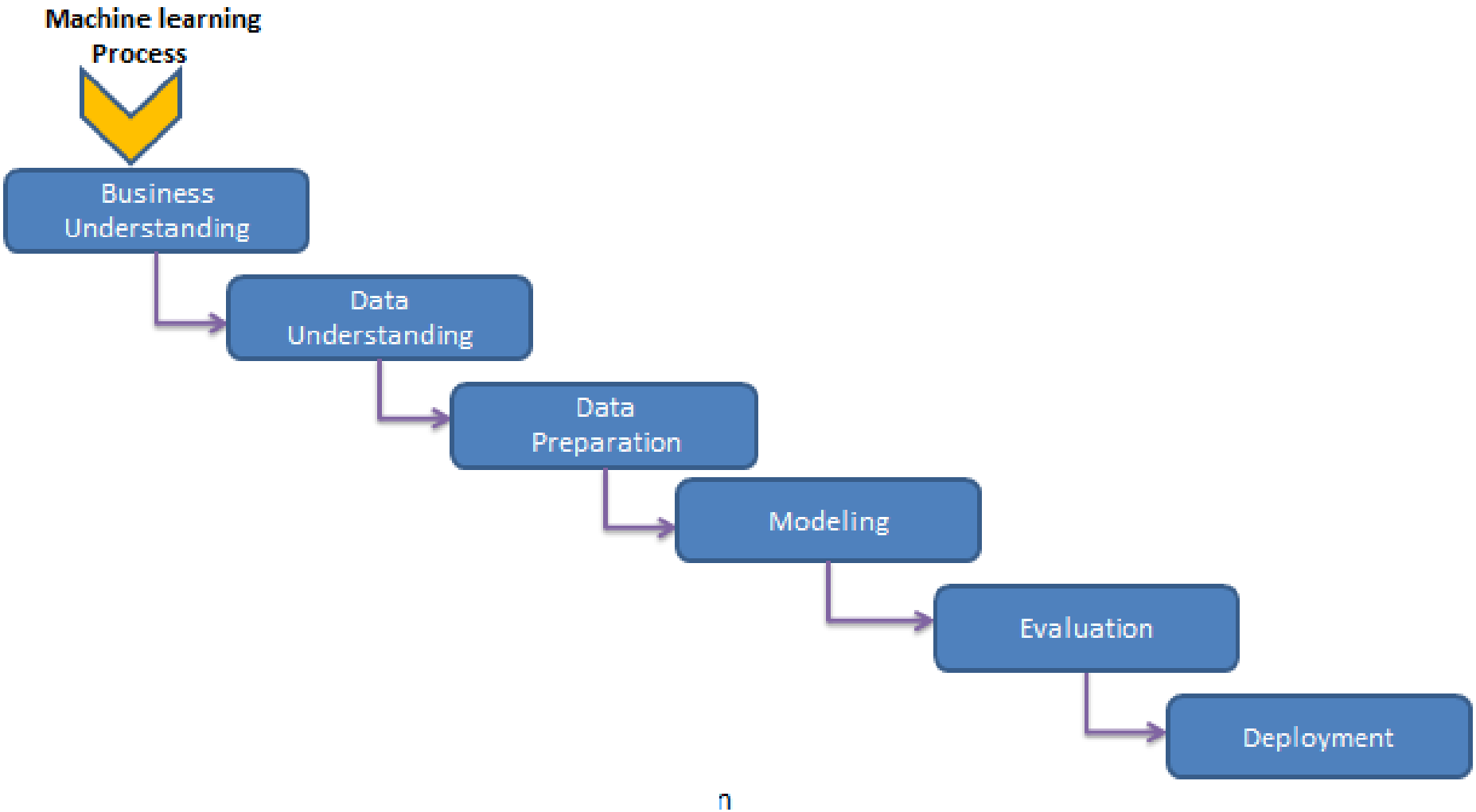


Figure 6: A full AI learning cycle; **Source:** IBM/DHL


Machine learning
Process
Business Understanding
Data Understanding
Data Preparation
Modeling
Evaluation
Deployment

n

Why do we need to learn?

- Example Problem: **Face Recognition**

- **Can you hand write all the rules to recognize a particular face?**

Why do we need to learn?

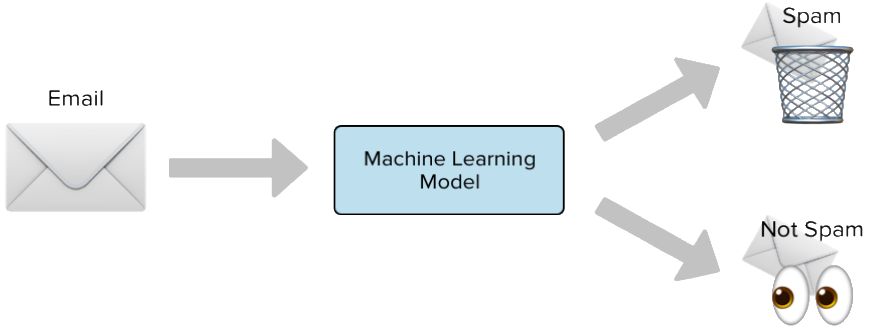
- Example Problem: **Face Recognition**

- **Training data:** a collection of images and labels (names)
- **Evaluation criterion:** correct labeling of new images

Why do we need to learn?

- Example problem: spam detection.
- Data consists of information from 4601 email messages, in a study to try to predict whether the email was “spam”. The data were collected in Hewlett-Packard labs and donated by George Forman.

- **Objective**: design an automatic spam detector.
- **Supervised learning problem**: class variables email/spam classification problem.



Why do we need to learn?

- Machine learning is programming computers to optimize a performance criterion using example data or past experience.

- **There is no need to "learn" to calculate payroll**

- Learning is used when:
  - Human expertise does not exist (navigating on Mars),
  - Humans are unable to explain their expertise (speech recognition)
  - Solution changes in time (routing on a computer network)
  - Solution needs to be adapted to particular cases (user biometrics)

What is Machine Learning?

- Learning is any process by which a system improves performance from experience.” ~ Herbert Simon

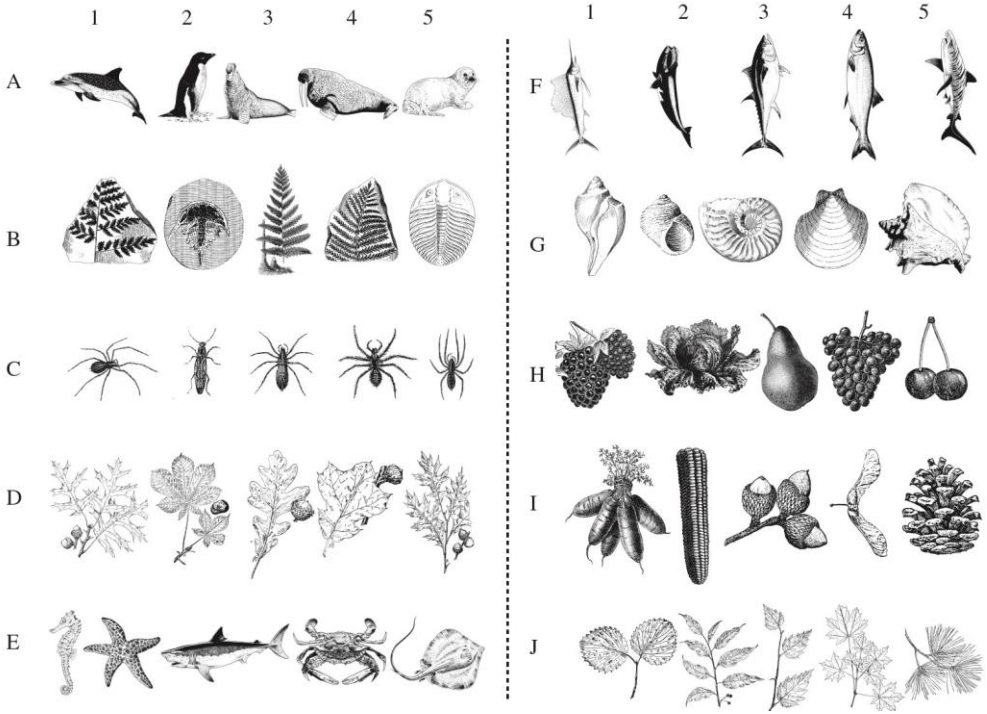
- Definition by Tom Mitchell (1998):

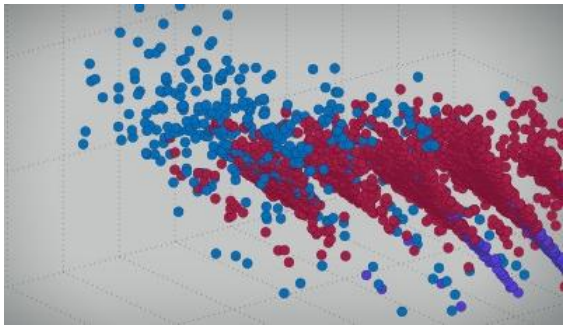
  Machine Learning is the study of algorithms that
  - improve their performance P
  - at some task T
  - with experience E.

  A well-defined learning task is given by <P, T, E>.

What is Machine Learning?

Machine Learning is only possible because there is a structure/pattern in this world

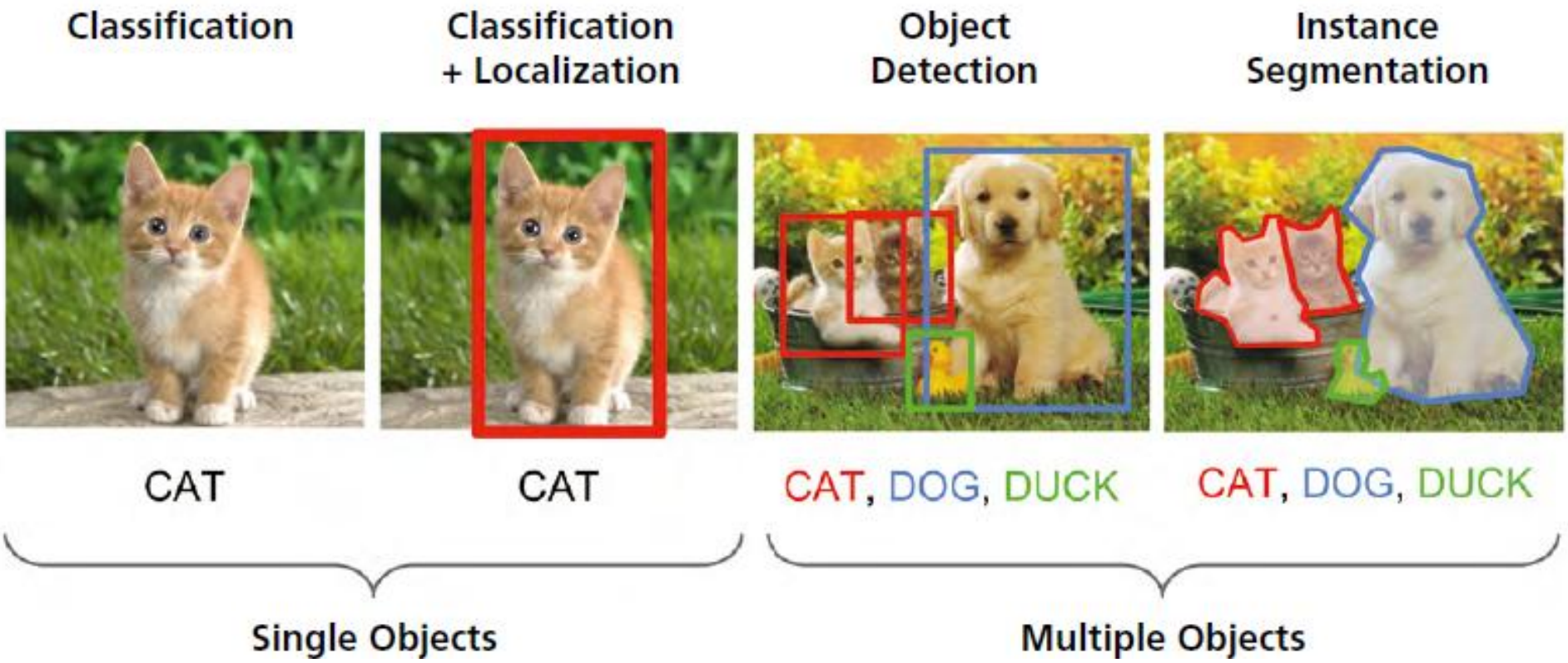




ML Applications

Problem Type	Inputs	Hidden Layers	Output
Image Recognition	Picture(s)	Person? Face? Gender? Age? Hair & eye color?	Is it you? (%)
Loan Approval	Loan application	Income? Credit history? Employment? Marital status?	Will you repay? (%)
Online Ad Placement	Social media profile, browsing history	Demographics? Browsing history metadata	Will you click? (%)

ML Applications



Machine Learning Task

Training set (labels known)

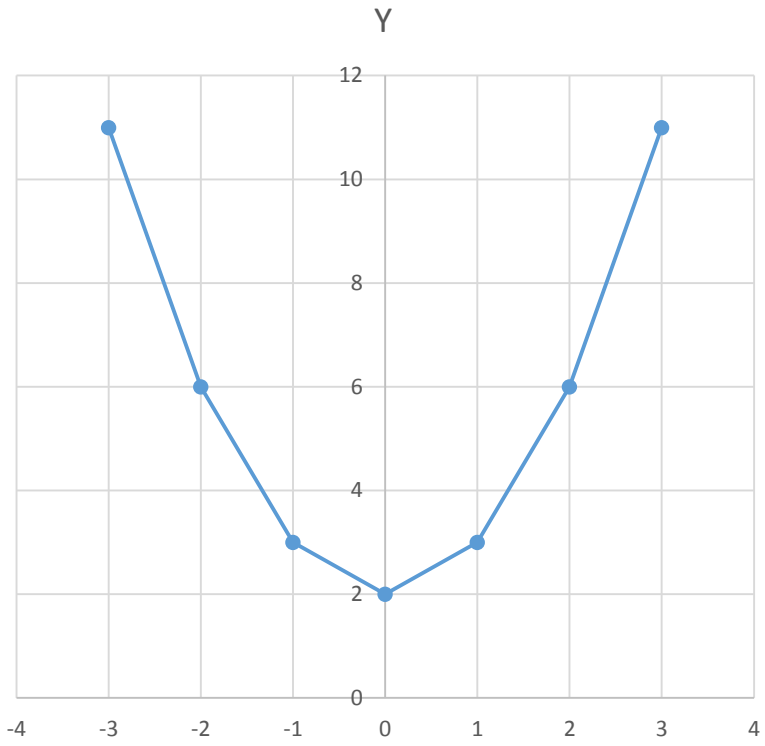
Test set (labels unknown)

Slide credit: L. Lazebnik

Guess the Function? $y = f(x)$

X	Y
-5	25
-4	16
-3	9
-2	4
-1	1
0	0
1	1
2	4
3	9
4	16
5	25

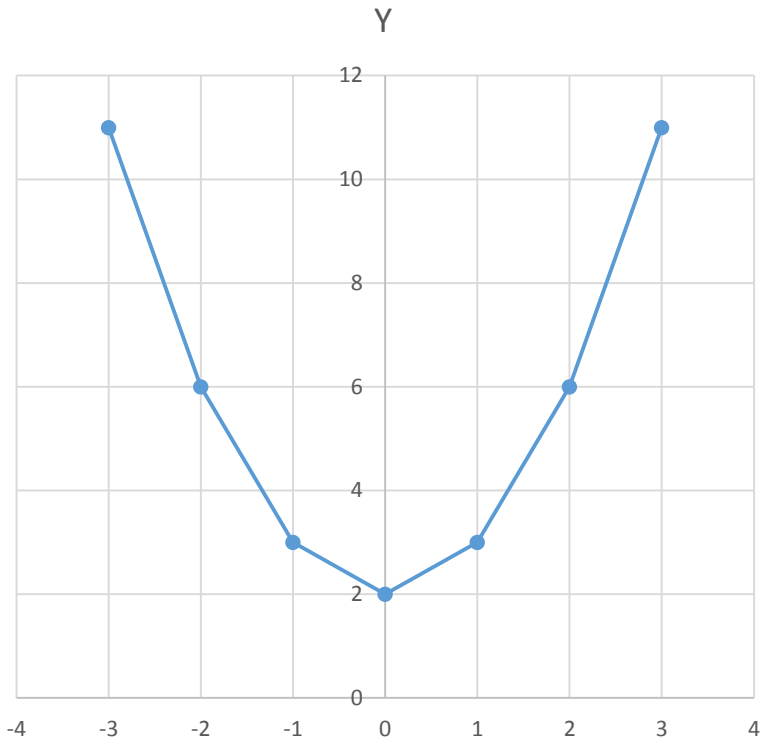
$$y = x^2$$



Guess the Function? $y = f(x)$

X	Y
-3	11
-2	6
-1	3
0	2
1	3
2	6
3	11

$$y = x^2 + 2$$



Guess the Function? $y = f(x)$

X	Y
-3	-5
-2	0
-1	3
0	4
1	3
2	0
3	-5

The machine learning framework

- Apply a prediction function to a feature representation of the image to get the desired output:

f() = “apple”

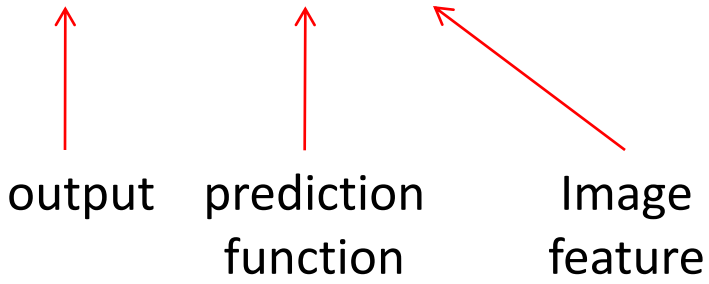
f() = “tomato”

f() = “cow”

Slide credit: L. Lazebnik

The machine learning framework

$$y = f(\mathbf{x})$$



Slide credit: L. Lazebnik

Image Categorization

Training

Training Images

Training Labels

Image Features

Classifier Training

Trained Classifier

Testing

Test Image

Image Features

Trained Classifier

Prediction

Outdoor

Slide: Derek Hoiem

Types of Learning

- **Supervised** (inductive) learning
  – Given: training data + desired outputs (labels)

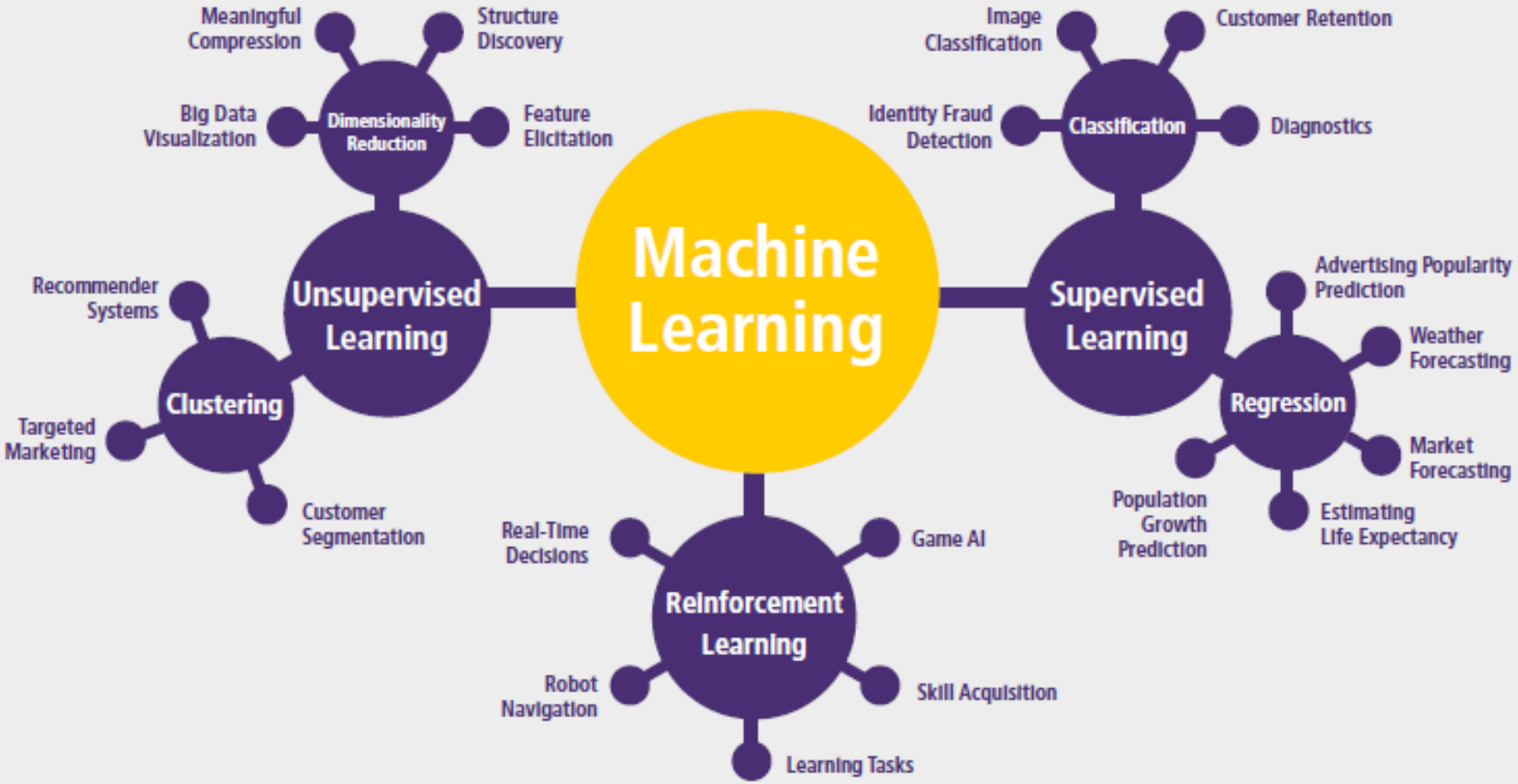
- **Unsupervised** learning
  – Given: training data (without desired outputs)

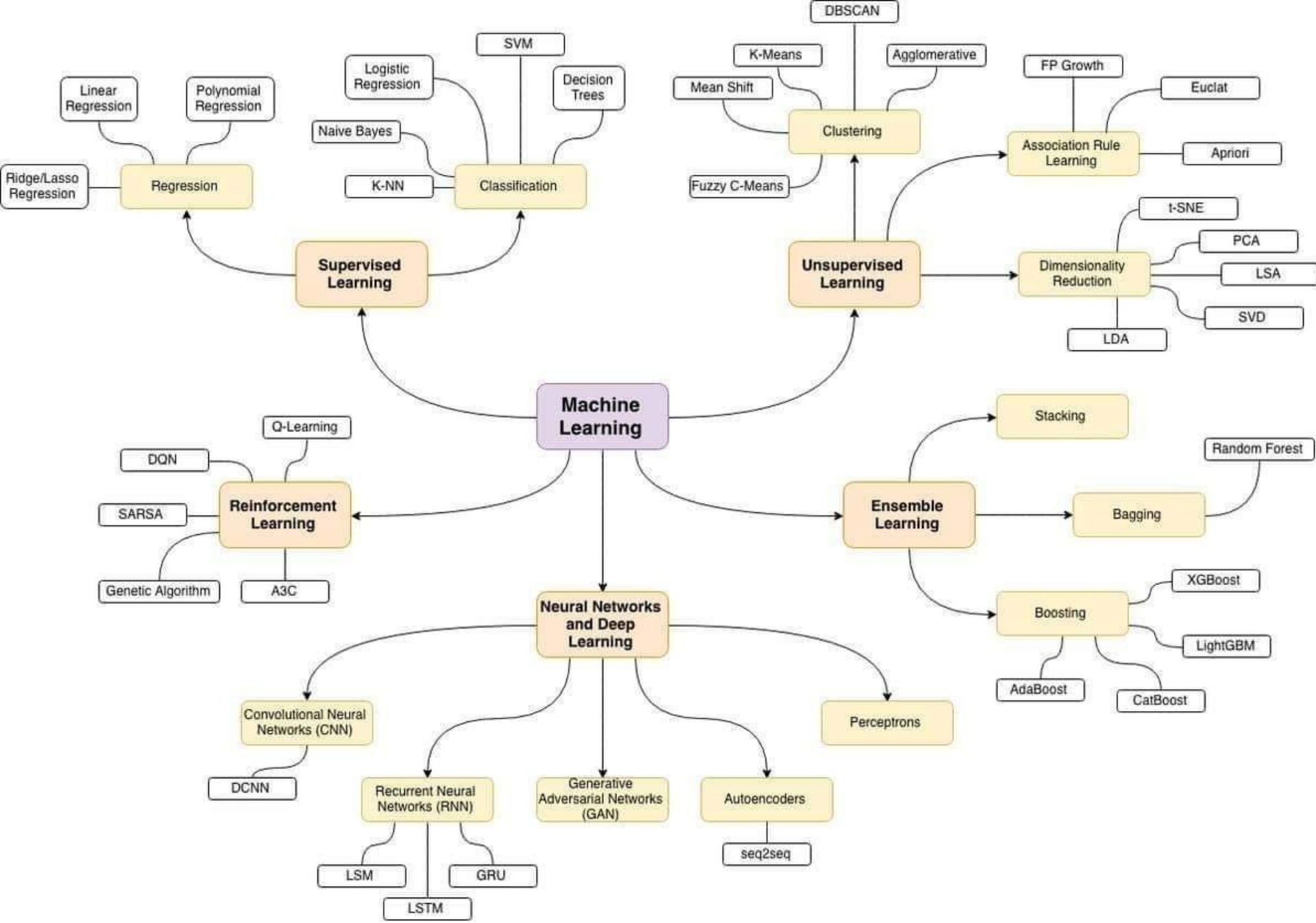
- **Semi-supervised** learning
  – Given: training data + a few desired outputs

- **Reinforcement** learning
  – Rewards from sequence of actions

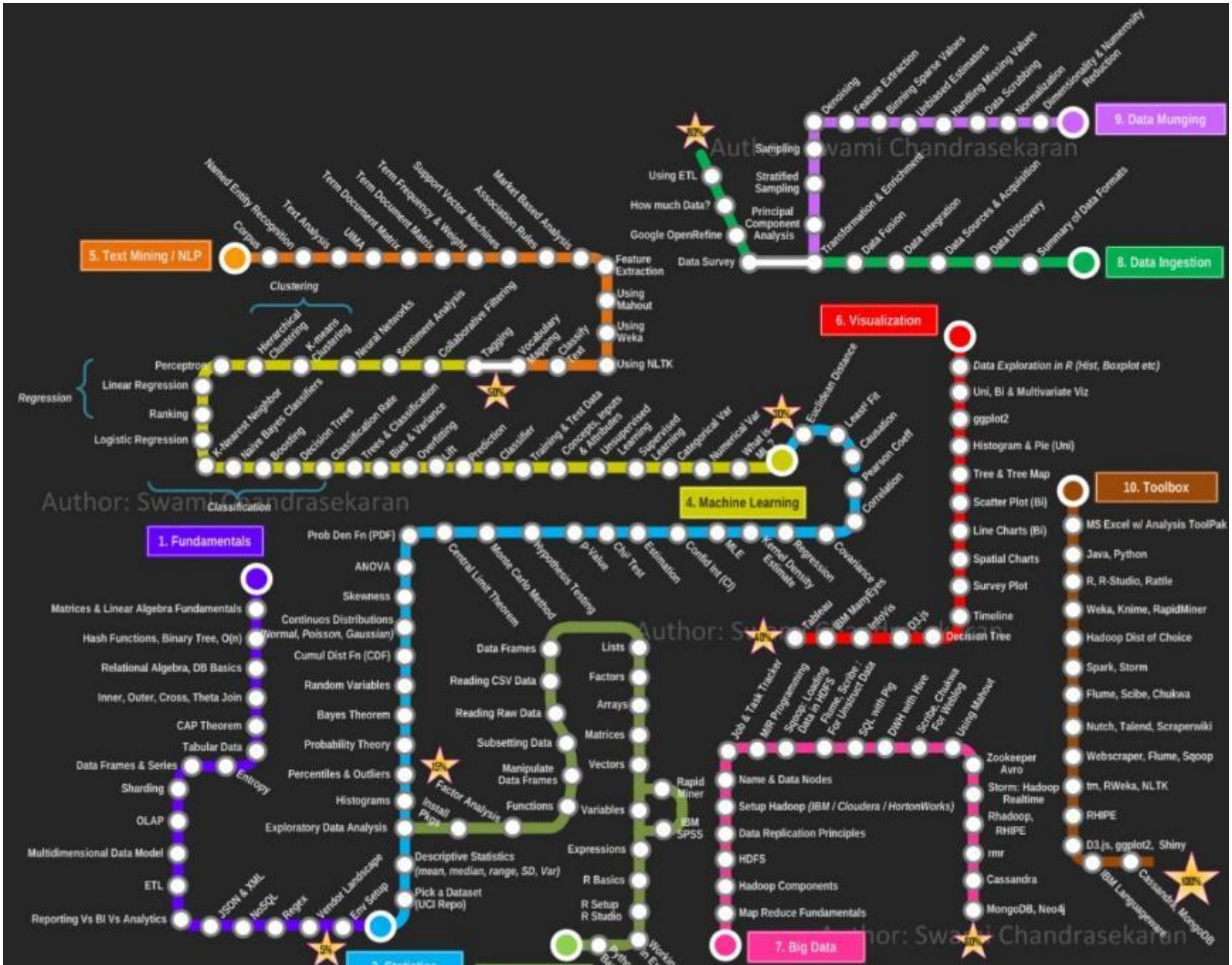
Training data = Feature Vectors extracted from the raw data

TAXONOMY OF MACHINE LEARNING METHODOLOGIES



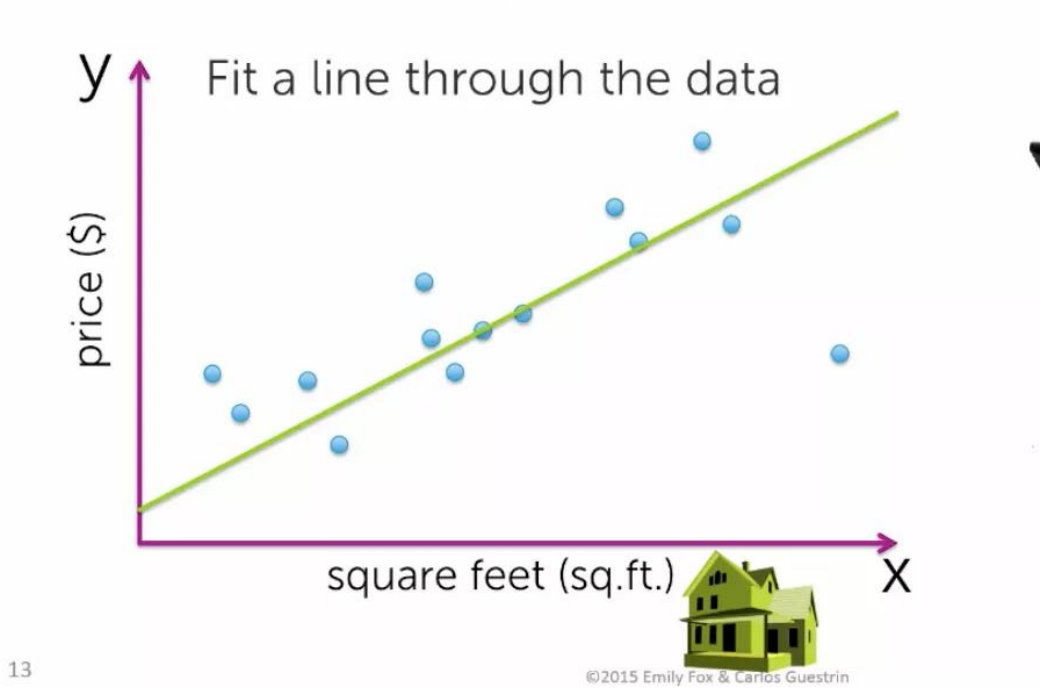

Machine Learning
Supervised Learning
Regression
Linear Regression
Polynomial Regression
Ridge/Lasso Regression
Classification
SVM
Logistic Regression
Decision Trees
Naive Bayes
K-NN
Unsupervised Learning
Clustering
DBSCAN
K-Means
Agglomerative
Mean Shift
Fuzzy C-Means
Association Rule Learning
FP Growth
Euclat
Apriori
Dimensionality Reduction
t-SNE
PCA
LSA
SVD
LDA
Reinforcement Learning
Q-Learning
DQN
SARSA
Genetic Algorithm
A3C
Ensemble Learning
Stacking
Bagging
Random Forest
Boosting
XGBoost
LightGBM
AdaBoost
CatBoost
Neural Networks and Deep Learning
Convolutional Neural Networks (CNN)
DCNN
Recurrent Neural Networks (RNN)
LSM
GRU
LSTM
Generative Adversarial Networks (GAN)
Autoencoders
seq2seq
Perceptrons


think big data
regression
Ordinary Least Squares Regression (OLSR)
Linear Regression
Logistic Regression
Stepwise Regression
Multivariate Adaptive Regression Splines (MARS)
Locally Estimated Scatterplot Smoothing (LOESS)
Jackknife Regression
regularization
Ridge Regression
Least Absolute Shrinkage and Selection Operator (LASSO)
Elastic Net
Least-Angle Regression (LARS)
instance based
also called cake-based, memory-based
k-Nearest Neighbour (kNN)
Learning Vector Quantization (LVQ)
Self-Organizing Map (SOM)
Locally Weighted Learning (LWL)
dimesionality reduction
Principal Component Analysis (PCA)
Principal Component Regression (PCR)
Partial Least Squares Regression (PLSR)
Sammon Mapping
Multidimensional Scaling (MDS)
Projection Pursuit
Discriminant Analysis (LDA, MDA, QDA, FDA)
deep learning
Deep Boltzmann Machine (DBM)
Deep Belief Networks (DBN)
Convolutional Neural Network (CNN)
Stacked Auto-Encoders
associated rule
Apriori
Eclat
FP-Growth
ensemble
Logit Boost (Boosting)
Bootstrapped Aggregation (Bagging)
AdaBoost
Stacked Generalization (blending)
Gradient Boosting Machines (GBM)
Gradient Boosted Regression Trees (GBRT)
Random Forest
bayesian
Naive Bayes
Gaussian Naive Bayes
Multinomial Naive Bayes
Averaged One-Dependence Estimators (AODE)
Bayesian Belief Network (BBN)
Bayesian Network (BN)
Hidden Markov Models
Conditional random fields (CRFs)
decision tree
Classification and Regression Tree (CART)
Iterative Dichotomiser 3 (ID3)
C4.5 and C5.0 (different versions of a powerful approach)
Chi-squared Automatic Interaction Detection (CHAID)
Decision Stump
M5
Random Forests
Conditional Decision Trees
clustering
Single-linkage clustering
k-Means
k-Medians
Expectation Maximisation (EM)
Hierarchical Clustering
Fuzzy clustering
DBSCAN
OPTICS algorithm
Non Negative Matrix Factorization
Latent Dirichlet allocation (LDA)
neural networks
Self Organizing Map
Perceptron
Back-Propagation
Hopfield Network
Radial Basis Function Network (RBFN)
Backpropagation
Autoencoders
Hopfield networks
Boltzmann machines
Restricted Boltzmann Machines
Spiking Neural Networks
Learning Vector quantization (LVQ)
...and others
Support Vector Machines (SVM)
Evolutionary Algorithms
Inductive Logic Programming (ILP)
Reinforcement Learning (Q-Learning, Temporal Difference,
State-Action-Reward-State-Action (SARSA))
ANOVA
Information Fuzzy Network (IFN)
Page Rank
Conditional Random Fields (CRF)


1. Fundamentals
Matrices & Linear Algebra Fundamentals
Hash Functions, Binary Tree, O(n)
Relational Algebra, DB Basics
Inner, Outer, Cross, Theta Join
CAP Theorem
Tabular Data
Data Frames & Series
Entropy
Sharding
OLAP
Multidimensional Data Model
ETL
Reporting Vs BI Vs Analytics
JSON & XML
NoSQL
Regex
Vendor Landscape
Env Setup
2. Statistics
Prob Den Fn (PDF)
ANOVA
Skewness
Continuos Distributions (Normal, Poisson, Gaussian)
Cumul Dist Fn (CDF)
Random Variables
Bayes Theorem
Probability Theory
Percentiles & Outliers
Histograms
Exploratory Data Analysis
Central Limit Theorem
Monte Carlo Method
Hypotheses Testing
p-Value
Chi² Test
Estimation
Confid Int (CI)
MLE
Kernel Density Estimate
Regression
Covariance
Correlation
Descriptive Statistics (mean, median, range, SD, Var)
Pick a Dataset (UCI Repo)
Factor Analysis
Install Pkgs
3. Programming
Data Frames
Reading CSV Data
Reading Raw Data
Subsetting Data
Manipulate Data Frames
Functions
Lists
Factors
Arrays
Matrices
Vectors
Variables
Expressions
R Basics
R Setup
R Studio
Python Basics
Working in Excel
Rapid Miner
IBM SPSS
4. Machine Learning
Perceptron
Linear Regression
Ranking
Logistic Regression
Regression
K-Nearest Neighbor
Naive Bayes Classifiers
Boosting
Decision Trees
Classification Rate
Trees & Classification
Bias & Variance
Overfitting
Lift
Prediction
Classifier
Training & Test Data
Concepts, Inputs & Attributes
Unsupervised Learning
Supervised Learning
Categorical Var
Numerical Var
What is ML?
Classification
Clustering
Hierarchical Clustering
K-means Clustering
Neural Networks
Sentiment Analysis
Collaborative Filtering
Tagging
Vocabulary Mapping
Classify Text
5. Text Mining / NLP
Named Entity Recognition
Corpus
Text Analysis
UIMA
Term Document Matrix
Term Document Matrix
Term Frequency & Weight
Support Vector Machines
Association Rules
Market Based Analysis
Feature Extraction
Using Mahout
Using Weka
Using NLTK
6. Visualization
Euclidean Distance
Least² Fit
Causation
Pearson Coeff
Correlation
Data Exploration in R (Hist, Boxplot etc)
Uni, Bi & Multivariate Viz
ggplot2
Histogram & Pie (Uni)
Tree & Tree Map
Scatter Plot (Bi)
Line Charts (Bi)
Spatial Charts
Survey Plot
Timeline
Decision Tree
Tableau
IBM ManyEyes
InfoVis
D3.js
7. Big Data
Job & Task Tracker
MR Programming
Sqoop: Loading Data in HDFS
Flume, Scribe : For Unstruct Data
SQL with Pig
DWH with Hive
scribe, Chukwa For Weblog
Using Mahout
Name & Data Nodes
Setup Hadoop (IBM / Cloudera / HortonWorks)
Data Replication Principles
HDFS
Hadoop Components
Map Reduce Fundamentals
Zookeeper
Avro
Storm: Hadoop Realtime
Rhadoop, RHIPE
rmr
Cassandra
MongoDB, Neo4j
8. Data Ingestion
Sampling
Stratified Sampling
Principal Component Analysis
Transformation & Enrichment
Data Fusion
Data Integration
Data Sources & Acquisition
Data Discovery
Summary of Data Formats
Using ETL
How much Data?
Google OpenRefine
Data Survey
9. Data Munging
Denoising
Feature Extraction
Binning Sparse Values
Unbiased Estimators
Handling Missing Values
Data Scrubbing
Normalization
Dimensionality & Numerosity Reduction
10. Toolbox
MS Excel w/ Analysis ToolPak
Java, Python
R, R-Studio, Rattle
Weka, Knime, RapidMiner
Hadoop Dist of Choice
Spark, Storm
Flume, Scibe, Chukwa
Nutch, Talend, Scraperwiki
Webscraper, Flume, Sqoop
tm, RWeka, NLTK
RHIPE
D3.js, ggplot2, Shiny
IBM Languageware
Cassandra, MongoDB
Author: Swami Chandrasekaran

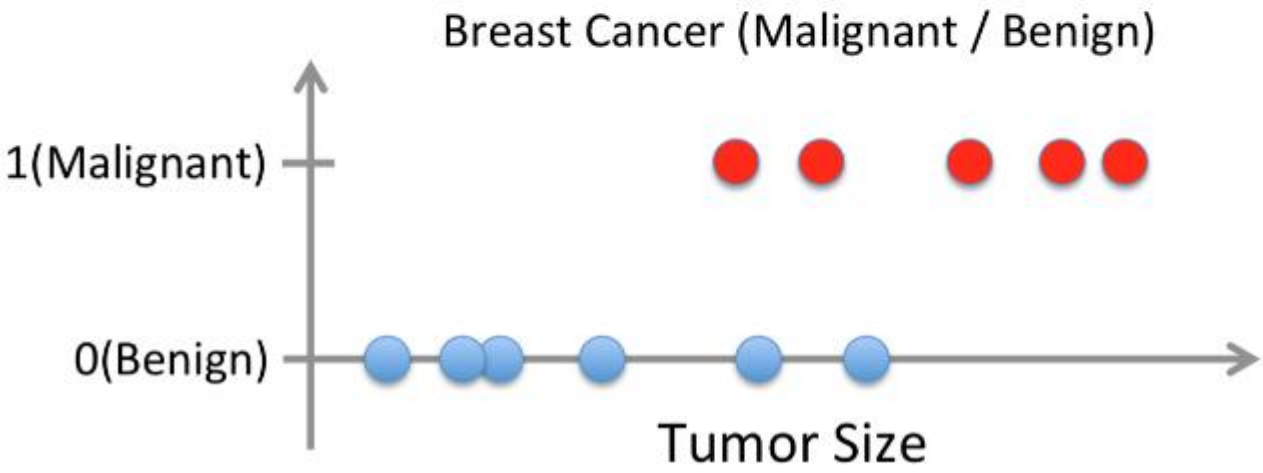
Supervised Learning: Regression

- Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x
  - y is real-valued == regression



Supervised Learning: Classification

- Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x
  - y is categorical == classification



Quiz

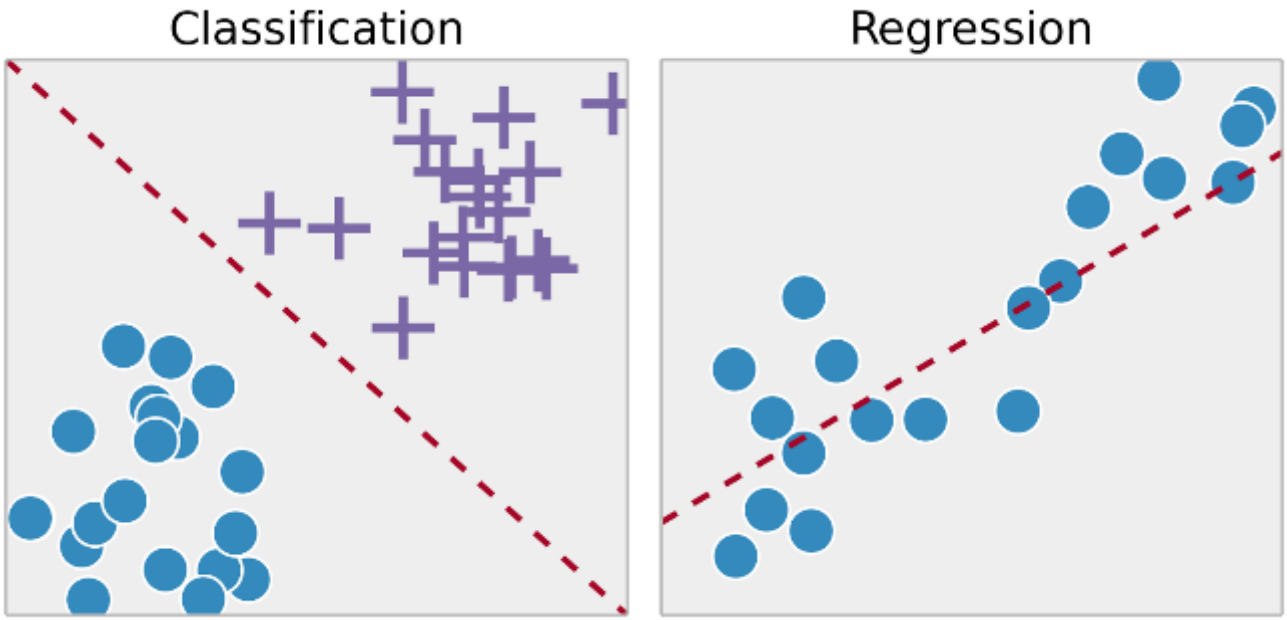
You're running a company, and you want to develop learning algorithms to address each of two problems.

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/compromised.

Should you treat these as classification or as regression problems?

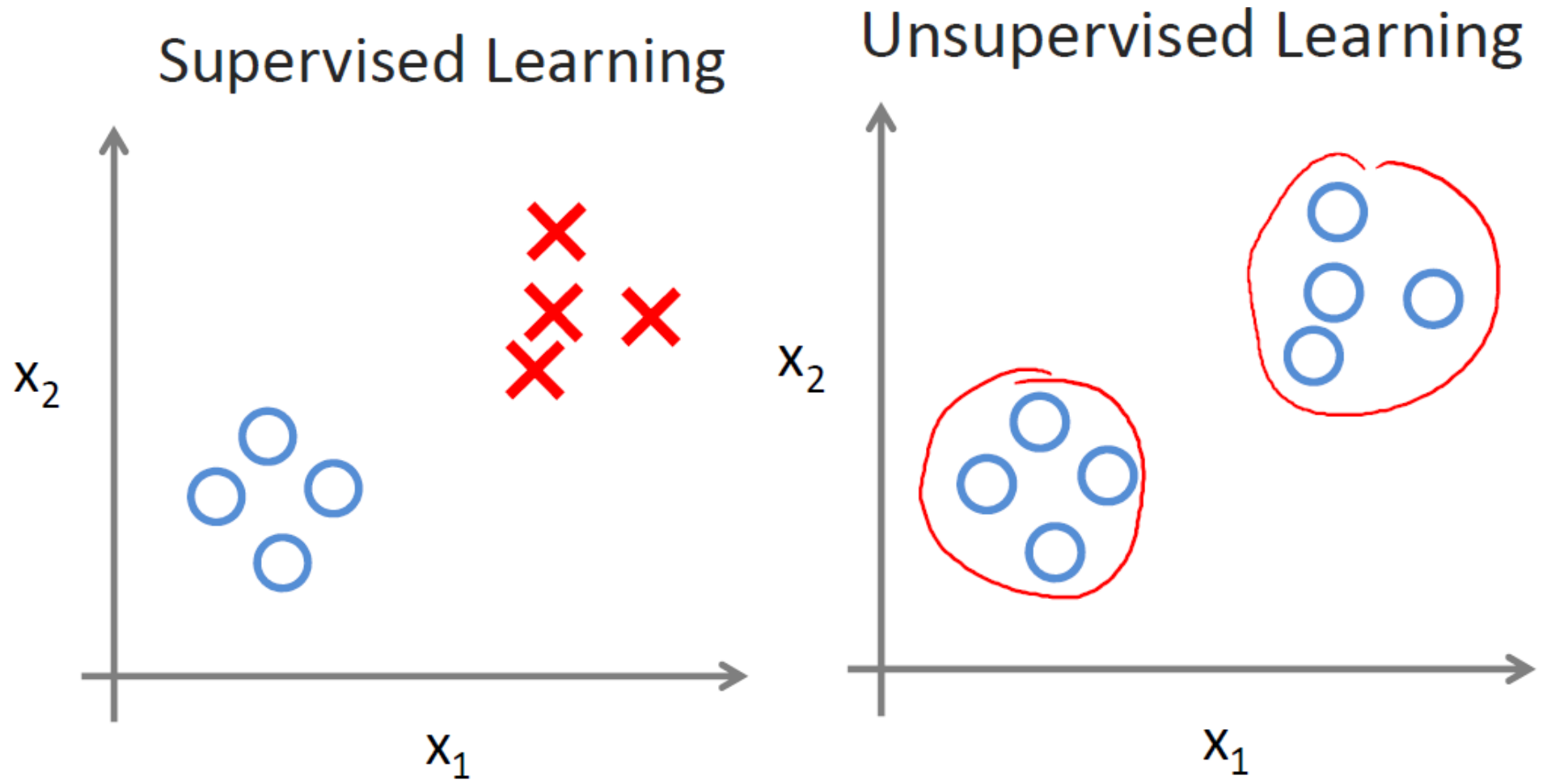
- ○ Treat both as classification problems.
- ○ Treat problem 1 as a classification problem, problem 2 as a regression problem.
- ○ Treat problem 1 as a regression problem, problem 2 as a classification problem.
- ○ Treat both as regression problems.

Supervised Learning



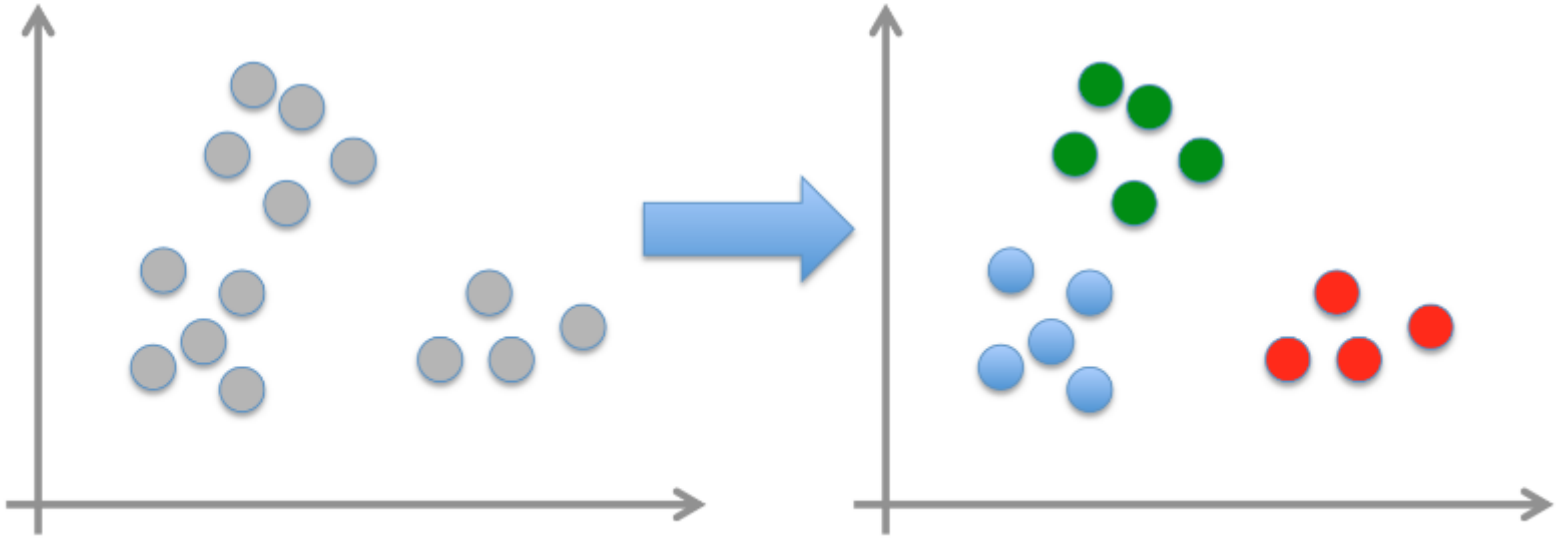
Un-Supervised Learning:

Find some structure in the data
Example: https://news.google.com/



Unsupervised Learning

- Given $x_1, x_2, \ldots, x_n$ (without labels)
- Output hidden structure behind the x's
  - E.g., clustering



Quiz

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

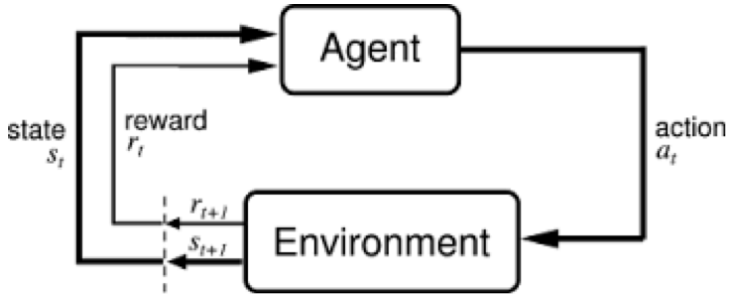
- [ ] Given email labeled as spam/not spam, learn a spam filter.
- [ ] Given a set of news articles found on the web, group them into set of articles about the same story.
- [ ] Given a database of customer data, automatically discover market segments and group customers into different market segments.
- [ ] Given a dataset of patients diagnosed as either having diabetes or not, learn to classify new patients as having diabetes or not.

Reinforcement Learning

- Given a sequence of states and actions with (delayed) rewards, output a policy
  - Policy is a mapping from states -> actions that tells you what to do in a given state

- Examples:
  - Credit assignment problem
  - Game playing
  - Robot in a maze
  - Balance a pole on your hand

Reinforcement Learning



ML in a Nutshell

- Every ML algorithm has three components:

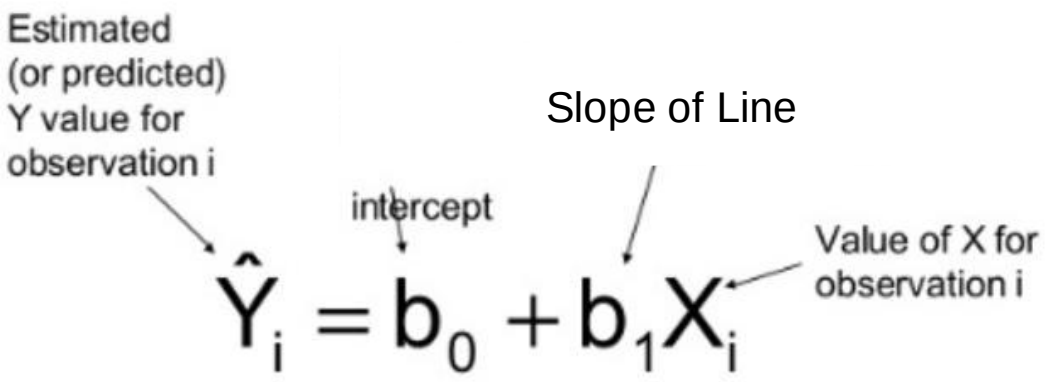
- **Representation**
  - (Linear Regression, Neural Networks, SVM, Decision Trees, Naïve Bayes, etc.)

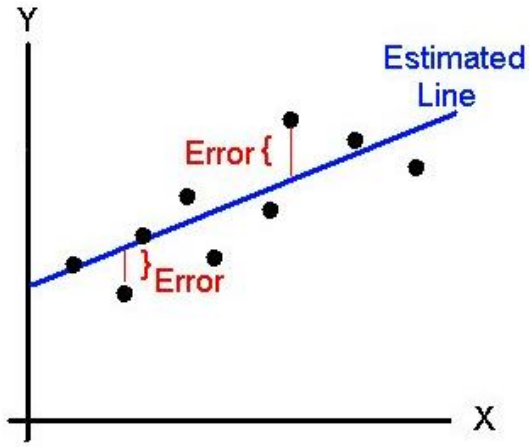
- **Optimization**
  - (Gradient Descent, Dynamic Programming, Divide and Conquer, Evolutionary Computation, etc.)

- **Evaluation**
  - (Accuracy, Precision, Recall, Cost/Utility, etc.)

Machine Learning Task

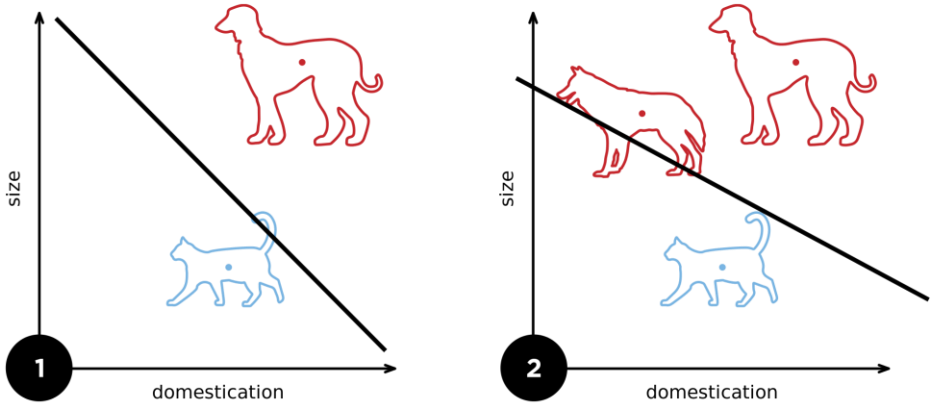
- At the very core, ML tries to fit a model on the data or finds out a decision boundary to separate the data belonging to various classes



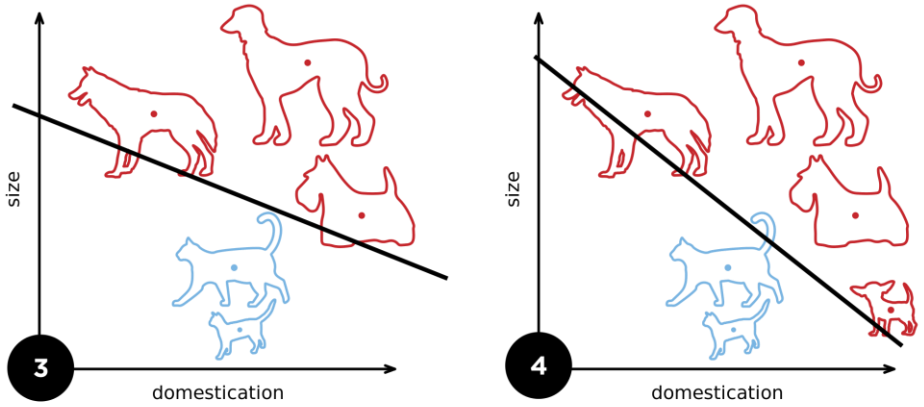


Linear Classifier/Expert

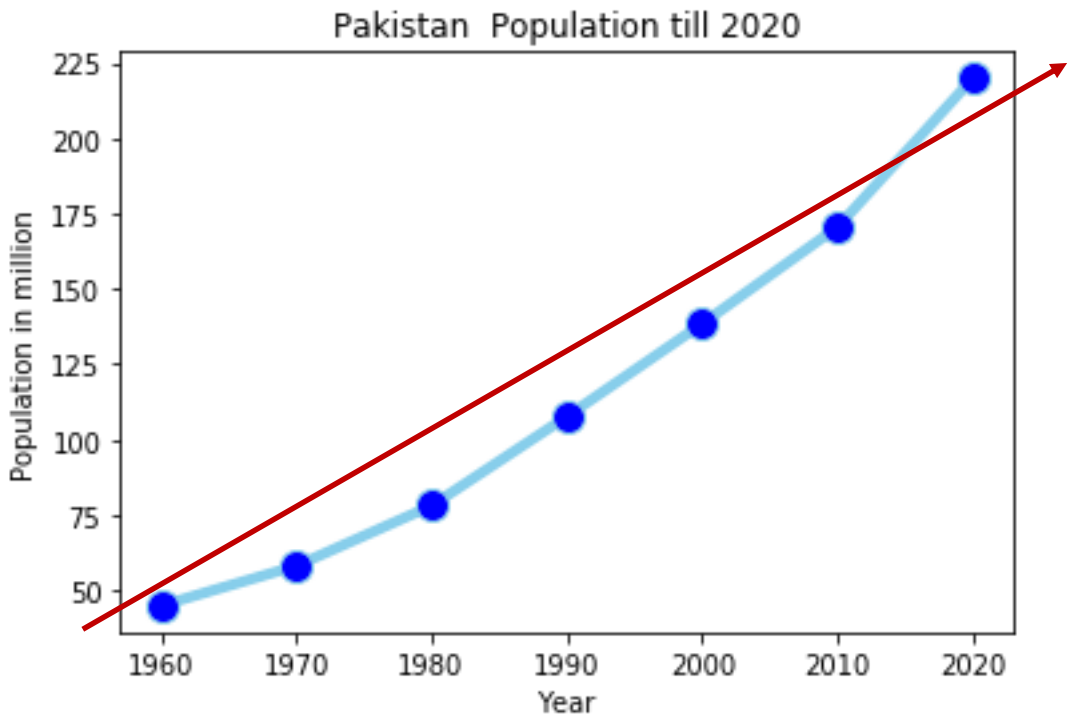
- It is all about finding the “right Hyper-plane” to separate vectors that belong to different classes



Playing with intercept and slope

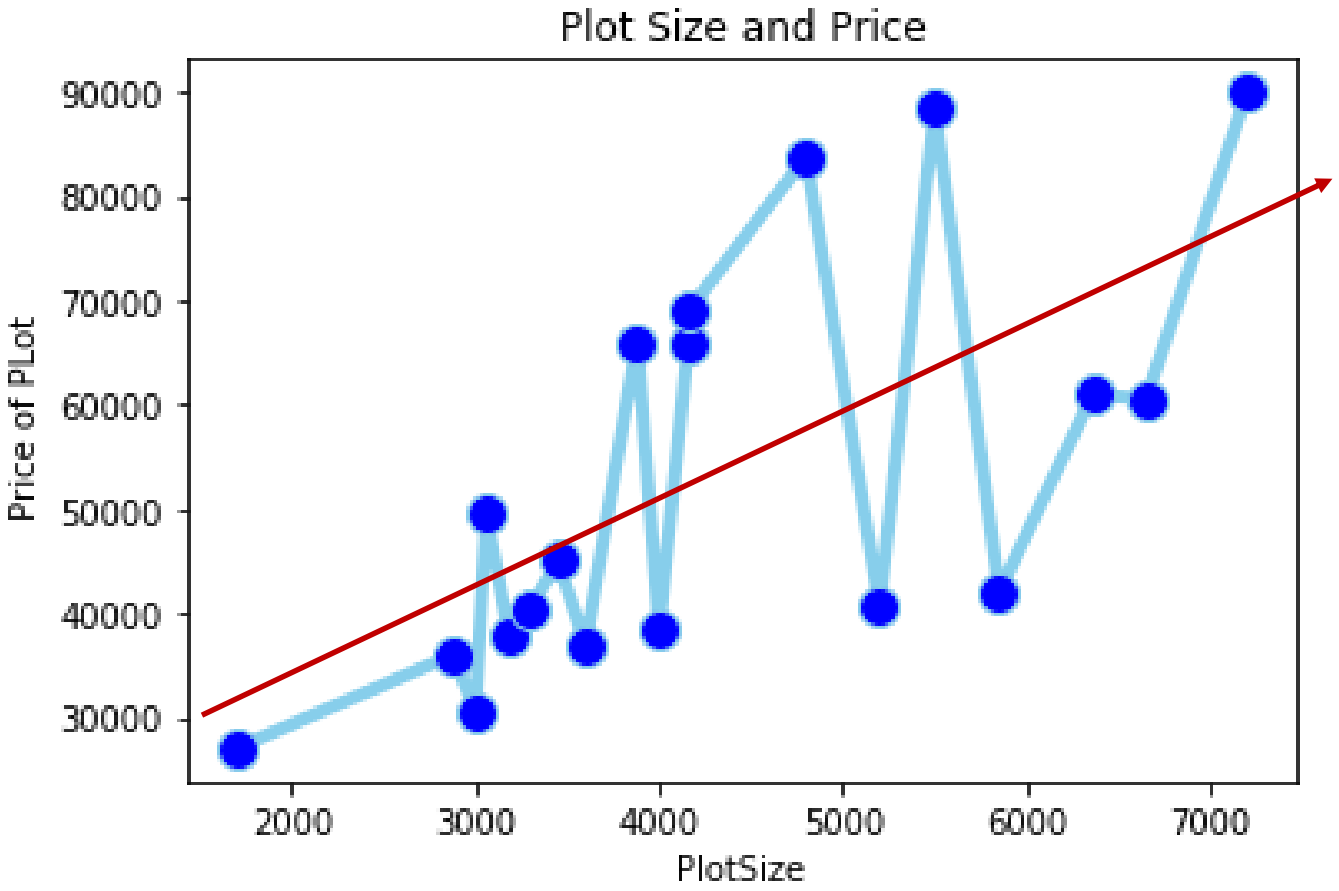


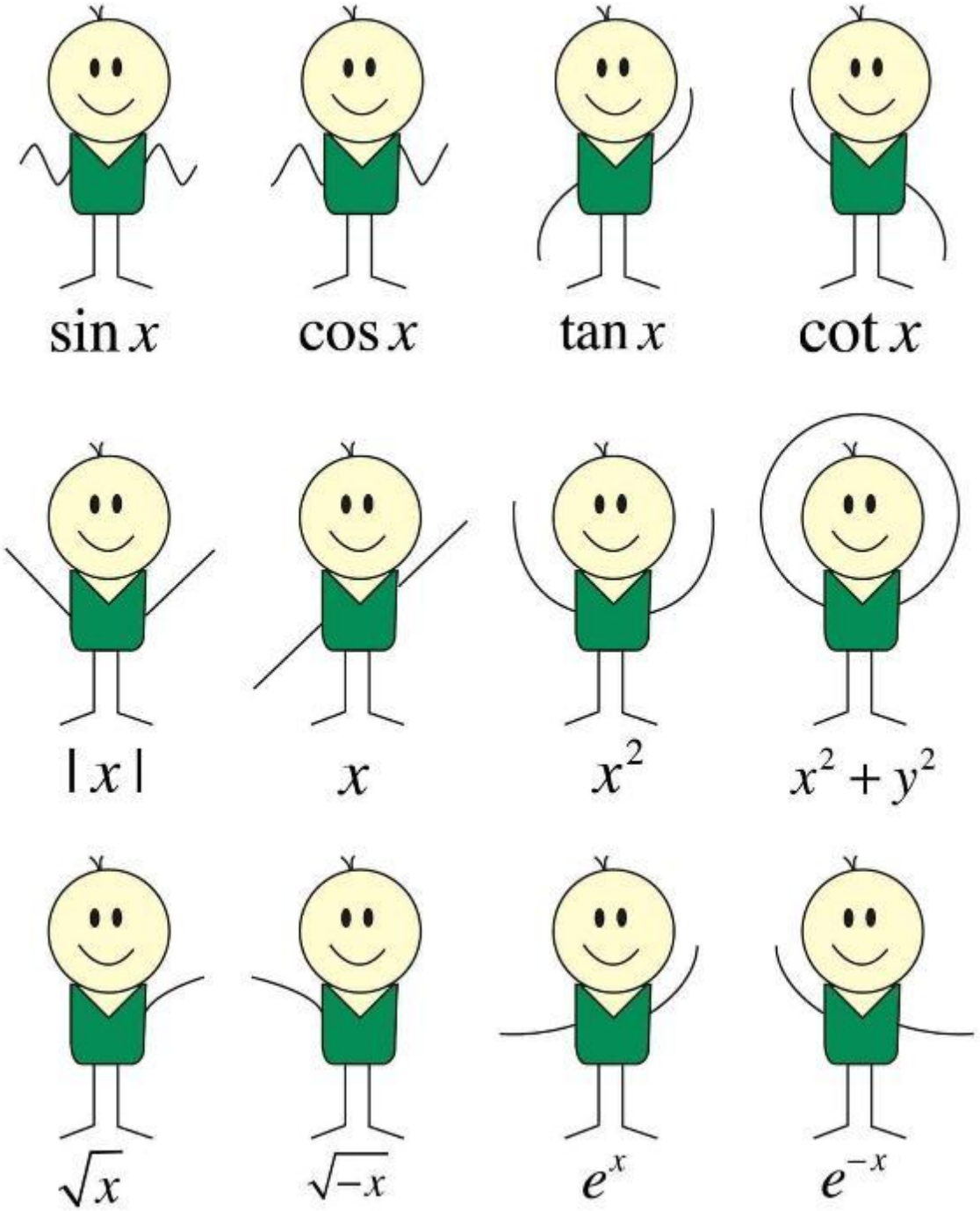
Year	Population
1960	44.91
1970	58.09
1980	78.07
1990	107.7
2000	138.5
2010	170.6
2020	220



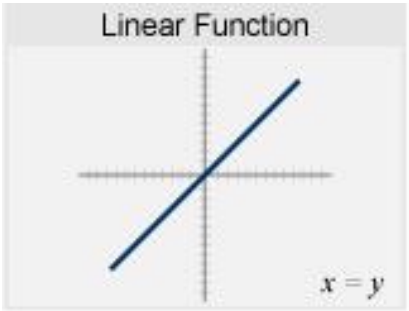
Example

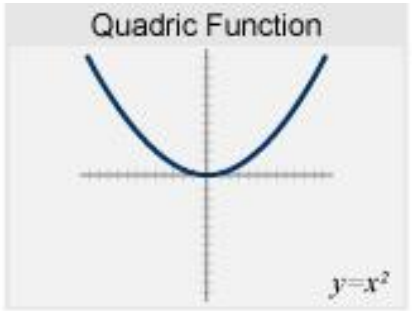
PRICE	PLOTSIZE
27000	1700
36000	2880
30500	3000
49500	3060
37900	3185
40500	3300
45000	3450
37000	3600
66000	3880
38500	4000
66000	4160
69000	4160
83800	4800
40750	5200
88500	5500
42000	5850
61000	6360
60500	6650
90000	7200

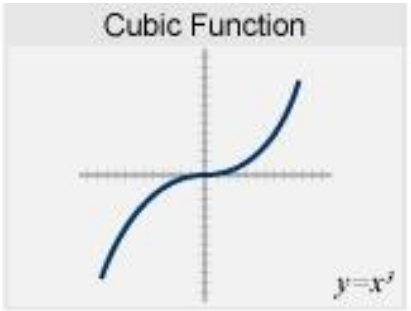


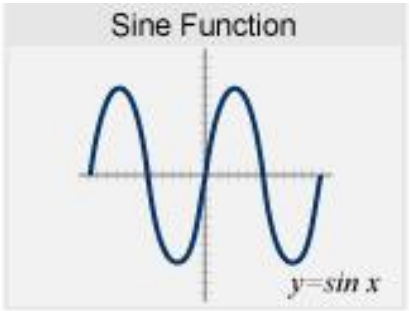

sin x
cos x
tan x
cot x
| x |
x
x²
x² + y²
√x
√−x
e^x
e^−x

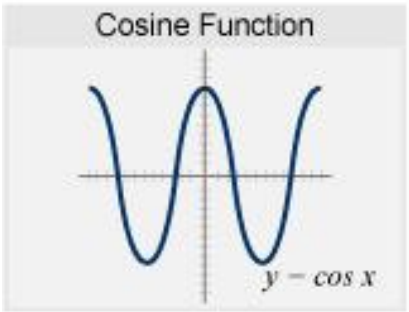
Math Functions

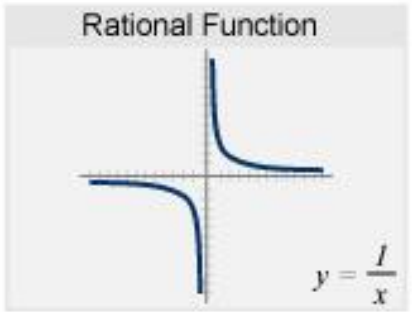


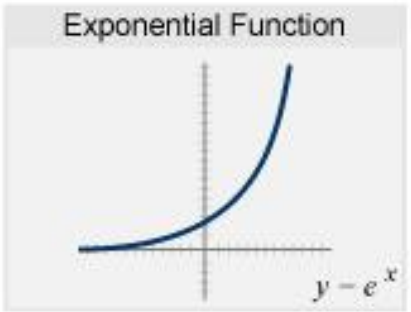


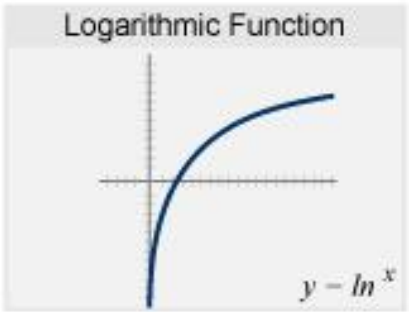




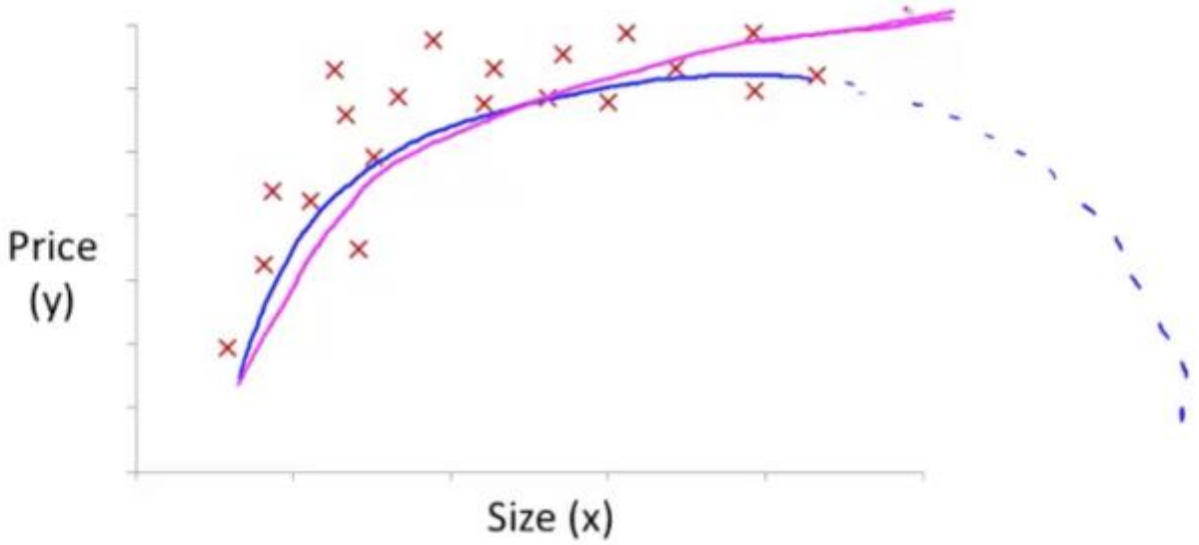






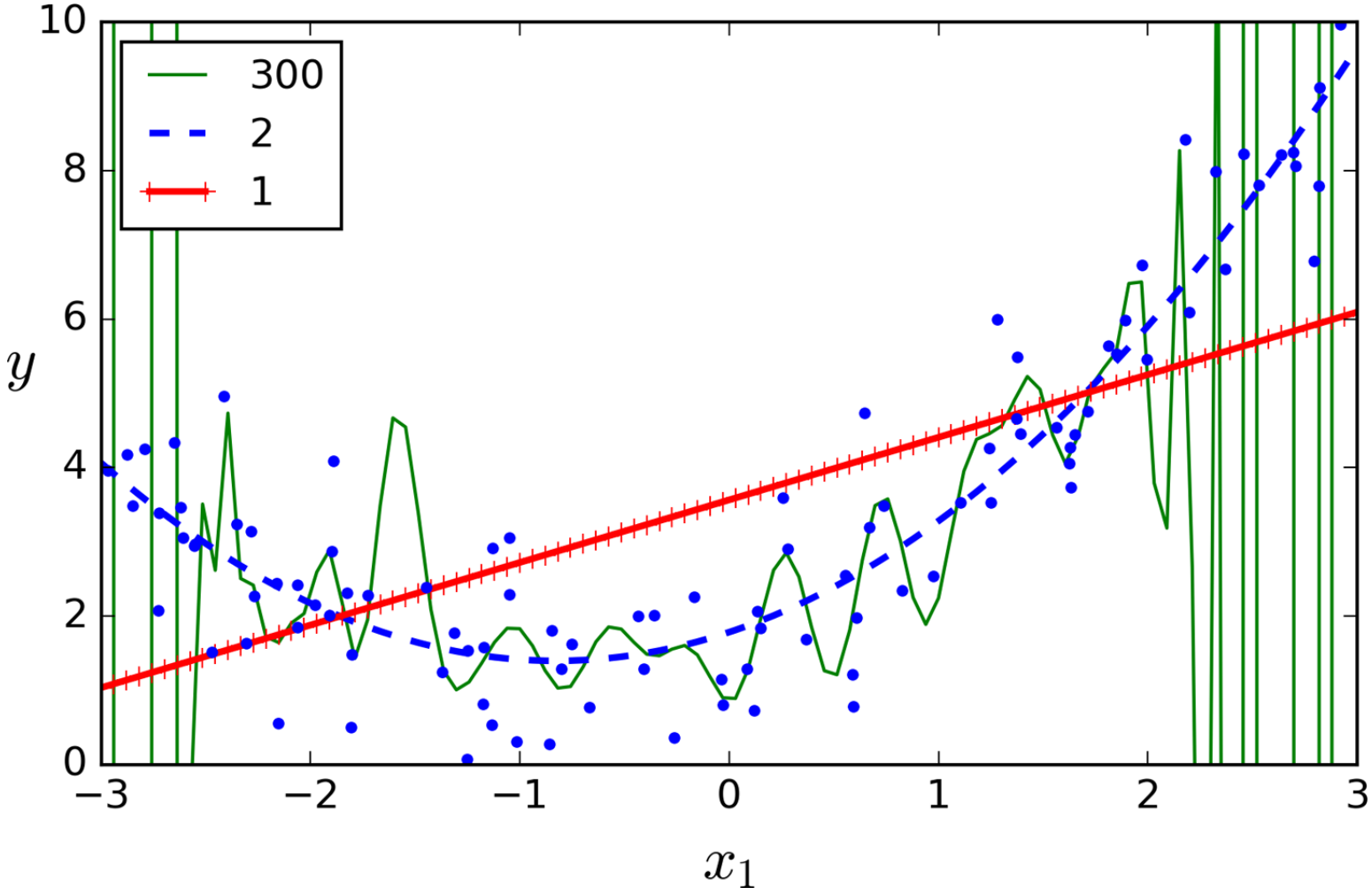


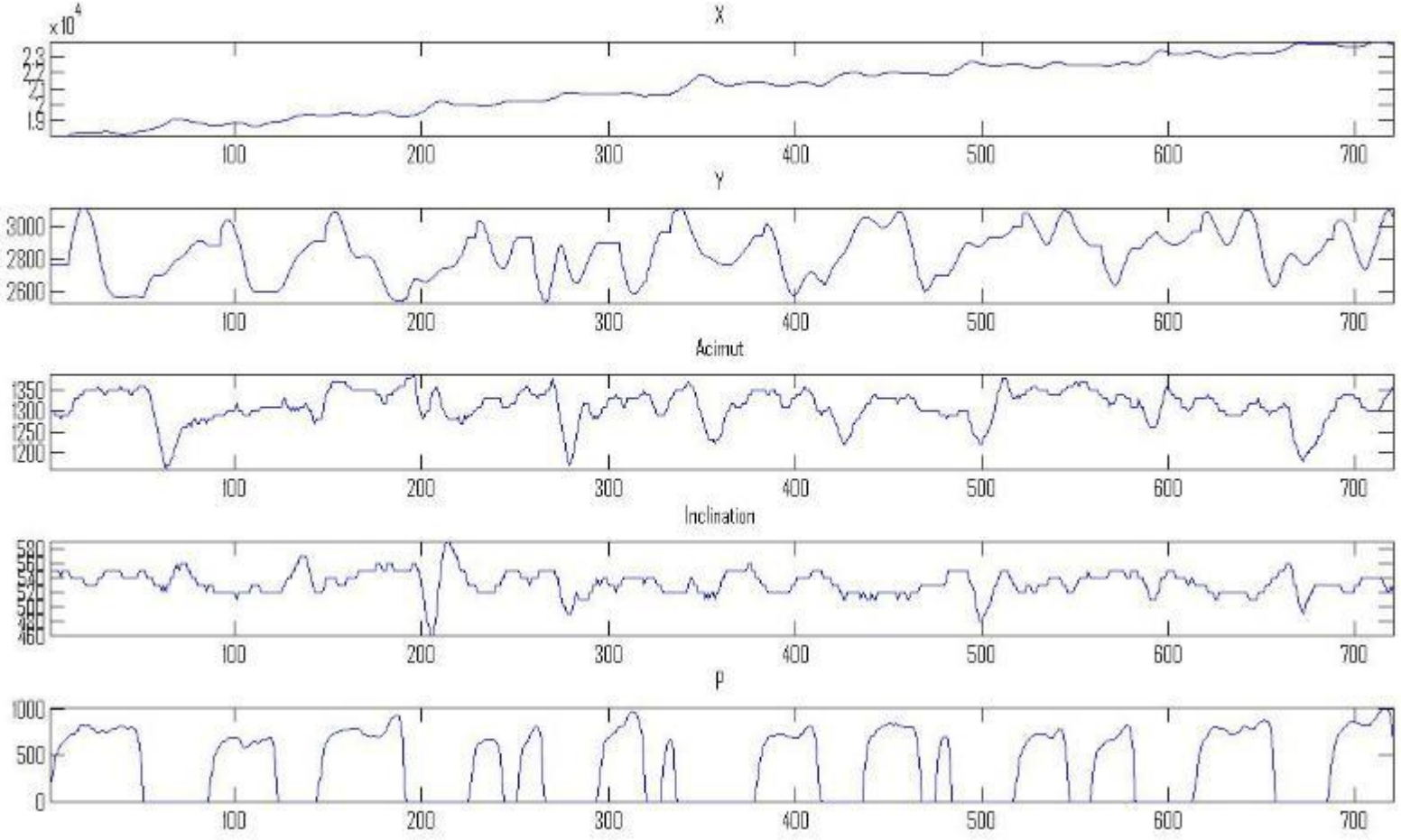
Choice of features

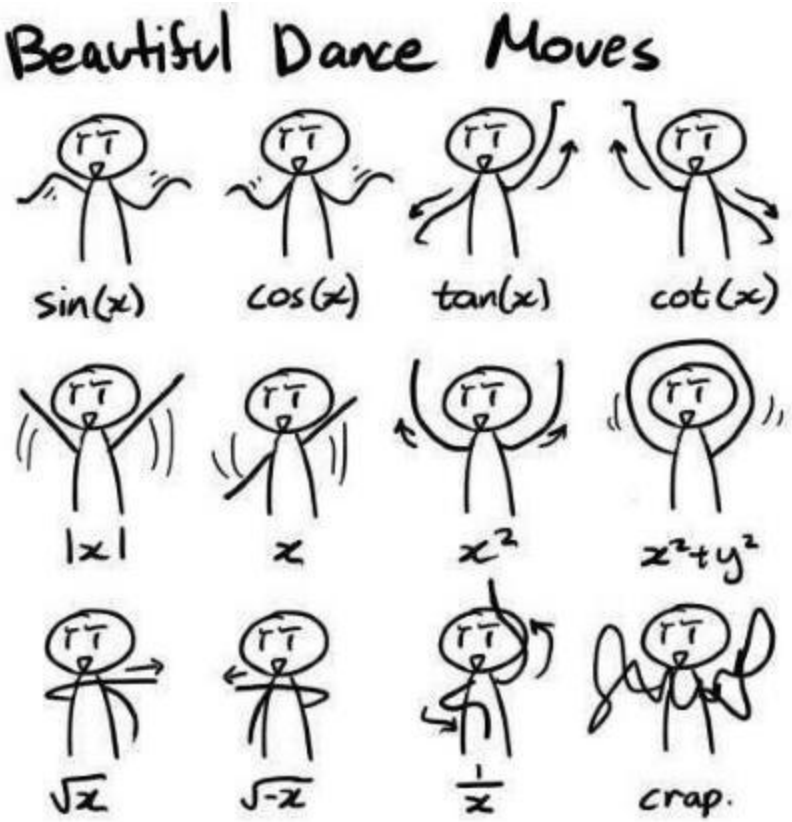


$$h_\theta(x) = \theta_0 + \theta_1(size) + \theta_2(size)^2$$

$$h_\theta(x) = \theta_0 + \theta_1(size) + \theta_2\sqrt{(size)}$$

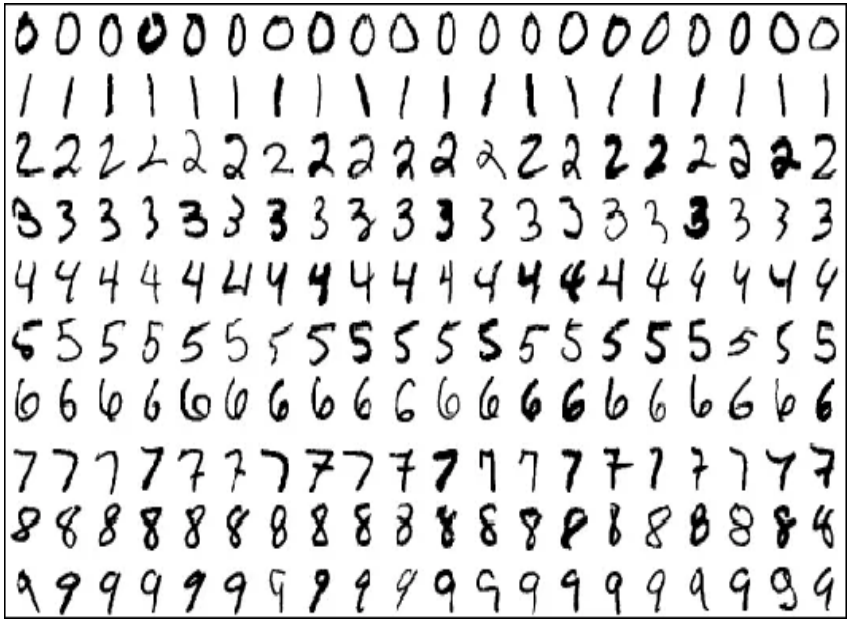

300
2
1
10
8
6
4
2
0
−3
−2
−1
0
1
2
3
y
x_1

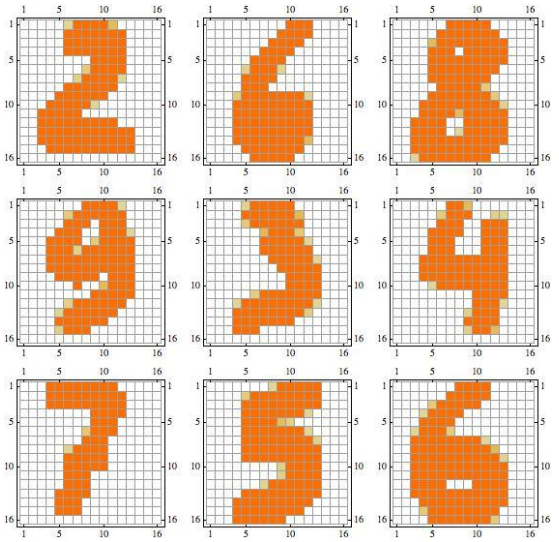

X
x 10^4
2.3
2.2
2.1
2
1.9
100
200
300
400
500
600
700
Y
3000
2800
2600
Acimut
1350
1300
1250
1200
Inclination
P
1000
500
0


Beautiful Dance Moves
sin(x)
cos(x)
tan(x)
cot(x)
|x|
x
x²
x²+y²
√x
√-x
1/x
crap.

Formulation as a ML Task

- **Handwritten Digits Recognition**



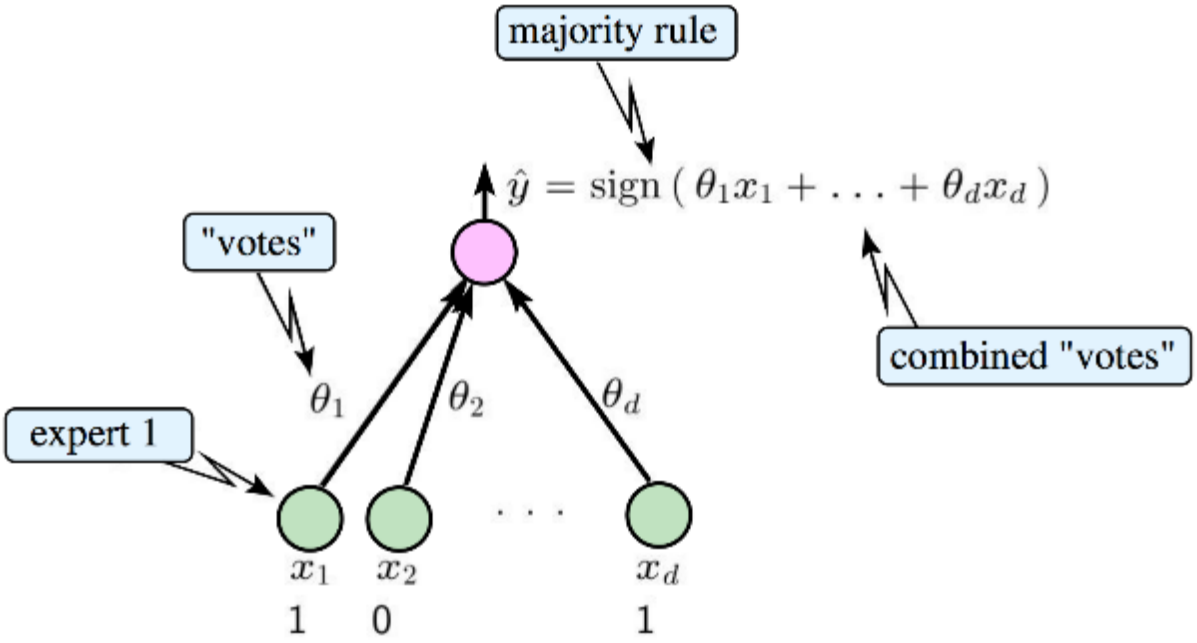


Linear Classifier/Expert

- We can understand the simple linear classifier

$$\hat{y} = f(x; \theta) = \text{sign}(\theta \cdot x) = \text{sign}(\theta_1 x_1 + \cdots + \theta_d x_d),$$

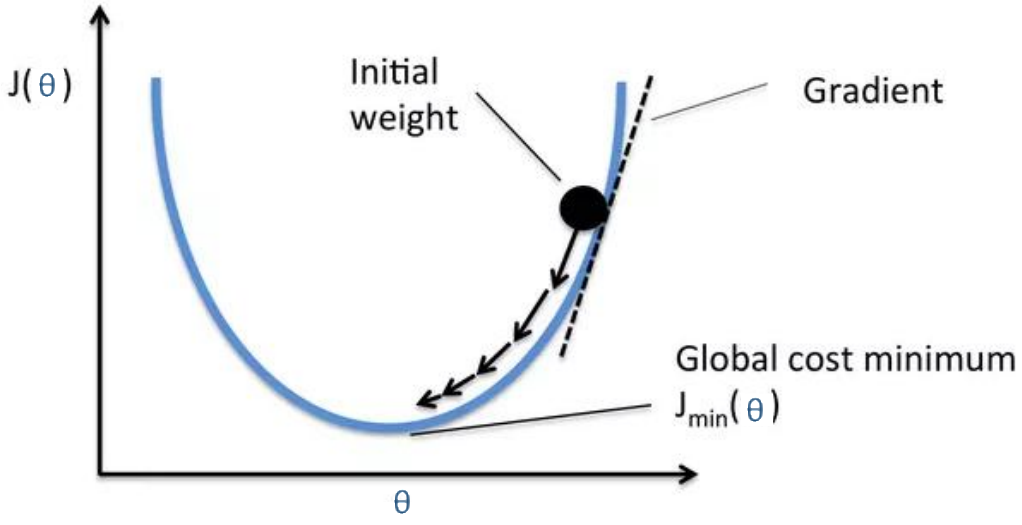
as a way of combining expert opinion (binary features)

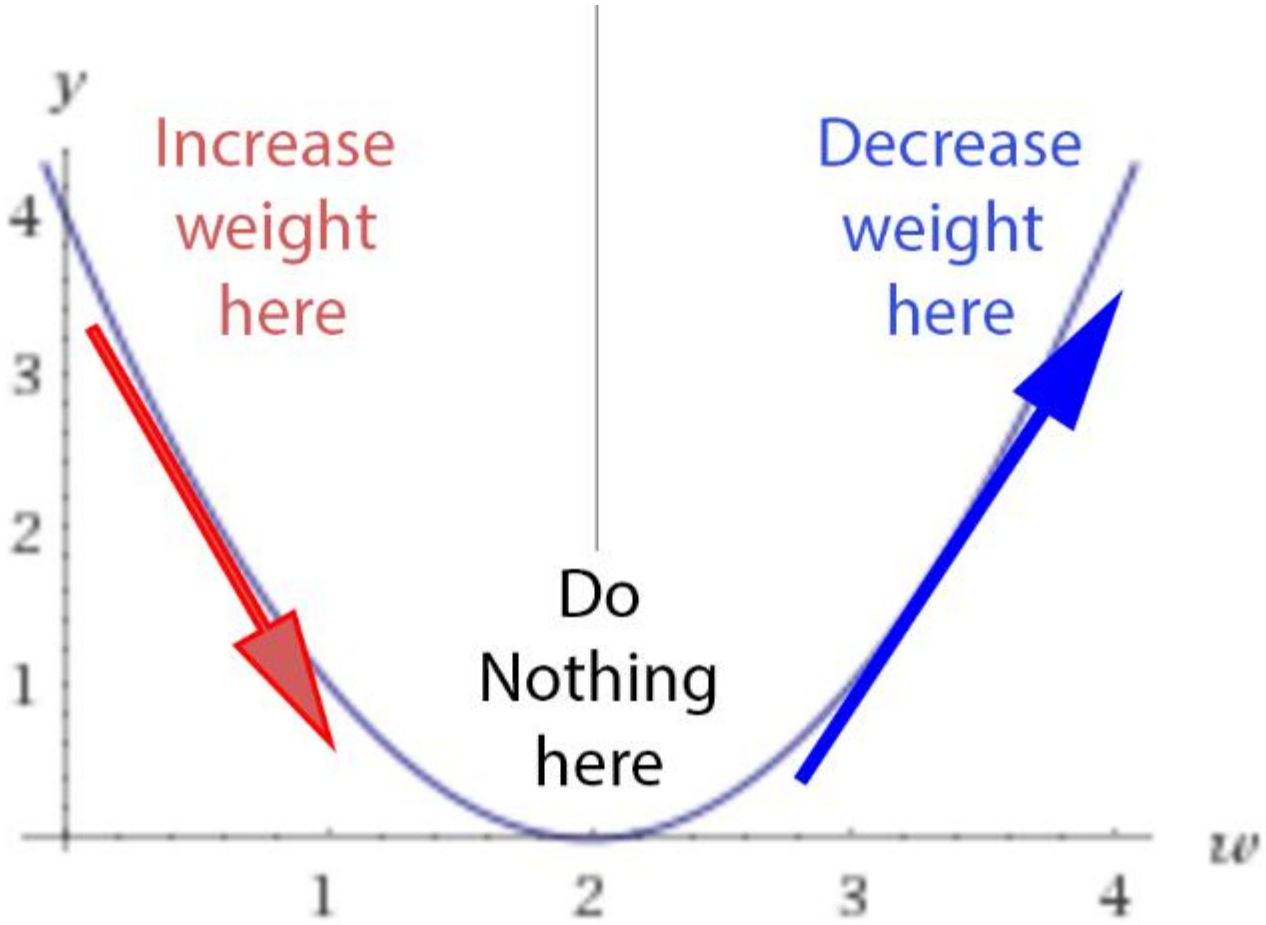


Linear Classifier/Expert

- How do we **adjust the parameters θ** based on the labeled examples?

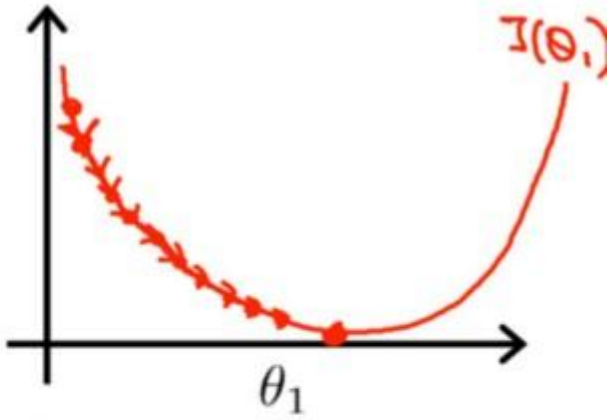
- **Gradient Descent**
- Standard loss/cost/objective function measures the squared error between y and the true value t
  - $J(\theta) = \mathbf{\Sigma} (y - y\hat{})^2$
- we can update the parameters:
- $\theta_{new} = \theta + \lambda \, . \, \partial J(\theta)/\partial\theta$, where λ = Learning Rate, J(θ) = disparity b/w target and actual value



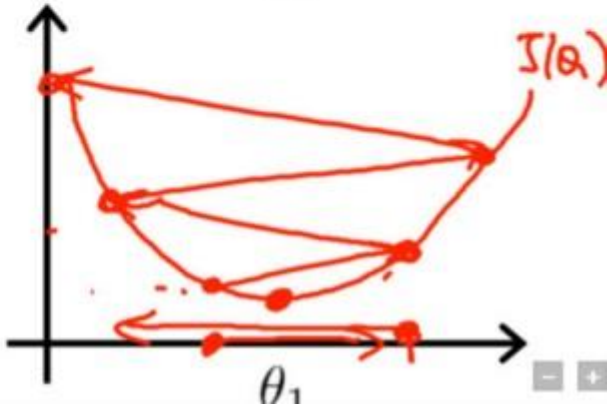

y
Increase weight here
Decrease weight here
4
3
2
1
Do Nothing here
1
2
3
4
w

$$\theta_1 := \theta_1 - \alpha \frac{\partial}{\partial \theta_1} J(\theta_1)$$

If α is too small, gradient descent can be slow.



If α is too large, gradient descent can overshoot the minimum. It may fail to converge, or even diverge.

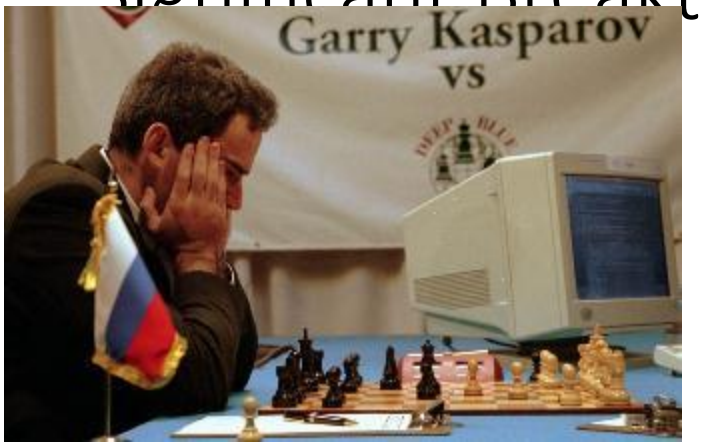


What can ML do today?

- Play a decent game of table tennis?
- Play the game of jeopardy?
- Drive safely along a curving mountain?
- Drive safely at Chowburjy Chowk?
- Buy weekly grocery on the web?
- Buy weekly grocery in Hyper star?
- Converse successfully with a person for an hour?
- Perform surgical operation?
- Put away the dishes and fold the laundry?
- Translate spoken Chinese into English at real time?
- Write an intentional funny story?

[Pieter Abbeel, Dan Klein, et. al]

Significant Breakthroughs



Deep Blue (1997)

IBM WATSON (2011)

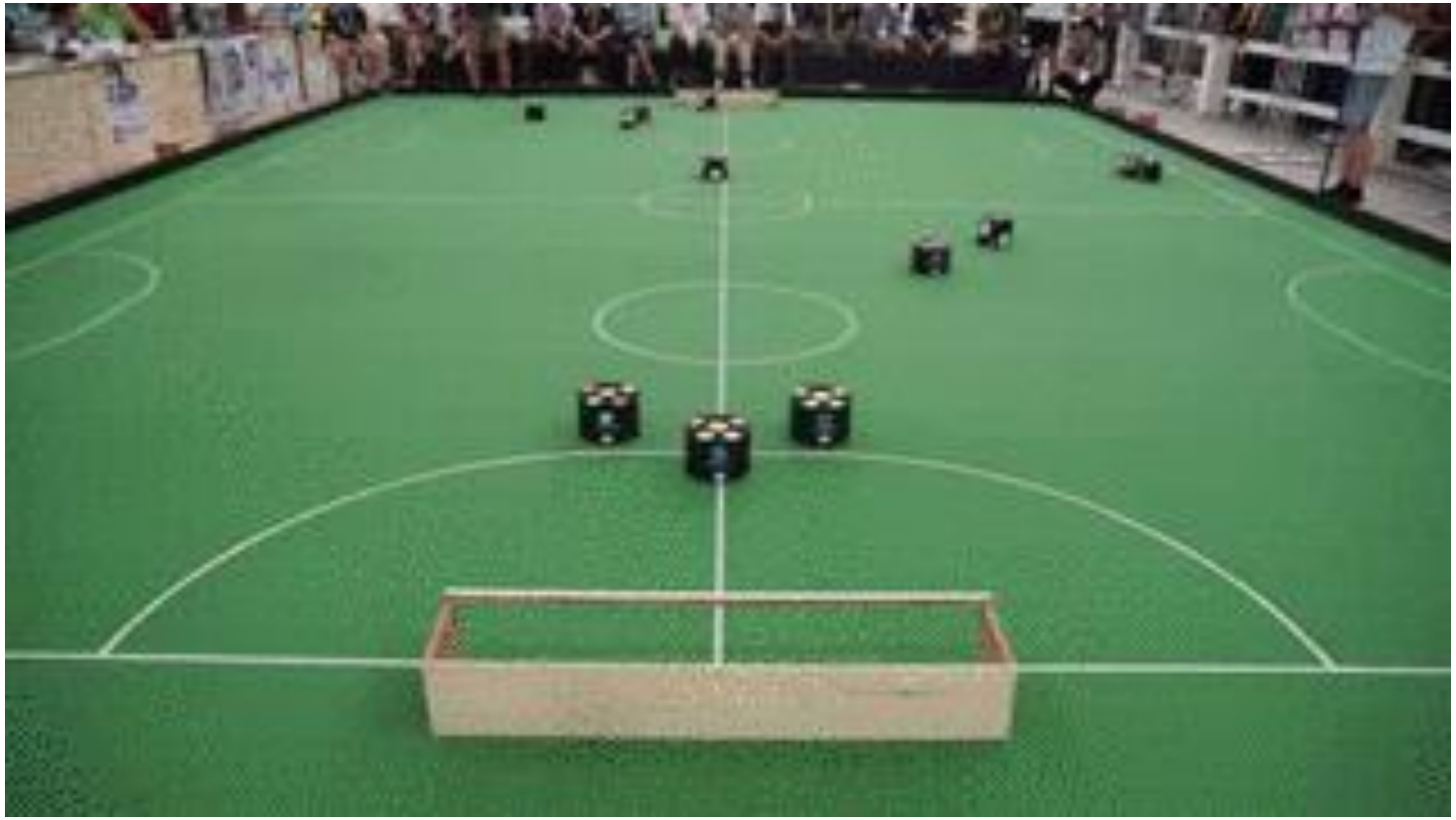
Human versus machine

Playing table tennis

Autonomous driving

Autonomous Robots

robocup



Machine Translation

Recommender systems

Customers who viewed this item also viewed these products

Dualit Food XL1500 Processor

$560

Add to cart

Kenwood kMix Manual Espresso Machine

★★★★☆

$250

Select options

Weber One Touch Gold Premium Charcoal Grill-57cm

$225

Add to cart

NoMU Salt Pepper and Spice Grinders

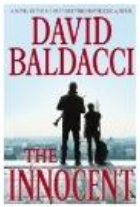
$3

View options

Amazon !!

Today's Recommendations For You

Here's a daily sample of items recommended for you. Click here to **see all recommendations**.



The Innocent (Kindle Edition) by David Baldacci

$14.99

Fix this recommendation

The Expats: A Novel (Kindle Edition) by Chris Pavone

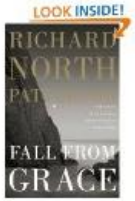
★★★★☆ (65) $12.99

Fix this recommendation

Stolen Prey (Kindle Edition) by John Sandford

$14.99

Fix this recommendation

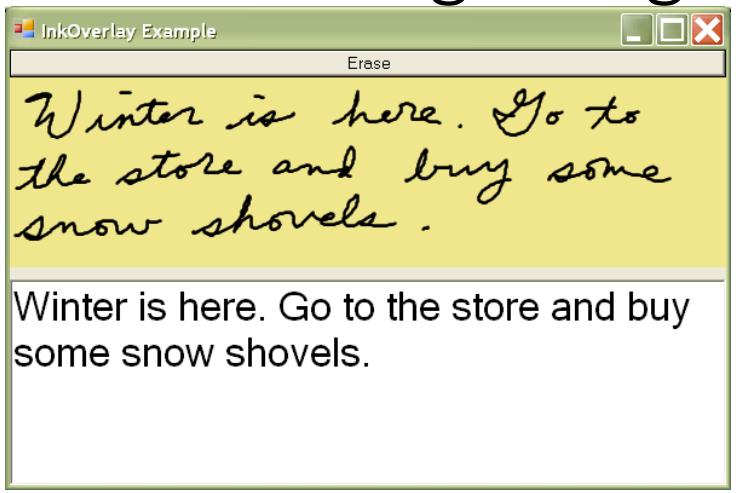


Fall from Grace (Kindle Edition) by Richard North Patterson

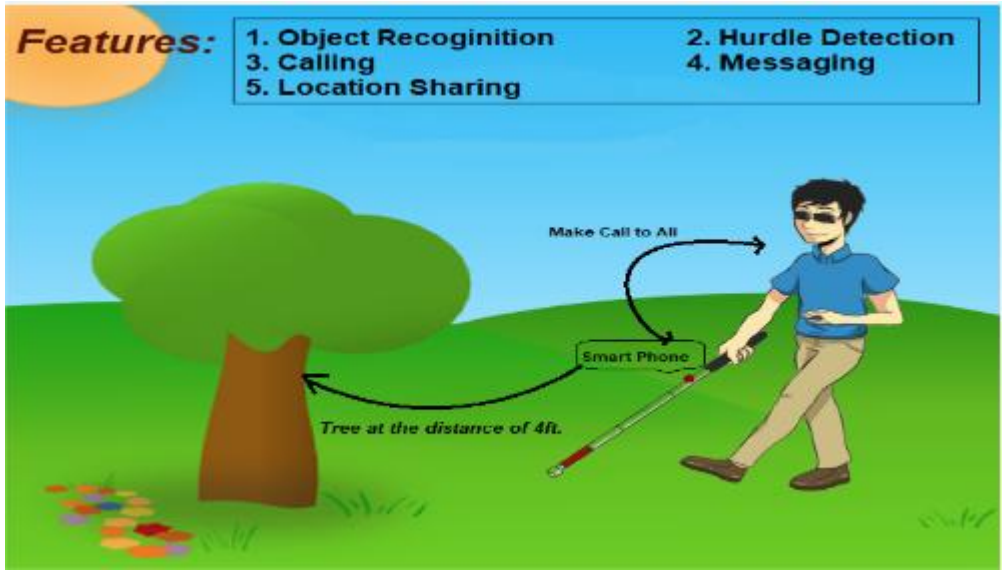
★★★½☆ (32) $12.99

Fix this recommendation

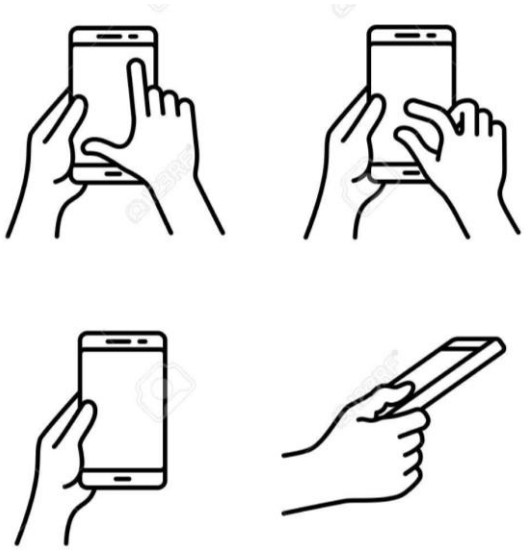
Handwriting recognition



ML at UMT



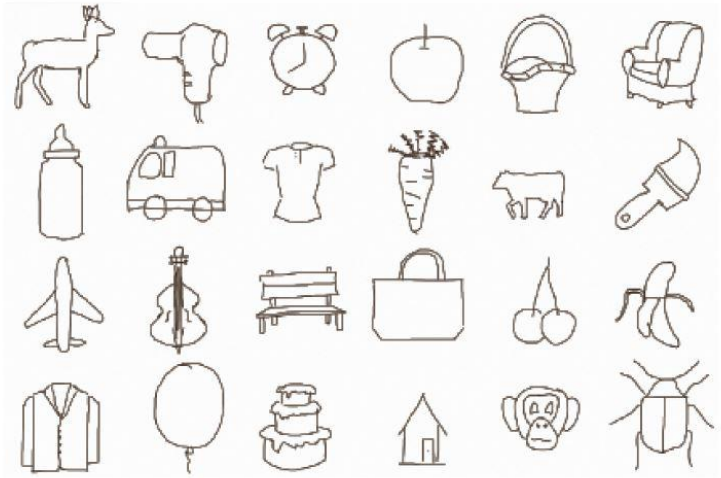
Smart Cane for the Blind



User Identification through
Gesture Recognition on Android

ML at UMT

Activity Recognition in Smart Homes



Object Recognition based on Sketches

Machine Learning at UMT

- **Cricket Match Commentary Generation using Deep Learning**
- **YouTube Video Categorization using Deep Learning.**
- **Text Summarization for Urdu Documents**
- **Fake News Detection using Deep Learning.**
- **Activity Recognition in Smart Homes using Machine Learning.**
- **Predicting Appliance Behaviour in Smart Dwellings.**
- **Sketch Recognition using Deep Learning.**
- **Medical Diagnostic ChatBot**
- **Dendrochronology (Estimating Tree Life) using Computer Vision Techniques.**
- **Sentiment Analysis for Political Opinion Mining**
- **Home Automation System, Smart Irrigation System.**
- **Twitter Sentiment Analysis for Marketing.**
- **Smart Buildings using Estimote Beacons.**
- **Indoor Positioning System using WIFI hotspots.**
- **Suspicious activity recognition through video streams.**
- **Buildings detection and area estimation using satellite images.**