Lecture 1 : An Introduction to Machine Learning

What is Machine Learning

- Arthur Samuel (1959). Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.

- Shapire: Machine learning studies how to automatically learn to make predictions based on past observations.

- The field of machine learning tries to build and understand systems that can automatically extract information from empirical data in order to improve their performance.

- As a scientific discipline, machine learning is an interdisciplinary (and relatively young) field focusing both on theoretical foundations of systems that learn, reason and act as well as on practical applications of these systems.

What is Machine Learning

- Given a collection of examples ("training data"),

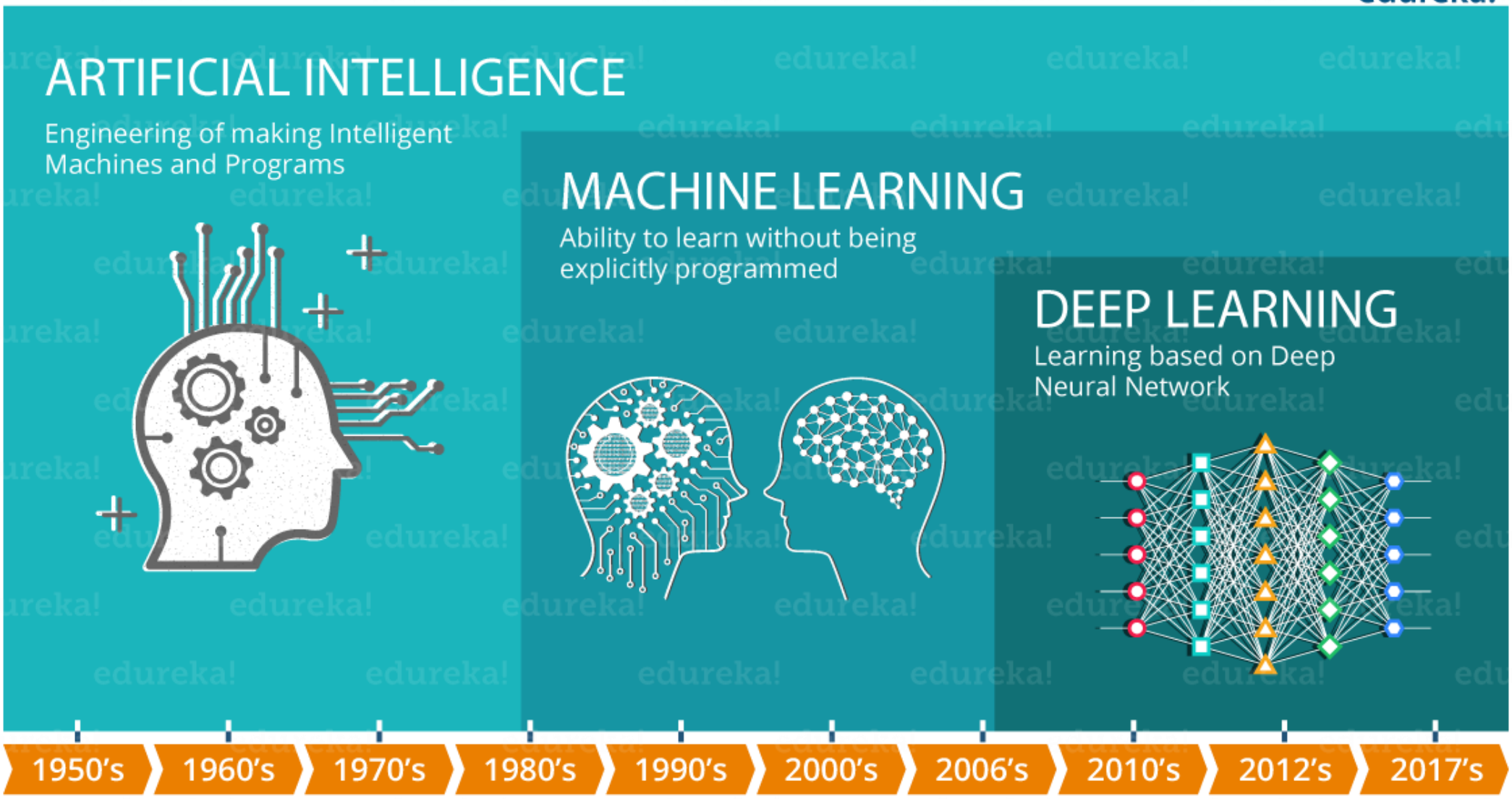
  predict something about novel examples
  - The novel examples are usually *incomplete*

- Example: sorting fish
  - Fish come off a conveyor belt in a fish factory
  - Your job: figure out what kind each fish is

Machine learning draws inspiration and concepts from many scientific fields

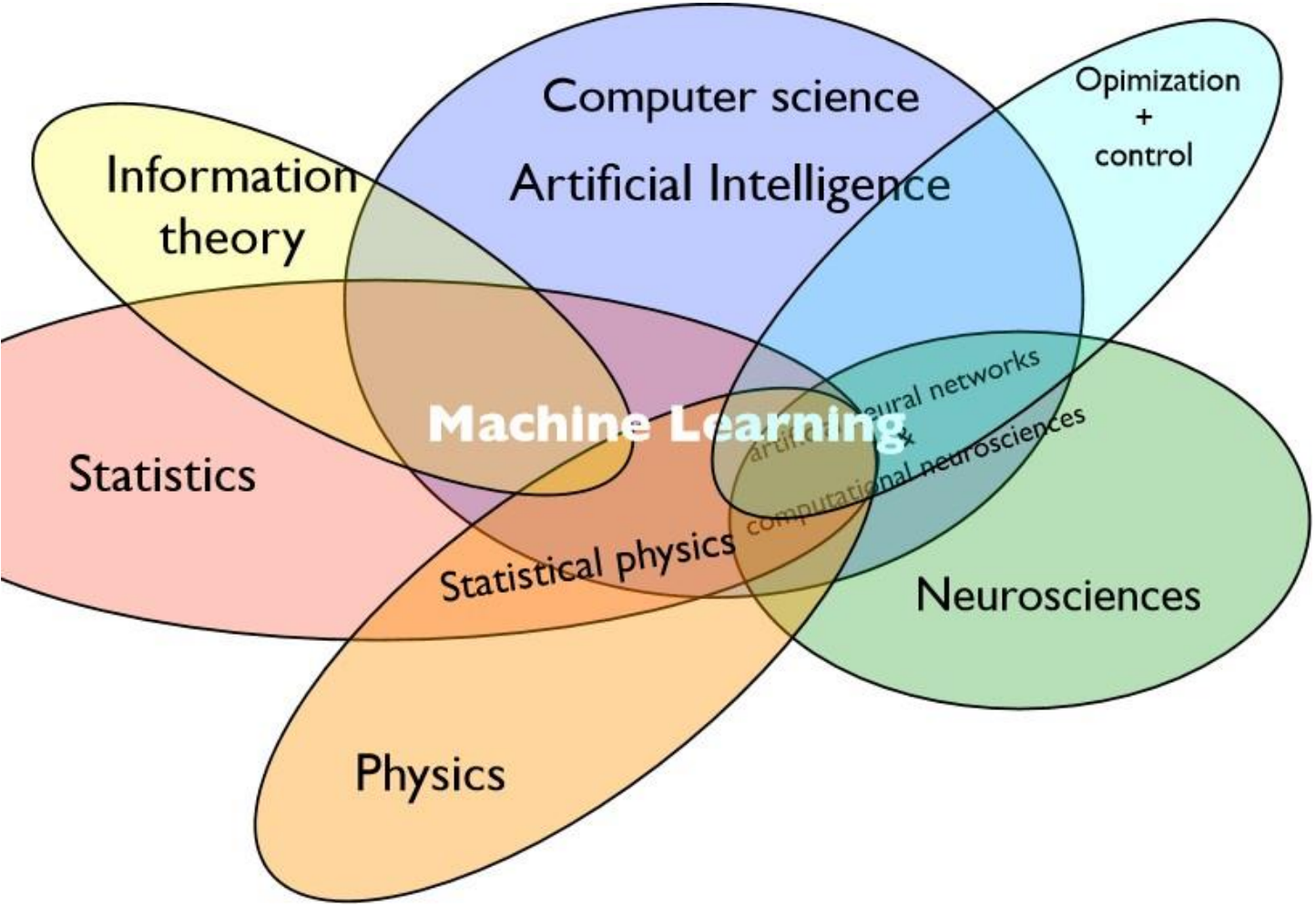
- Statistics: Inference from data, probabilistic models, learning theory, ...
- Mathematics: Optimization theory, numerical methods, tools for theory, ...
- Engineering: Signal processing, system identification, robotics, control, information theory, data-mining, ...
- Computer science: Artificial intelligence, computer vision, information retrieval, datastructures, implementations ...
- Economics: decision theory, operations research, econometrics, ...
- Psychology/Cognitive science: Computational linguistics, learning, reinforcement learning, movement control, ...
- Computational Neuroscience: Neural networks, principles of neural information processing, ...

Current view of Artificial Intelligence, Machine Learning & Deep Learning



Edureka blog – what-is-deep-learning

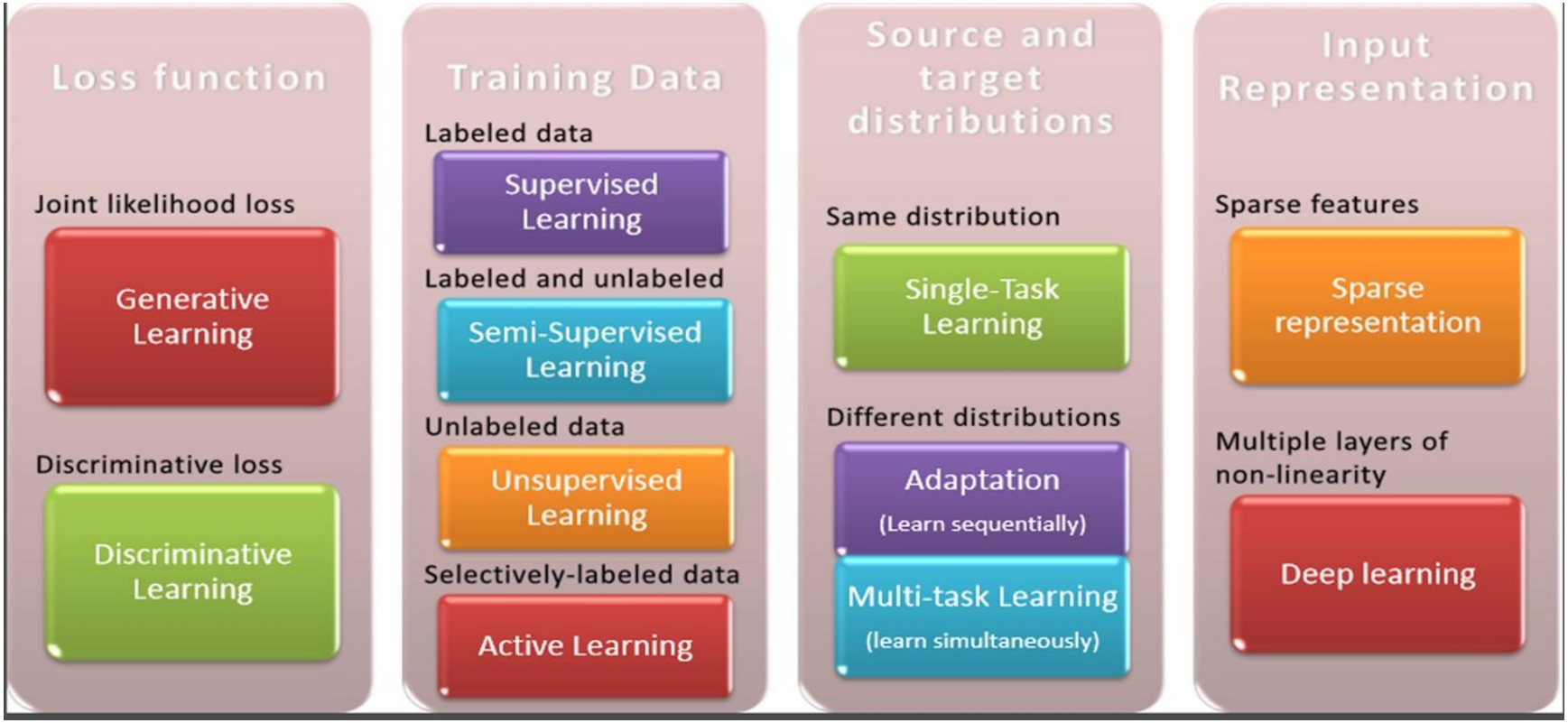
Current view of Machine Learning founding & disciplines



Edureka blog – what-is-deep-learning

Machine Learning Paradigms : An Overview

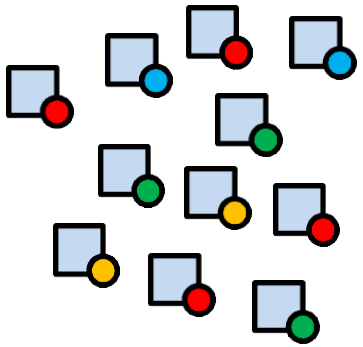
Machine learning



Supervised Machine Learning (classification)

Training phase (usually offline)

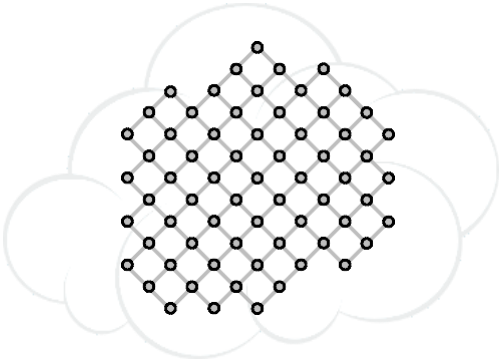
Training data set



measurements (features)
&
associated 'class' labels

(colors used to show class labels)

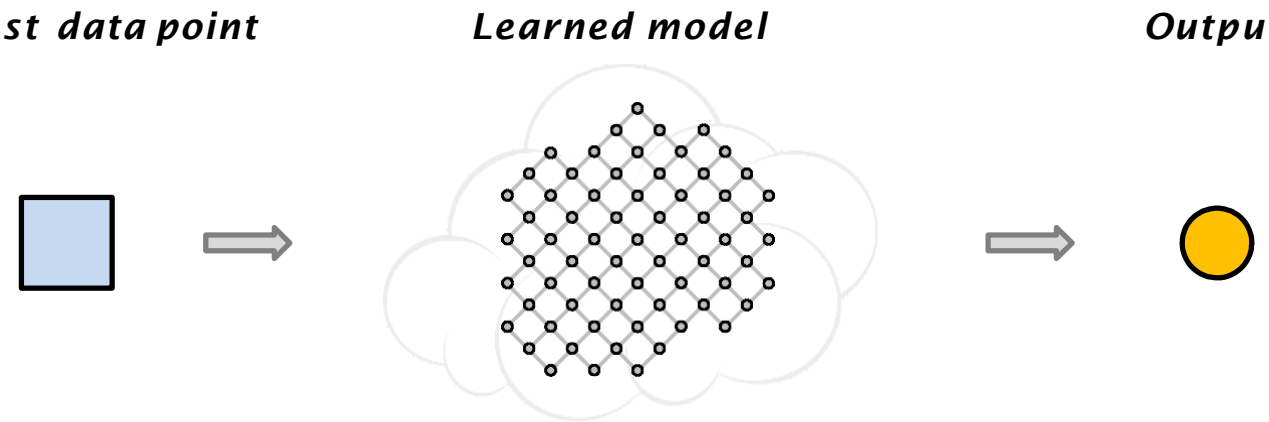
Learned model



Parameters/weights
(and sometimes structure)

Supervised Machine Learning (classification)

Test phase (run time, online)

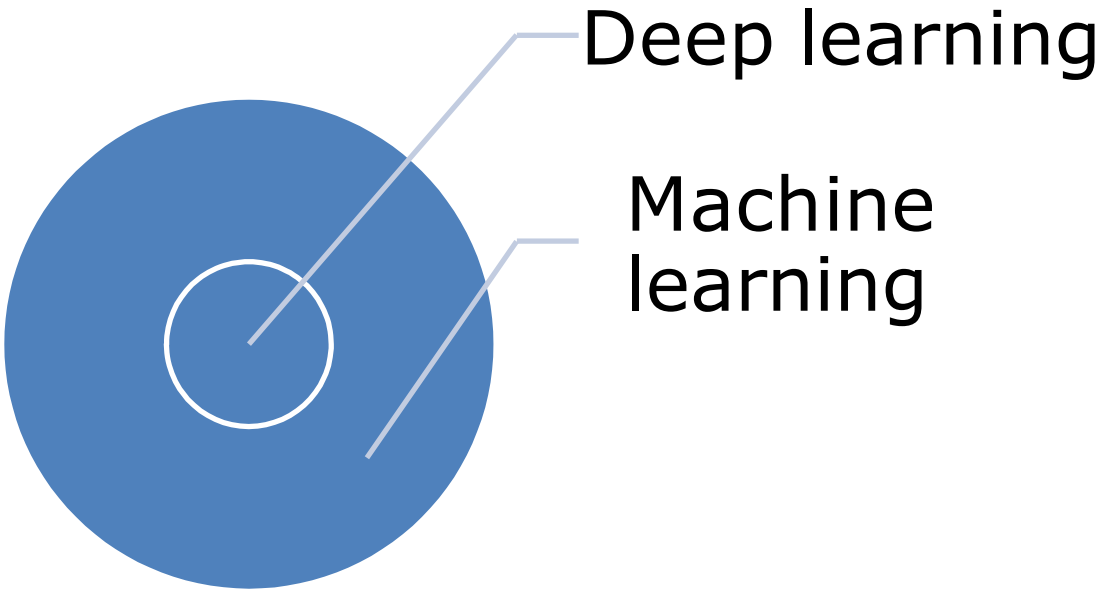


What Is Deep Learning ?

Deep learning

From Wikipedia, the free encyclopedia

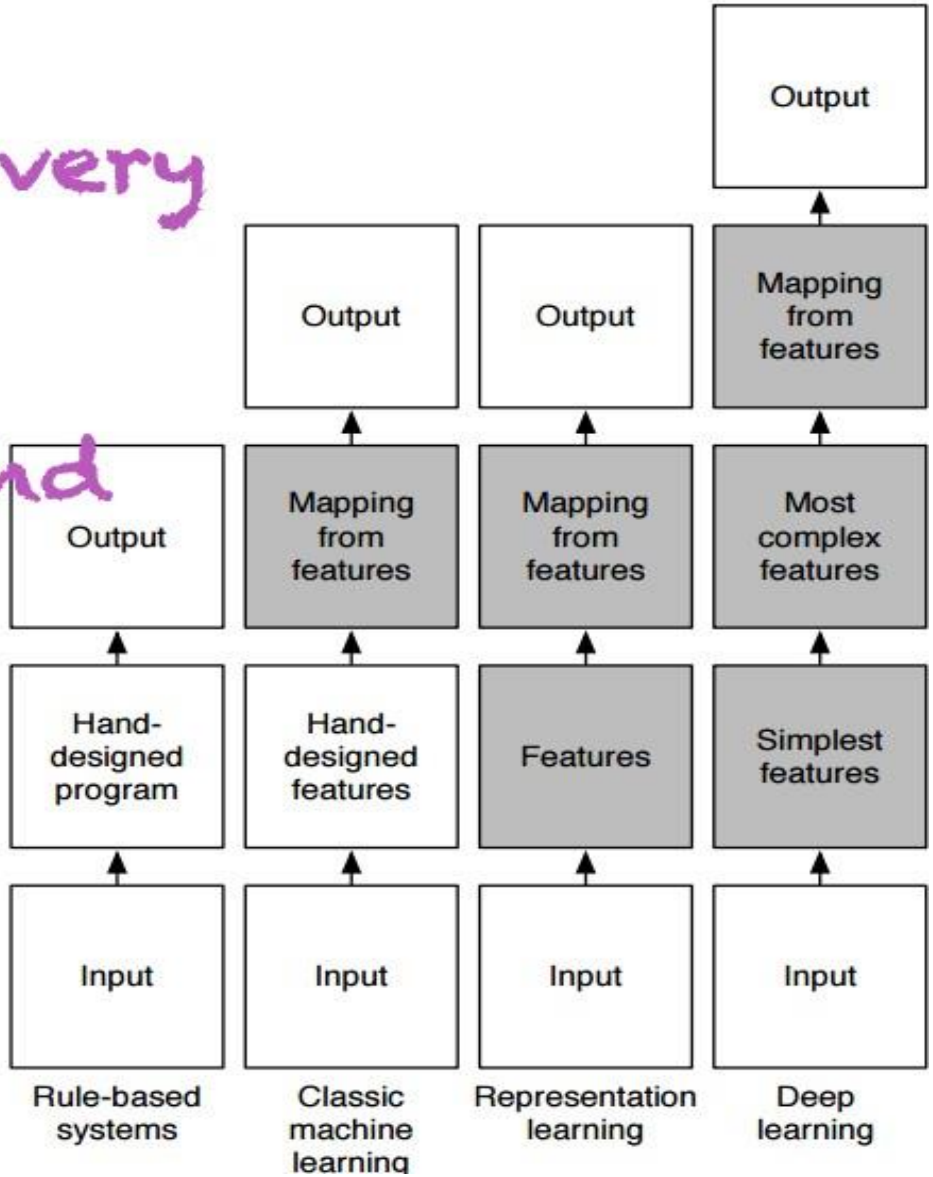
Deep learning (*deep machine learning*, or *deep structured learning*, or *hierarchical learning*, or sometimes *DL*) is a branch of machine learning based on a set of algorithms that attempt to model high-level abstractions in data by using model architectures, with complex structures or otherwise, composed of multiple non-linear transformations.[1](p198)[2] [3][4]



Evolution of Machine Learning

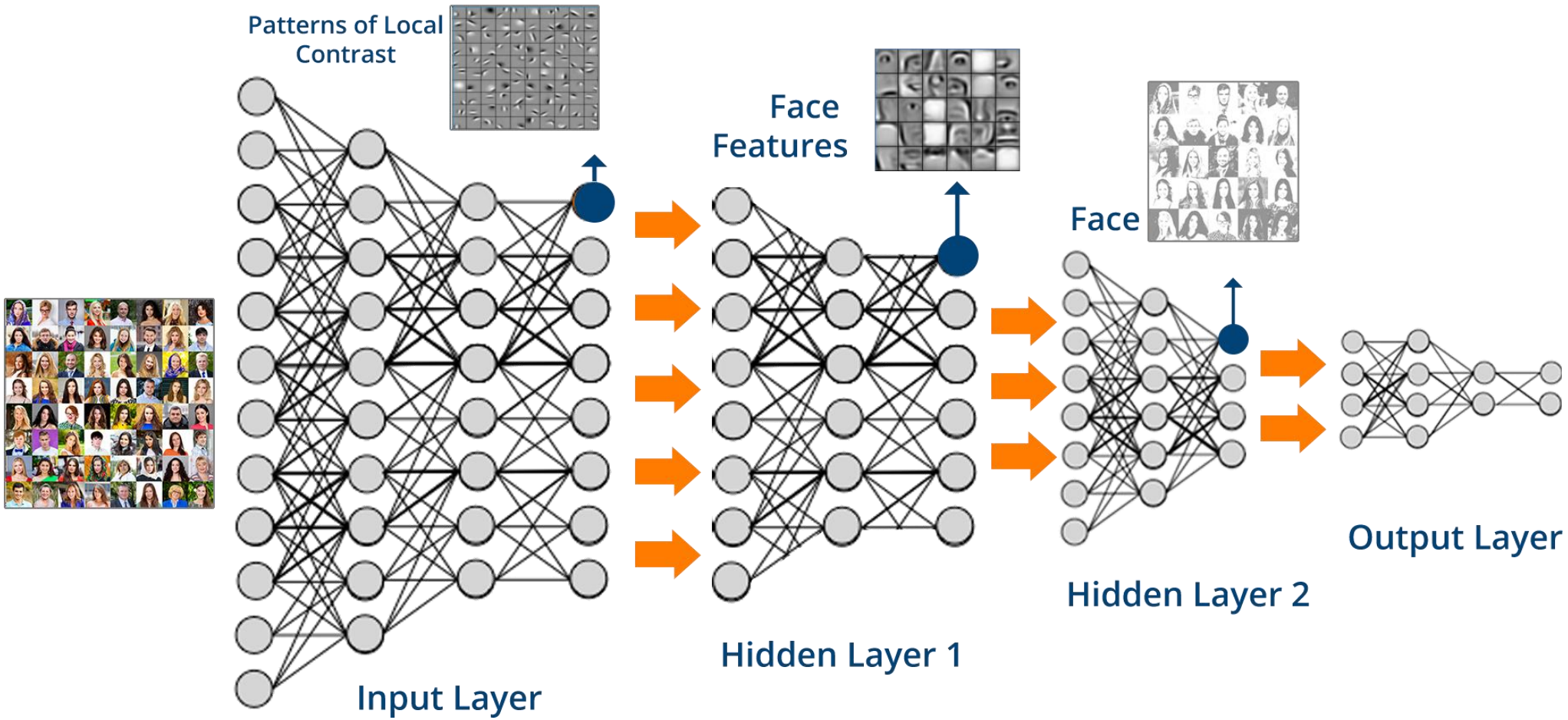
Automating Feature Discovery

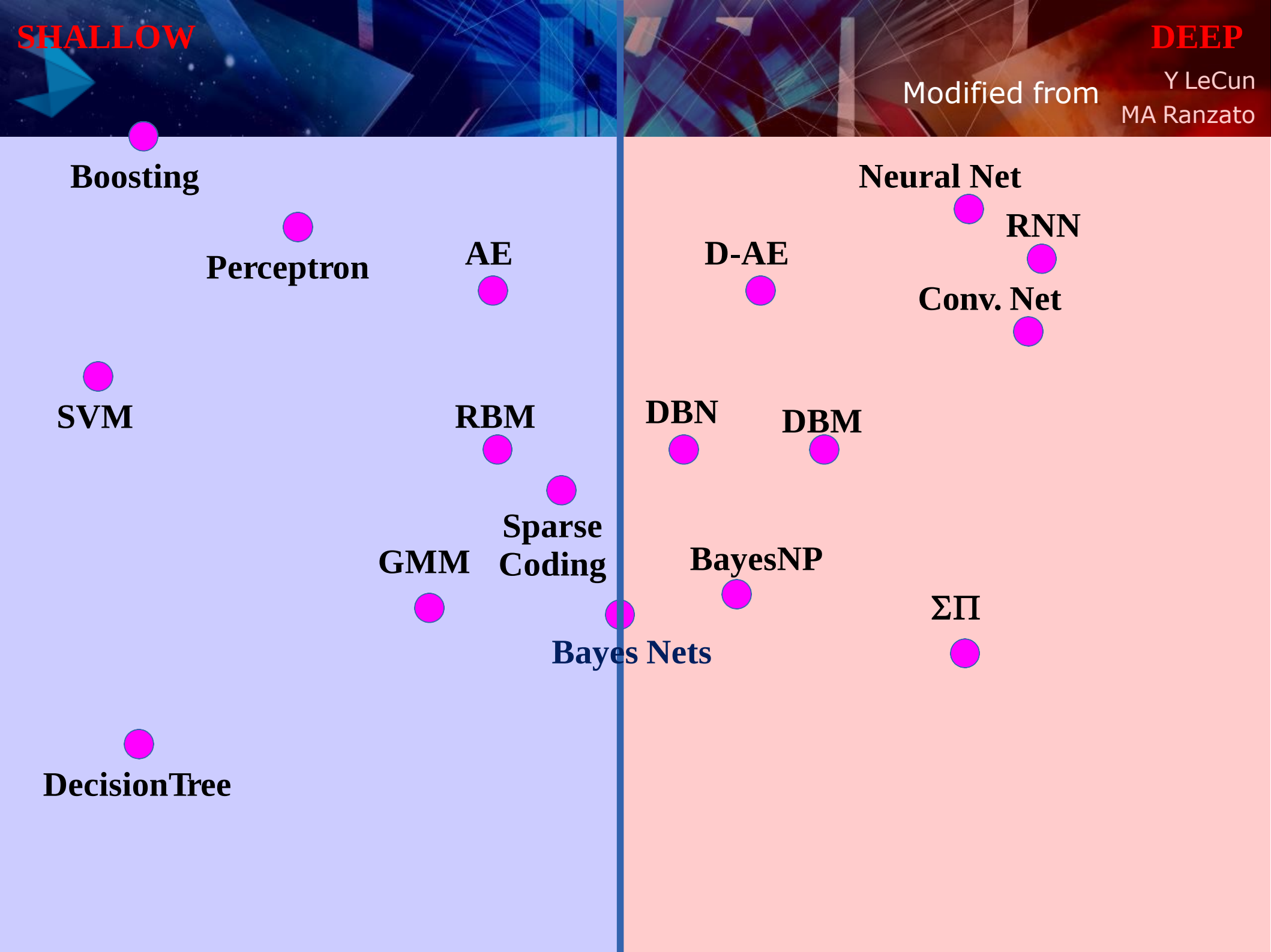
Discovering and representing higher-level abstractions



(Slide from: Yoshua Bengio)

Face Recognition

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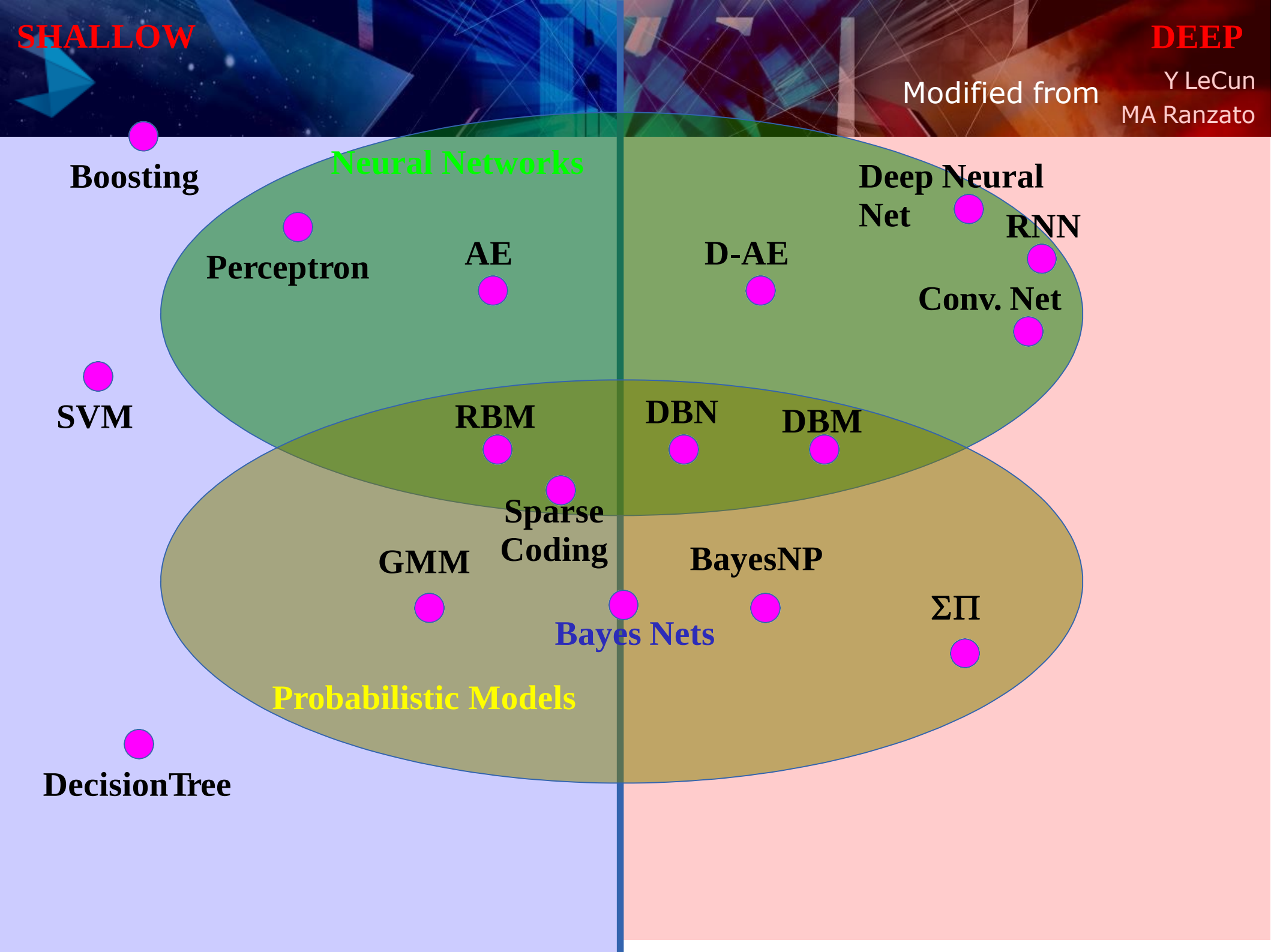
DEEP
Modified from
Y LeCun
MA Ranzato
Boosting
Perceptron
AE
D-AE
Neural Net
RNN
Conv. Net
SVM
RBM
DBN
DBM
Sparse
Coding
GMM
BayesNP
ΣΠ
Bayes Nets
DecisionTree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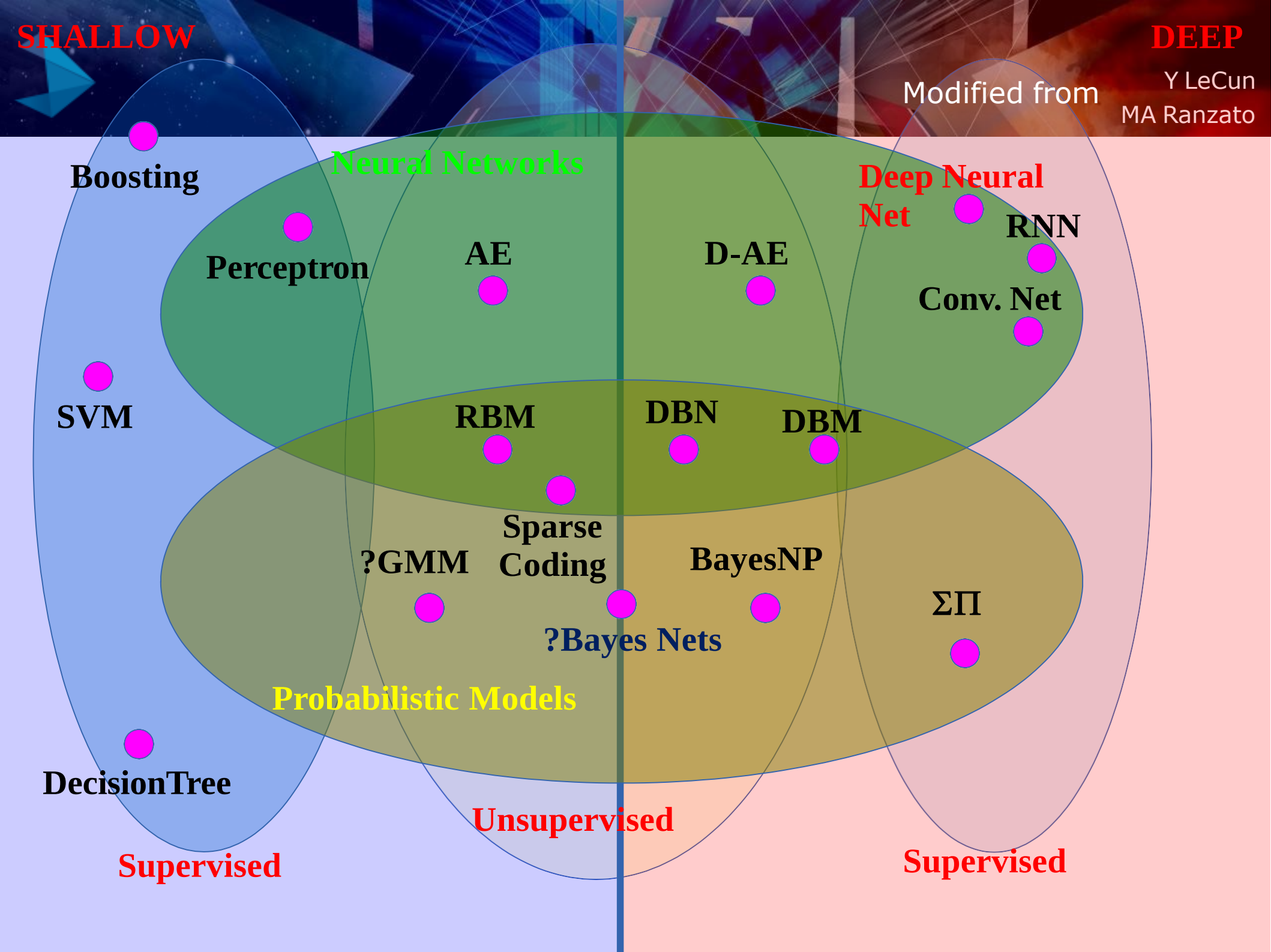
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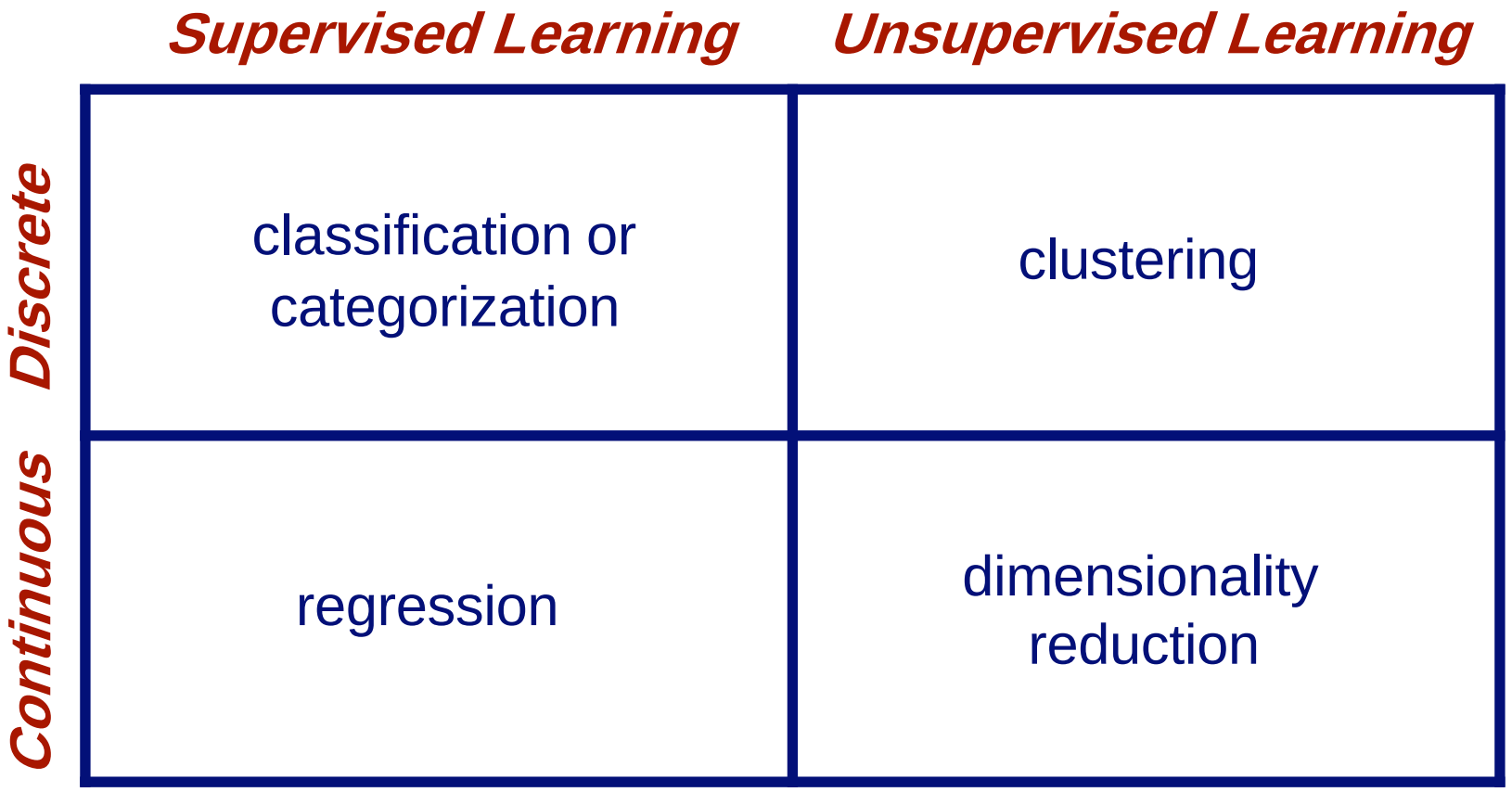
Supervised

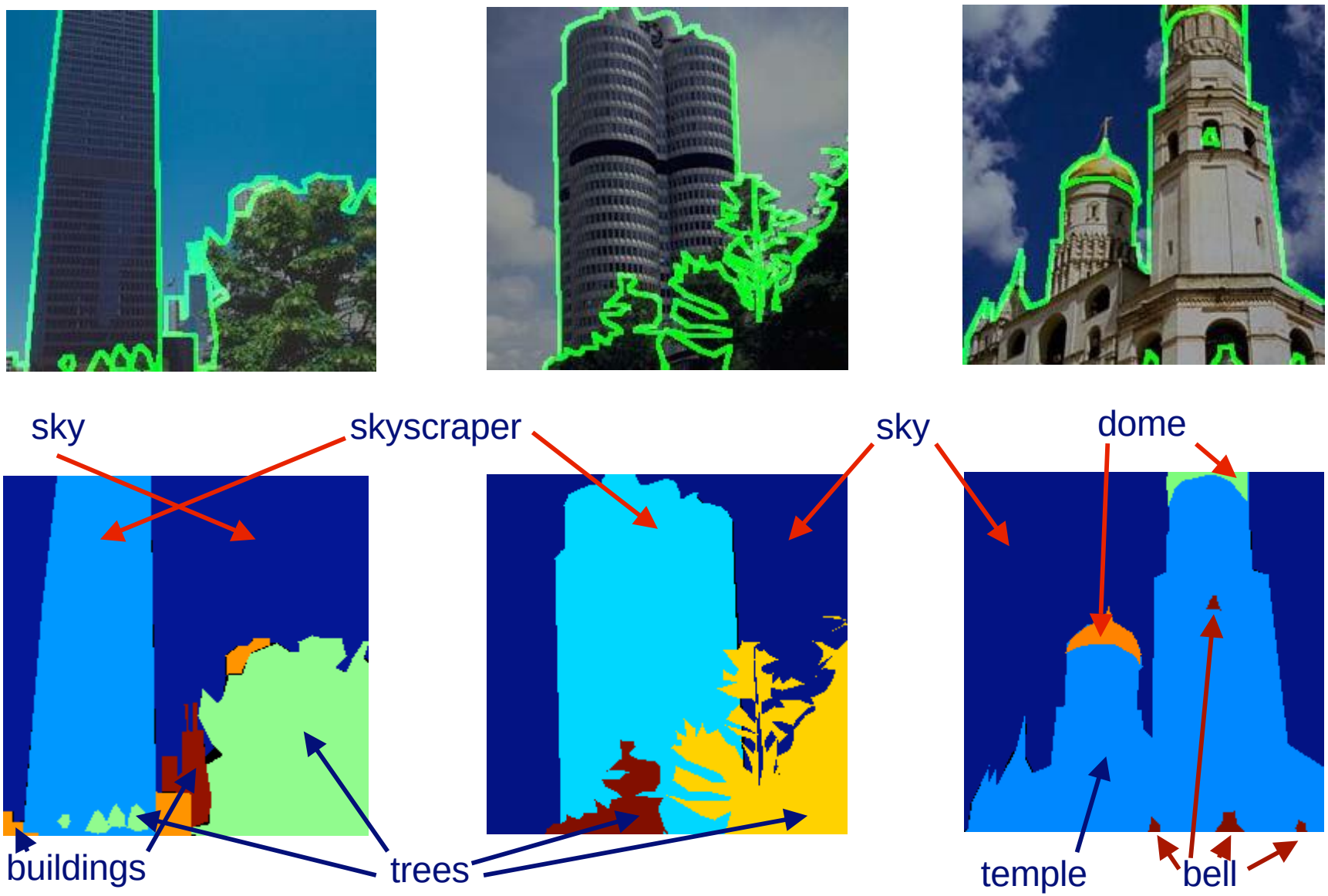
Machine Learning Problems



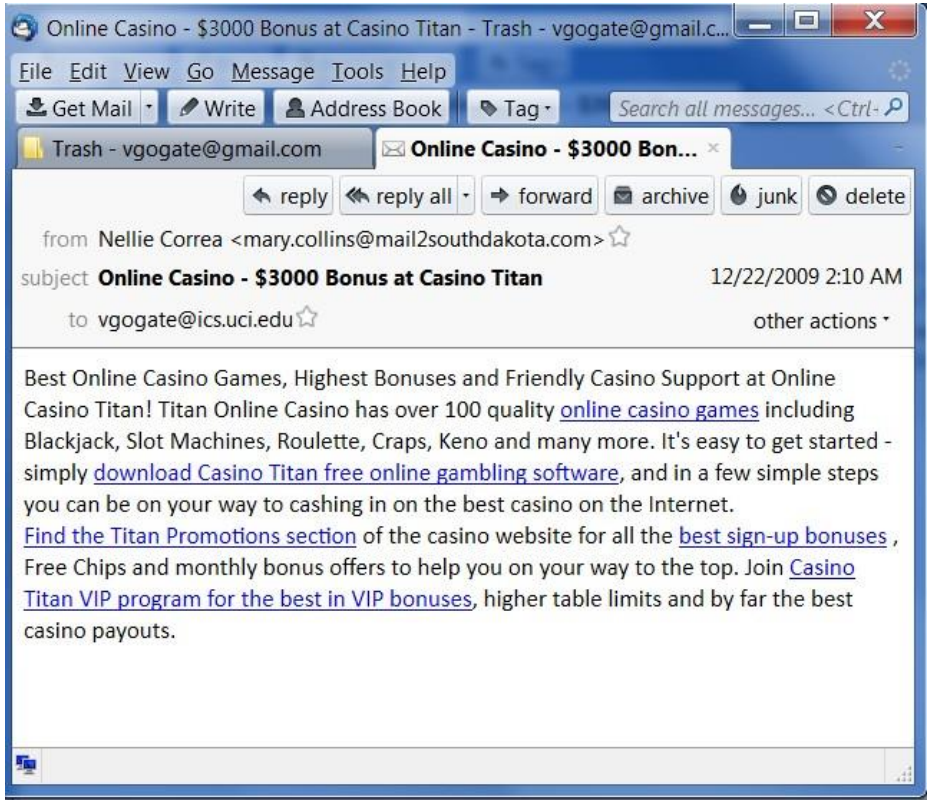
Machine Learning: Applications

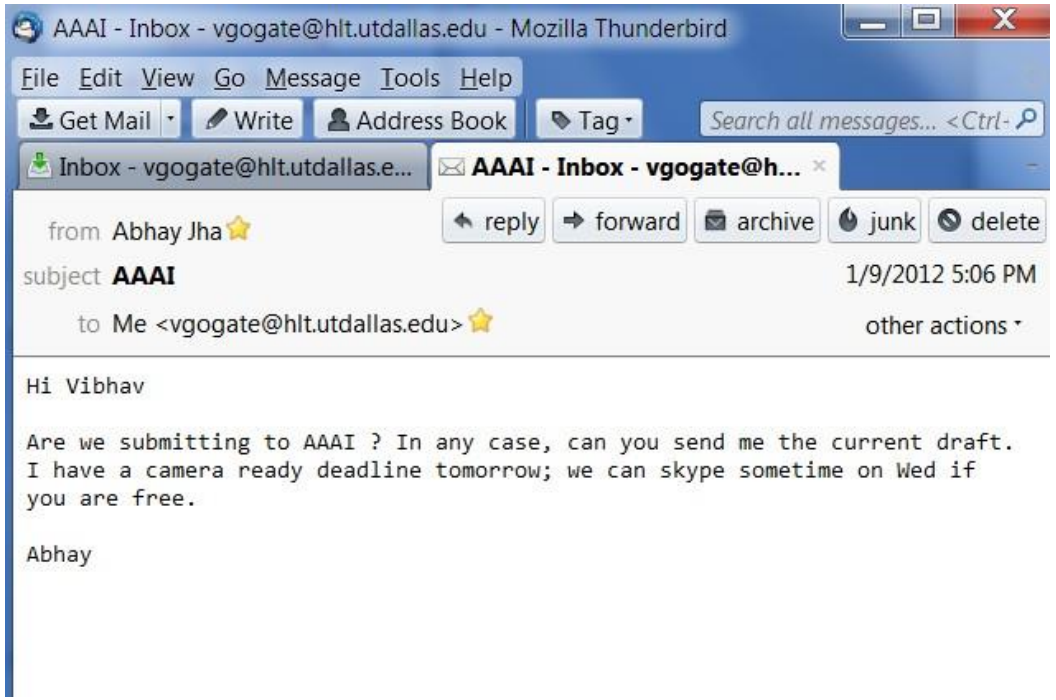
Examples of what you will study in class in action!

Visual Object Recognition



Classification Example: Spam Filtering





Classify as “Spam” or “Not Spam”

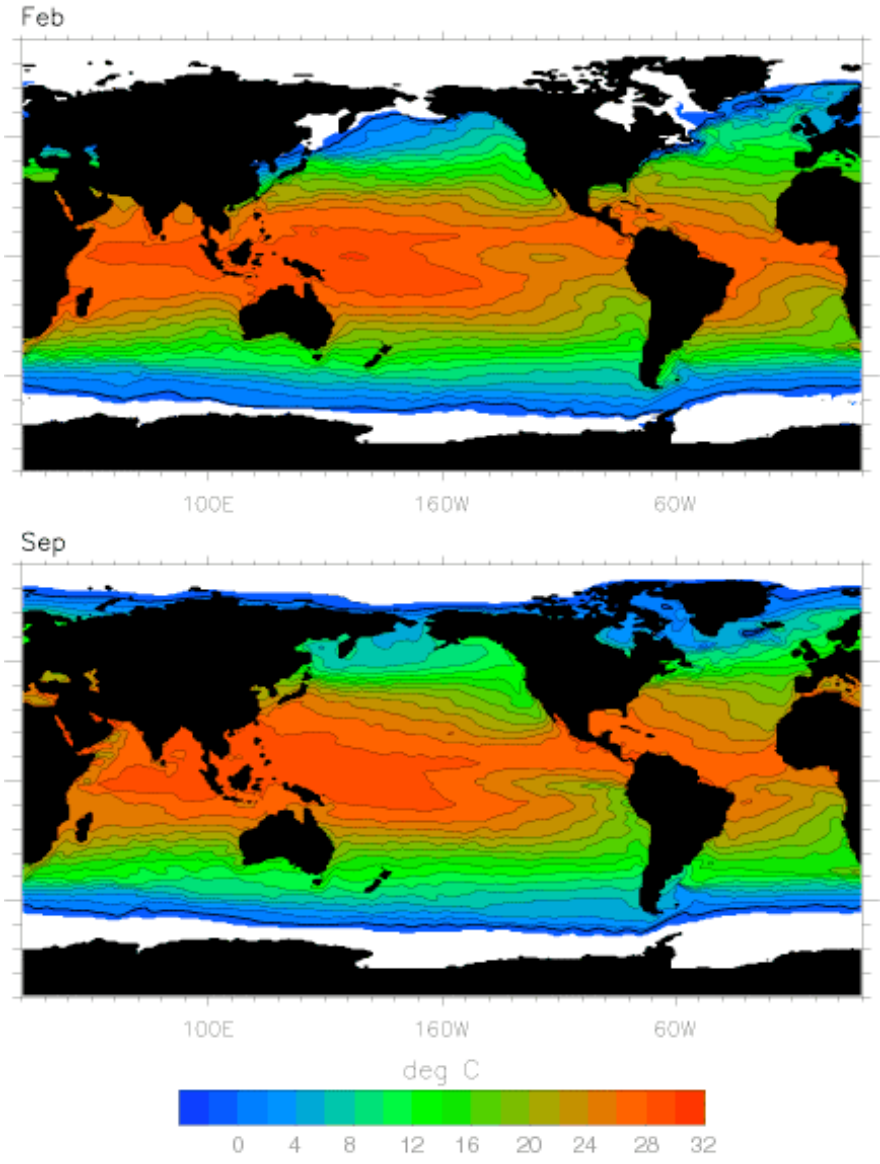
Classification Example: Weather Prediction

Classification: Which one of them ?
cloudy, rainy, sunny, snow

Regression :
what is Temperature Value?

Climate Modeling

- Satellites measure sea-surface temperature at sparse locations
  - Partial coverage of ocean surface
  - Sometimes obscured by clouds, weather
- Would like to infer a dense temperature field, and track its evolution



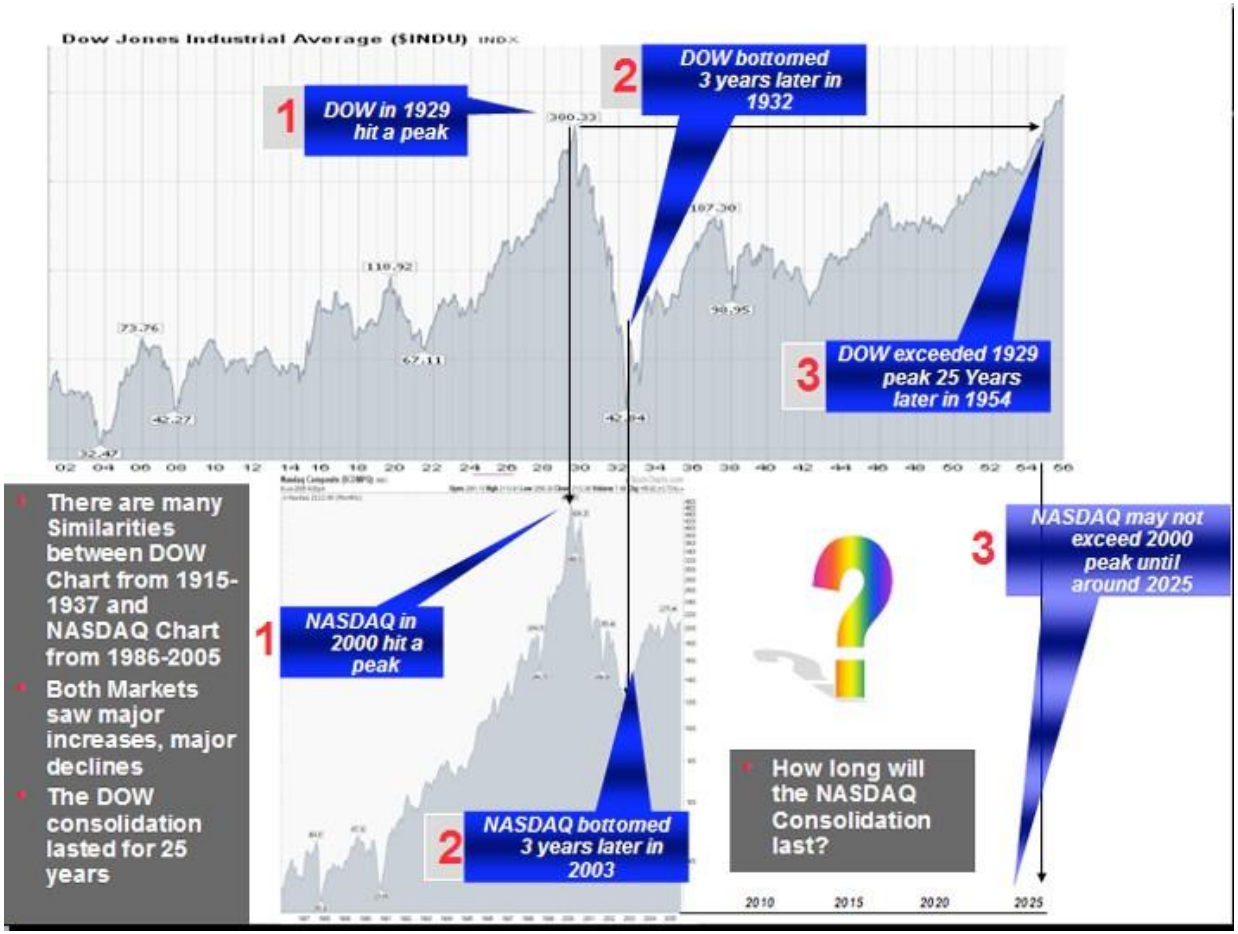
NASA Seasonal to Interannual Prediction Project
http://ct.gsfc.nasa.gov/annual.reports/ess98/nsipp.html

Regression example: Predicting Gold/Stock prices

Good ML can make you rich (but there is still some risk involved).

Given historical data on Gold prices, predict tomorrow's price!

Financial Forecasting

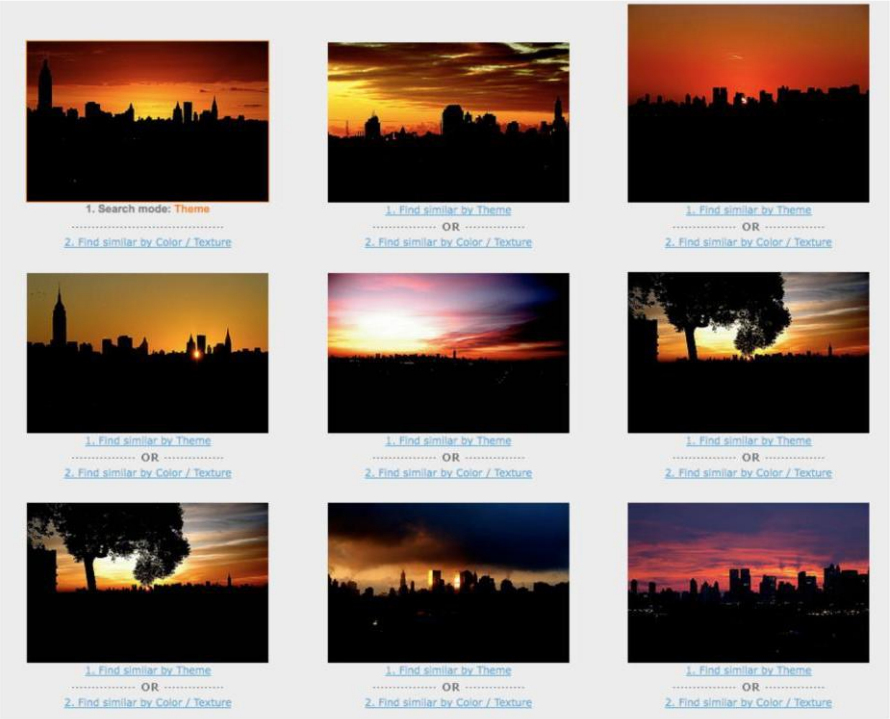


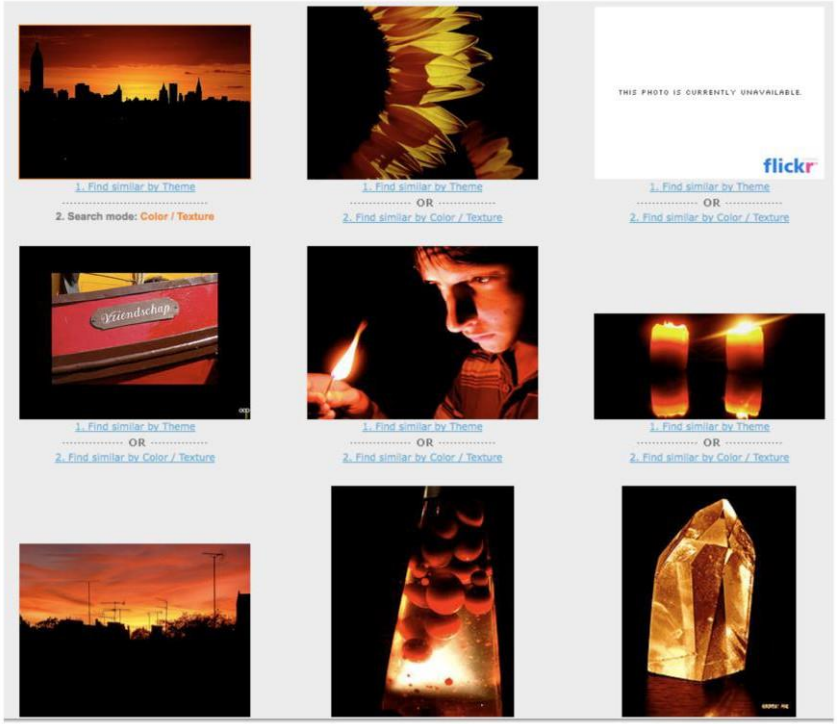
http://www.steadfastinvestor.com/

- Predict future market behavior from historical data, news reports, expert

Similarity Determination

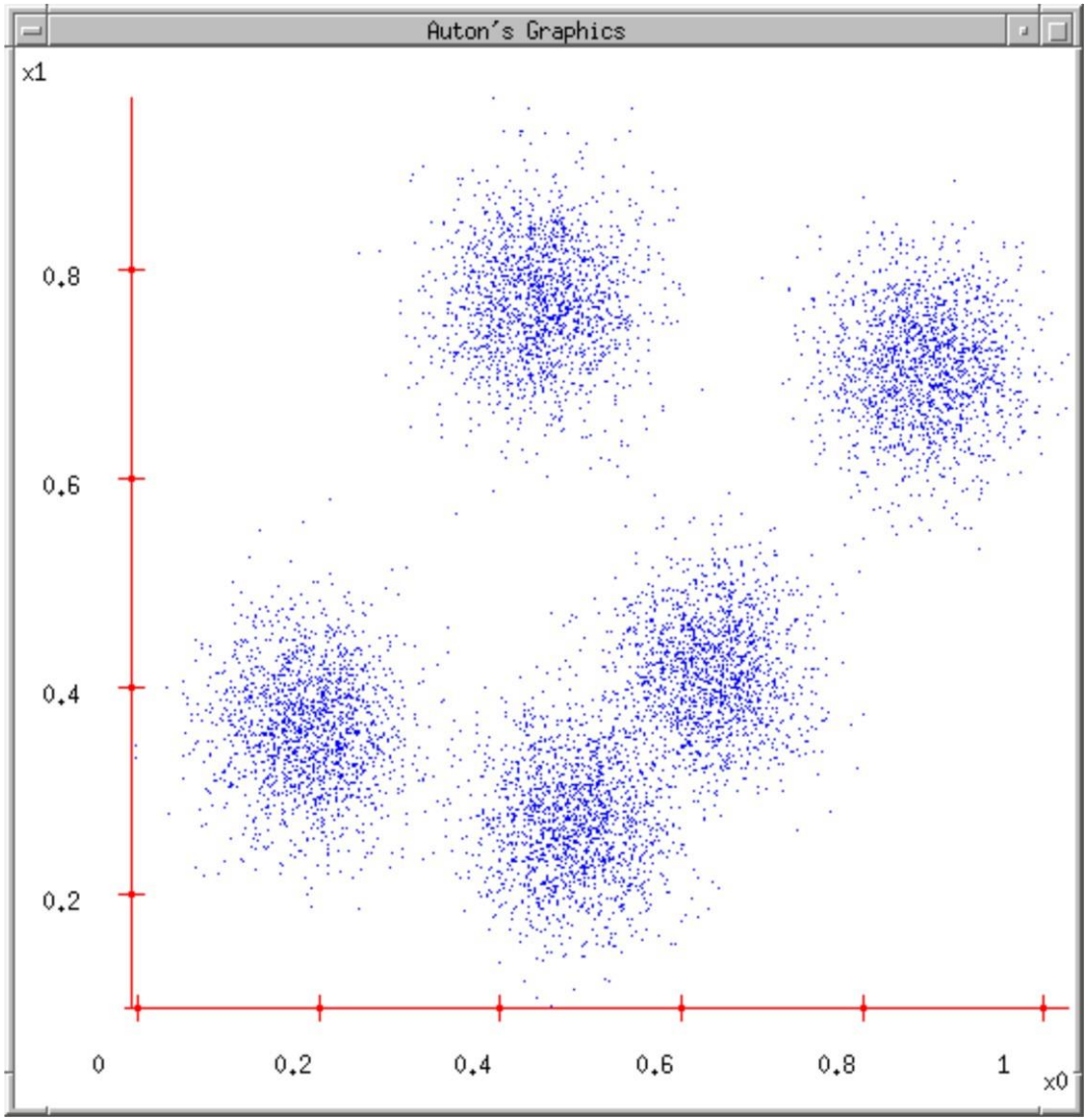
Given Images: find Similar Images





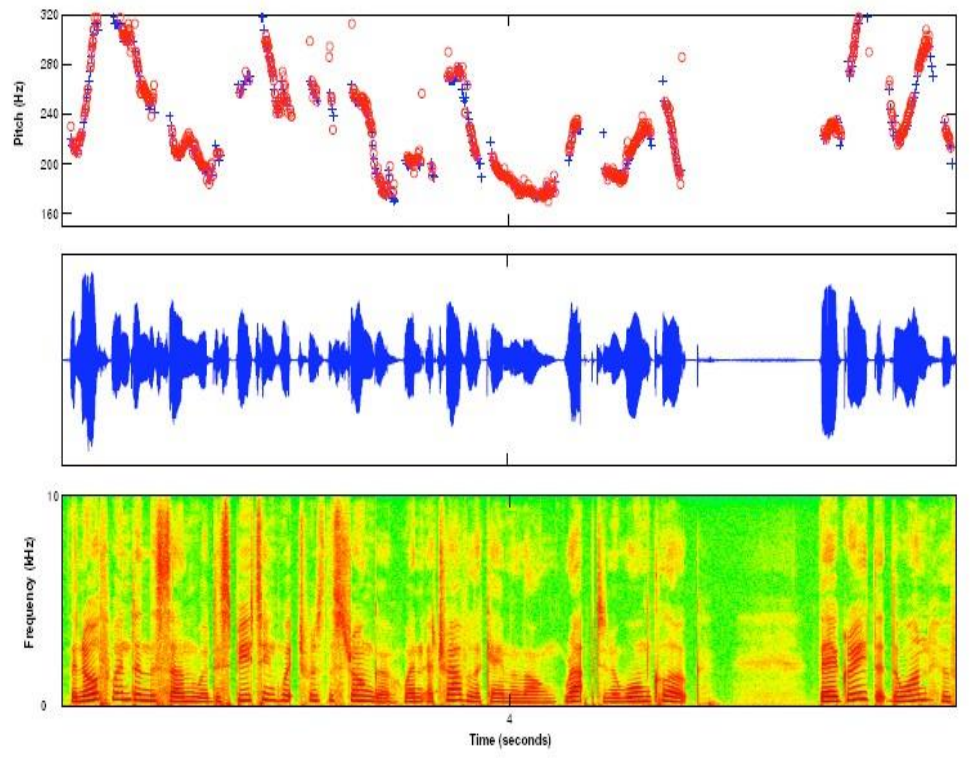
Clustering: Discover Structure in data

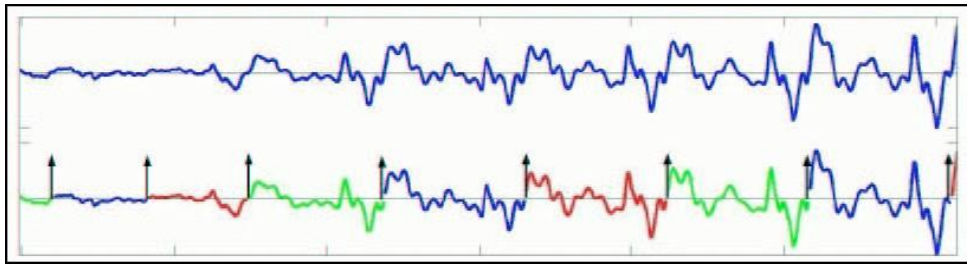
Group Similar Things



Speech Recognition

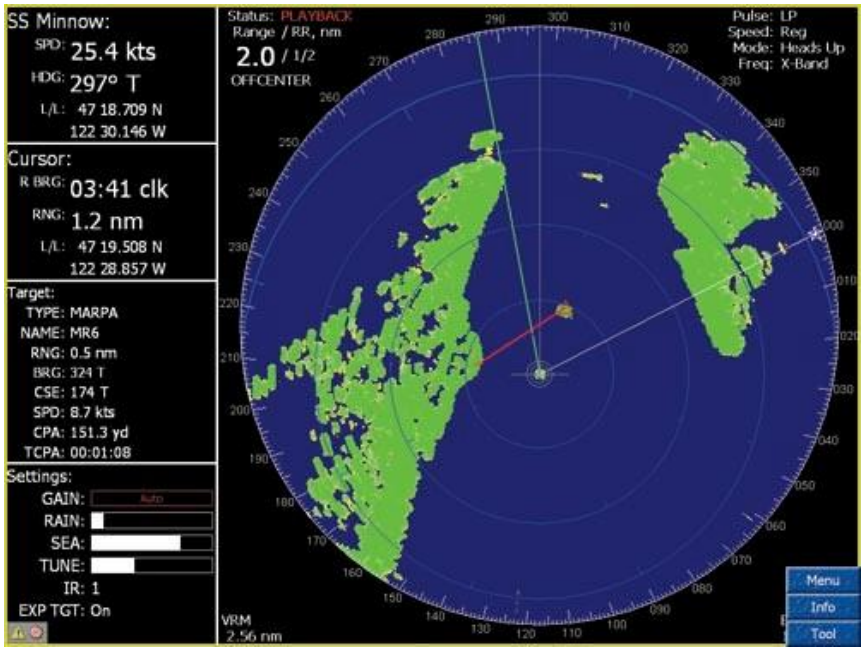
- Given an audio waveform, robustly extract & recognize any spoken words
- Statistical models can be used to
  - ➢ Provide greater robustness to noise
  - ➢ Adapt to accent of different speakers
  - ➢ Learn from training



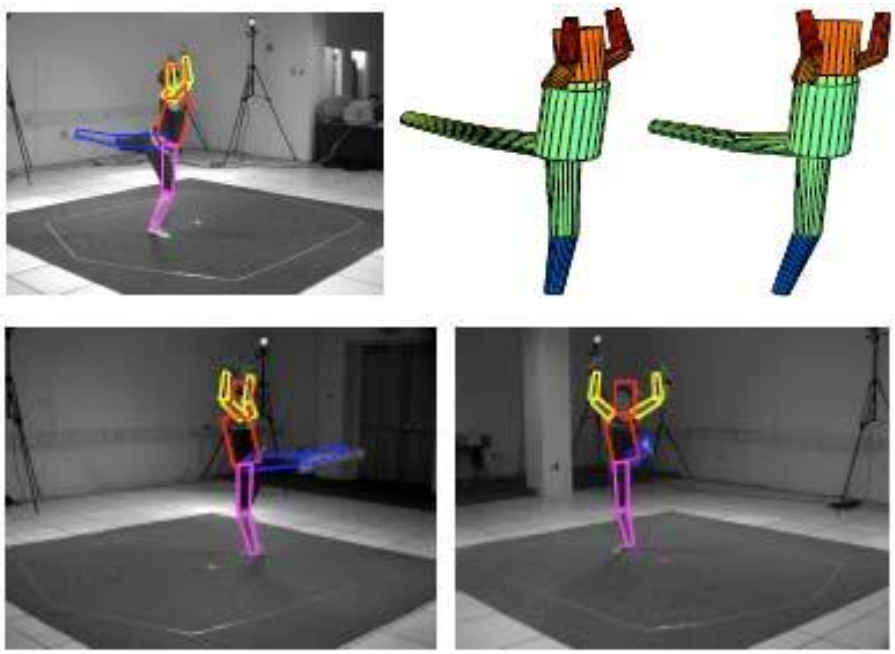


S. Roweis, 2004

Target Tracking



Radar-based tracking of multiple targets



Visual tracking of articulated objects

(L. Sigal et. al., 2006)

- Estimate motion of targets in 3D world from indirect, potentially noisy measurements

Machine learning has grown in leaps and bounds

- The main approach for
  - Speech Recognition
  - Robotics
  - Natural Language Processing
  - Computational Biology
  - Sensor networks
  - Computer Vision
  - Web
  - And so on

Required Basics for ML

- Prerequisites: comfort with basic
  - Programming
  - Calculus
  - Linear algebra
  - Probability