BT5153

Applied Machine Learning for Business Analytics

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Course Staff

https://nusmsba.github.io/

Agenda

1. Course Overview
2. What is Machine Learning?
3. Machine Learning is everywhere
4. Overview of machine learning
5. What may be a qualified Group Project

What BT5153 covers

Goals of this Course

Learn and improve upon the applications of machine learning

- Understand conceptually the mechanism of machine learning algorithms
- Implement the whole data science pipeline
- Select appropriate machine learning tools/techniques for business applications.

Course Background and Overview

- After DSC5106 Foundation in Data Analytics I
- Together with BT5151 Foundation in Data Analytics II
- Basic Machine Learning/Data Mining models have been covered in these two above modules
- In BT5153:
  - "**Advanced**" topics
  - **Hands-on** Experiences
  - In each lecture, roughly **75% Slides** and **25% IPython notebooks**.
  - More **Practical** Assignments/Exams

Models

- Representation Learning
  - Autoencoder
  - Word Embeddings
- Bayesian Learning
  - Naive Bayes
  - Hidden Markov Models
- Deep Learning
  - Neural Networks
  - Convolutional Neural Network
  - Recurrent Neural Network
  - Variational Autoencoder
  - Generative Adversarial Networks
- Model Ensembles

Applications

- Spam Detection
- Document Classification
- Recommendation
- Machine Translation
- Image Categorization
- Sentiment Analysis
- Image/Text Generation
- Portfolio Optimization
- Name Entity Recognition
- Part-of-Speech Tagging
- Etc

Hands-on Experience

- **Understanding domain, prior knowledge**
- **Date integration, selection, clearing, pre-processing, etc**
- Learning models (little math, more intuitive ideas)
- Compare models
- **Model Interpretability**
- Consolidating and deploying discovered knowledge
- **Apply discovered knowledge to practical problems**
- Python programming is not the teaching focus.

Course Assessment

- Assignments:
  - One week individual assignment (10%):
  - A two-week mini kaggle competition (10%)
- Midterm Exam (30%)
- Group Project (50%)
  - Project Proposal (10%)
  - Final Presentation (20%)
  - Final Report (20%)

Course Schedule

ML Practices

Date	Topic	Lecture	Assignment
Fri 01/17	Introduction to Machine Learning	TBU	N.A.
Fri 01/24	Machine Learning Practice	TBU	N.A.
Fri 01/31	Explainability-Accuracy Tradeoff	TBU	Form your team

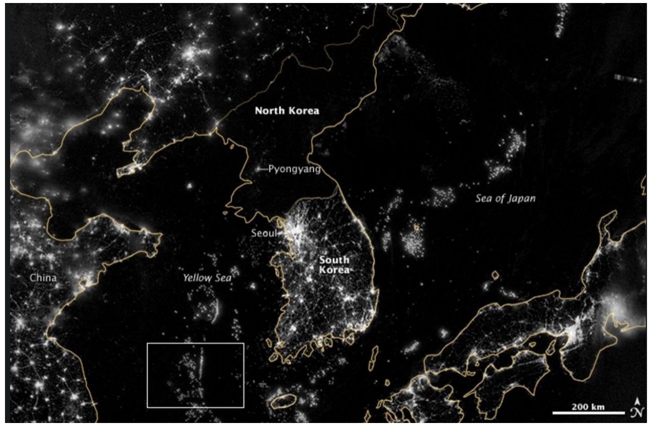
Probabilistic ML Model

Date	Topic	Lecture	Assignment
Fri 02/07	Bayesian Learning: Navie Bayes	TBU	N.A.
Fri 02/14	Bayesian Learning: Hidden Markov Model	TBU	Group Project Proposal Due

Deep Learning and Representation Learning

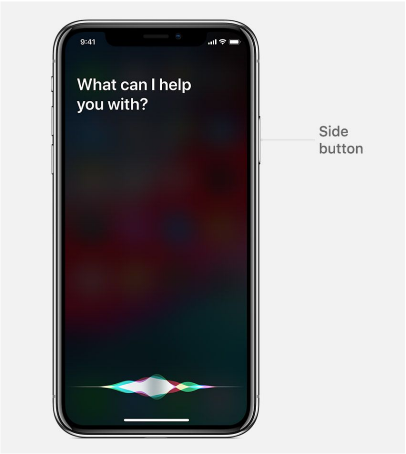
Date	Topic	Lecture	Assignment
Fri 02/21	From Logistic Regression to Deep Learning	TBU	Individual Assignment Out
Fri 02/28	Recess Week	N.A.	Individual Assignment Due
Fri 03/06	Representation Learning: Autoencoder	TBU	Kaggle Start
Fri 03/13	Representation learning: Word2Vec	TBU	In-class Midterm Exam
Fri 03/20	Convolutional Neural Networks: Why It Works	TBU	Kaggle Due
Fri 03/27	Generative Model	TBU	N.A.
Fri 04/03	Group Presentation 1	N.A.	N.A.
Fri 04/10	Good Friday	N.A.	N.A.
Fri 04/17	Group Presentation 2	N.A.	N.A.
Fri 04/24	Reading Week	N.A.	Final Report

Face Recognition



GDP Prediction

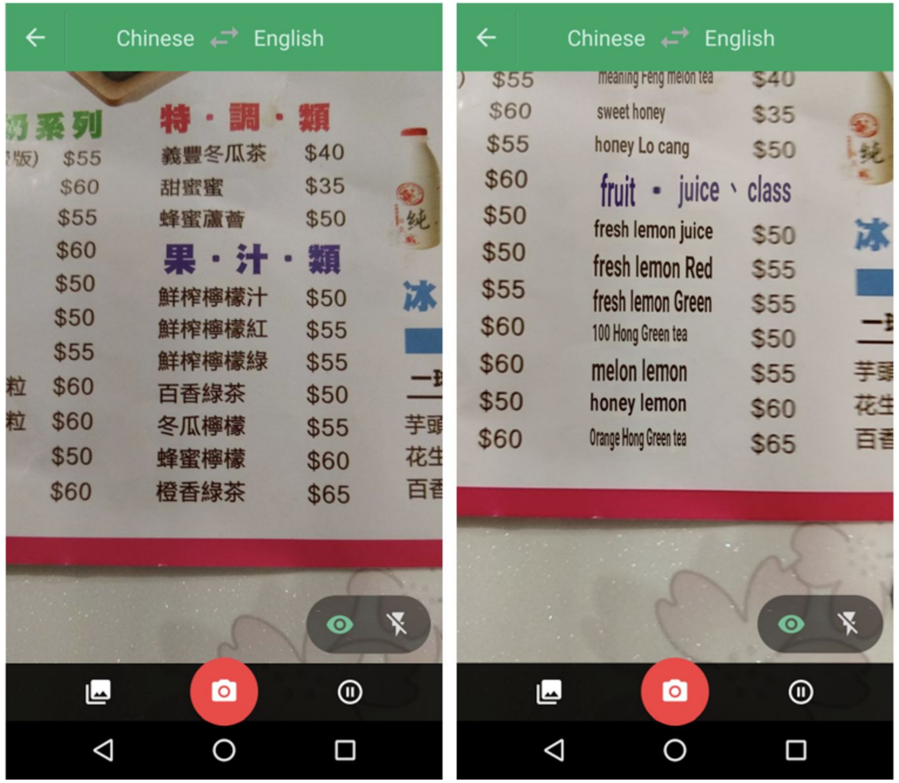
Alphago



Siri

Hedge fund use ML for trading

Special Effects in Tiktok



Machine Translation

Self-driving Car

Amazon Recommendation

What is Machine Learning

Mat Velloso
@matvelloso

Follow

Difference between machine learning and AI:

If it is written in Python, it's probably machine learning

If it is written in PowerPoint, it's probably AI

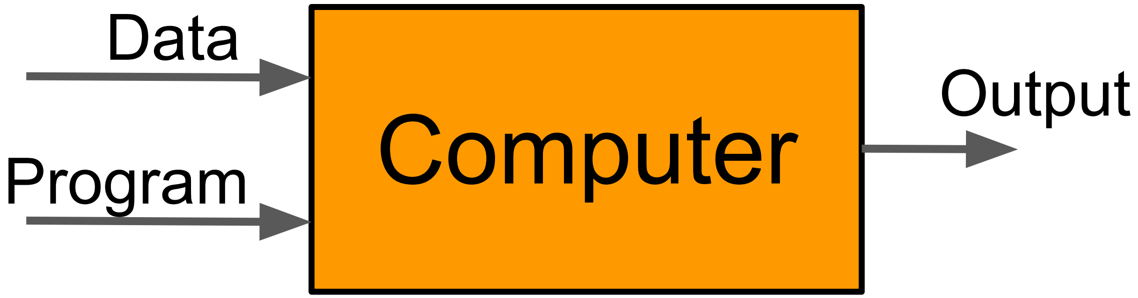
5:25 PM - 22 Nov 2018

8,541 Retweets **23,778** Likes

Python Programming

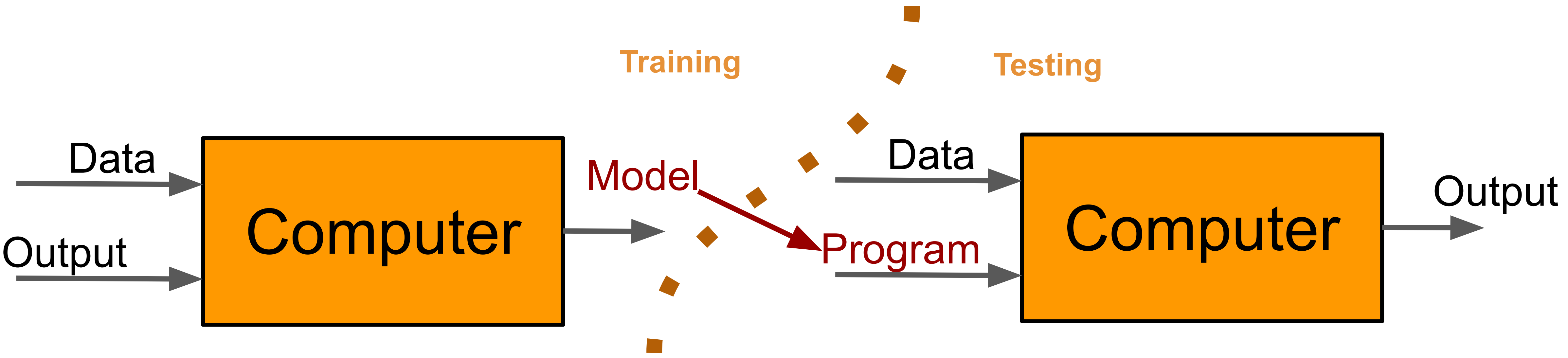
```
In [1]: a   =  3
        b   =  1
        q   = 3*a + 2*b
        print('result is {}'.format(a + b))
```

```
result is 4
```



Machine Learning

```
]: from sklearn.neighbors import KNeighborsClassifier
   from sklearn.metrics import accuracy_score
   #create an object of KNN
   neigh = KNeighborsClassifier(n_neighbors=3)
   #train the algorithm on training data and predict using the testing data
   pred = neigh.fit(data_train, target_train).predict(data_test)
```



Definition of Machine Learning

"A computer program is said to learn from experience **E**
with respect to some class of tasks **T**
and performance measure **P**,
if its performance at tasks in **T**, as measured by **P**,
improves with experience **E**"

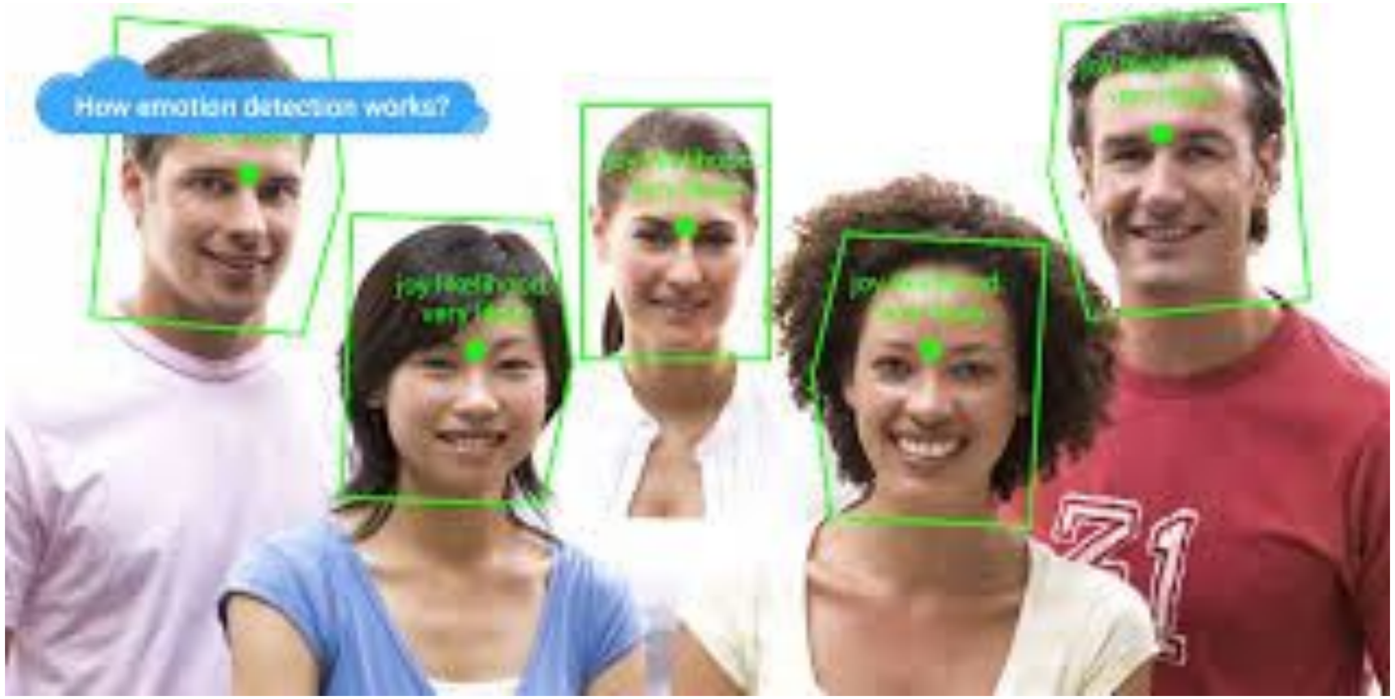
Tom Mitchell

T, **P**, **E** are three basic elements to define a complete machine learning tasks

AlphaGo

T : **Play Go Games**
P : **Win rates of all matches**
E : **Match Experiences with many go players or itself**

Face Recognition



T : **Identify or verify human faces**
P : **Accuracy that human faces are detected**
E : **Dataset of labelled human faces**

Machine Translation

T : **Translate source language into target language**
P : **Accuracy that human faces are detected**
E : **Corpus of source-target language pairs**

More about E

- For machine learning algorithms, E is **data**.

- Data types:
  - Unstructured vs Structured
  - Raw vs Processed

Computers Processable and Understandable

The very import step for Machine Learning Project is that how to **preprocess these unstructured/raw data.**

Structured

- Structured: Table (Matrix) or Tensor

Features

Labels

Player	Height (inches)	Weight (pounds)	Position
Player 1	76	225	C
Player 2	75	195	PG
Player 3	72	180	SF
Player 4	82	231	PF

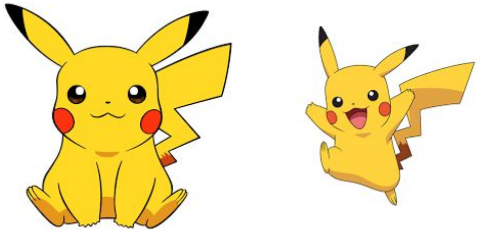
Feature Values

Data Sample

Unstructured

- The original data can not be stored in an “table”
- More abstract, more fuzzy, and more high-dimensionality

Images



Audio

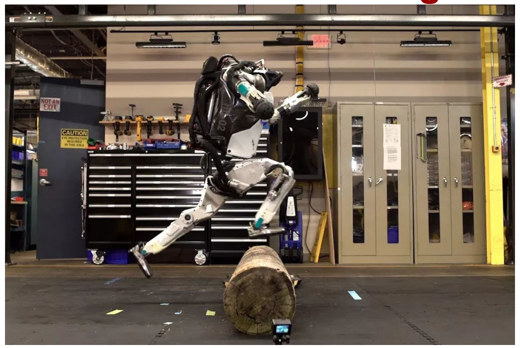
Video

Text

Content

This module provides students a deep overview of various advanced machine learning techniques applied to business analytics tasks. The focus of this course will be the key and intuitive idea behind machine learning models and hands-on examples instead of theoretical analysis. The tentative topics include machine learning pipeline, unsupervised learning, structure learning, Bayesian learning, deep learning and generative models. The programming languages used will be Python.

Environment around agent



Raw Data

- Unstructured Data such as images and text
- Some structured data like categorical data

Labels

Position

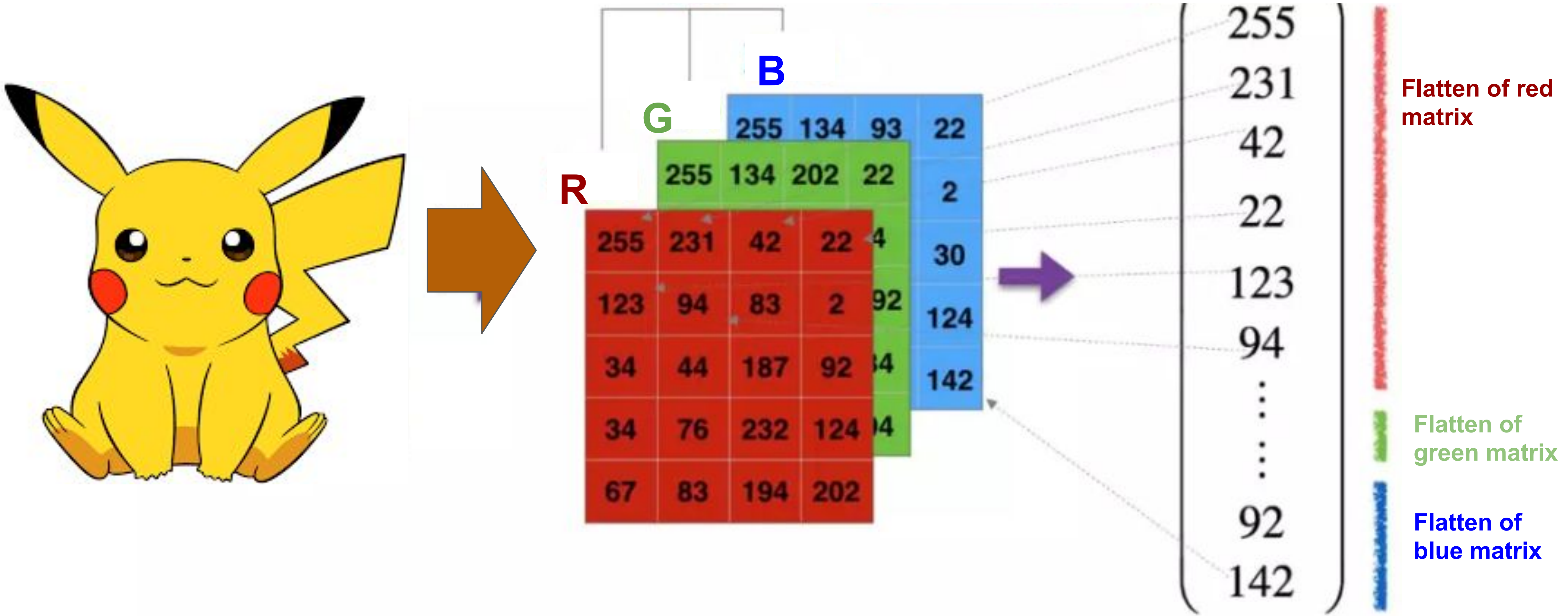
C

PG

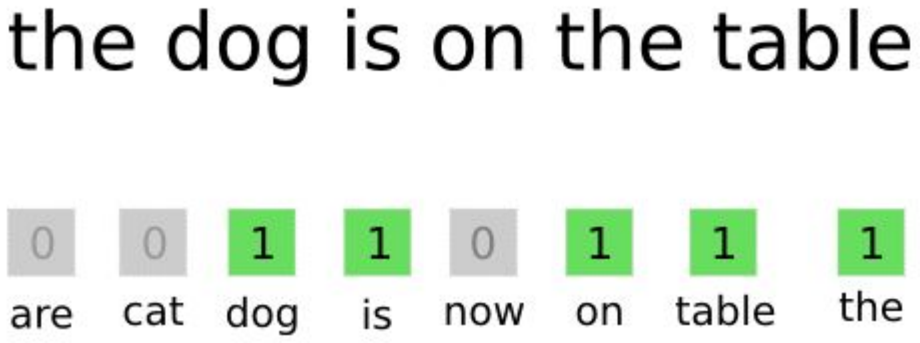
SF

PF

Processed Data (from Raw)



Processed Data (from Raw)



Processed Data (from Raw)

Position	Label
C	0
PG	1
SF	2
PG	1
PF	1

Position	Label
C	1 0 0 0
PG	0 1 0 0
SF	0 0 1 0
PG	0 0 1 0
PF	0 0 0 1

Which one is better?

Terms

- Artificial Intelligence: **Intelligence** exhibited by machines to mimic a human mind
- Machine Learning: Computers being able to learn without hand-coding each step
- Deep Learning: **Multi-layered** algorithms for learning from data
- Data Science: Methods, processes, and systems to extract insights from data
- Analytics: Discovery of meaningful patterns in data

What is what

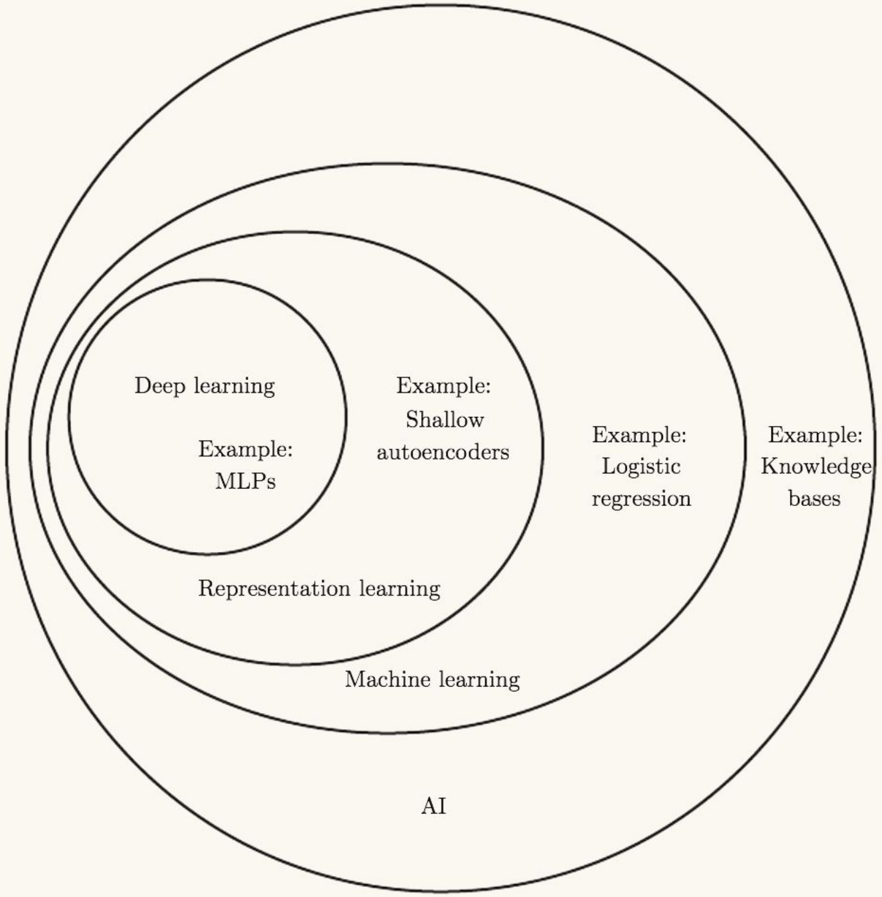


Figure 1.4: A Venn diagram showing how deep learning is a kind of representation learning, which is in turn a kind of machine learning, which is used for many but not all approaches to AI. Each section of the Venn diagram includes an example of an AI technology.

Goodfellow, Ian, et al. *Deep learning*. Vol. 1. Cambridge: MIT press, 2016.

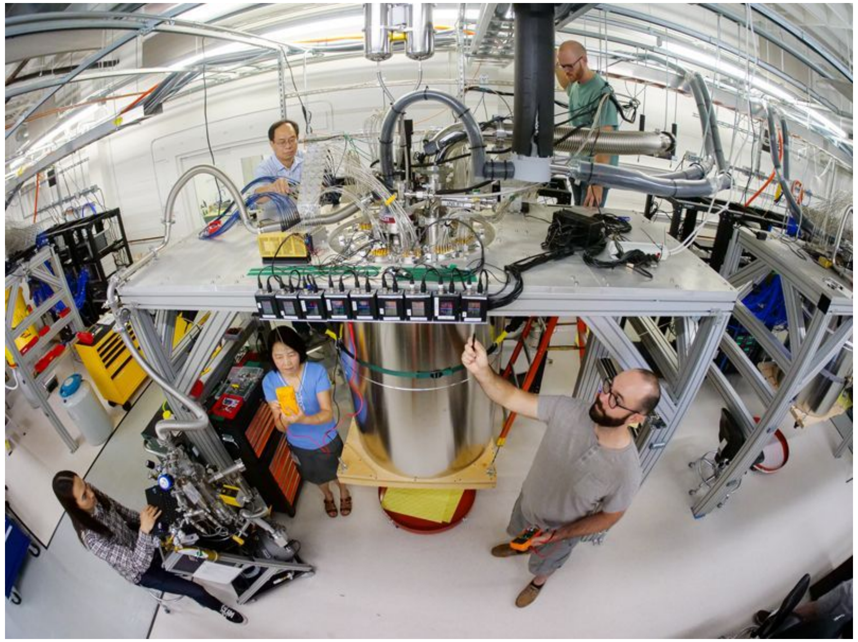
Machine Learning is everywhere

Why Study Machine Learning?

- Reduce Human Efforts:
  - Allow the computers learn automatically
  - Writing rule-based program is too **challenginging**
  - Let the data **SPEAK**
- Machine learning brings better career opportunity
  - The trend will be **MLaas** (Machine learning as a service)
  - Machine learning engineer, Data scientist, Data Product Manager, Cloud Engineer, etc

Why Machine Learning is Powerful?

- Recent progress in algorithms and theory
- Big data era
  - Flow of online data and mobile data
  - 5G is developing
  - Cloud computing
- Computational power is available
  - TPU, GPU, **Quantum Computing**, 。。。。



Google Quantum Computer

Three Niches for Machine Learning

- **Data mining**
  - Use historical data to improve decisions.
- **Software applications that are hard to be programmed by hand**
  - Speech Recognition
  - Autonomous Driving
  - Etc
- **User modeling**
  - Recommendation System
  - Micro-credit Loan
  - Etc

Credit Risk Analysis

Customer103: (time=t0)

Years of credit: 9
Loan balance: $2,400
Income: $52k
Own House: Yes
Other delinquent accts: 2
Max billing cycles late: 3
Profitable customer?: ?

Customer103: (time=t1)

Years of credit: 9
Loan balance: $3,250
Income: ?
Own House: Yes
Other delinquent accts: 2
Max billing cycles late: 4
Profitable customer?: ?

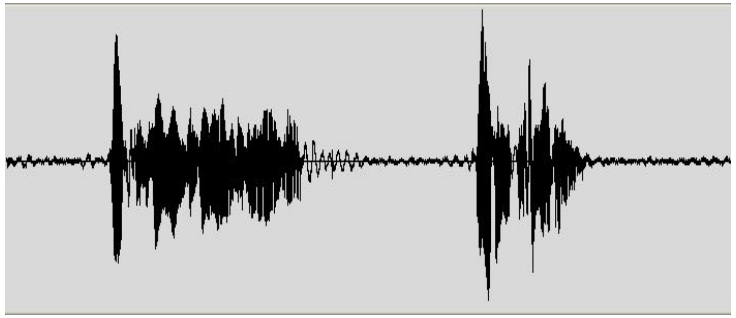
...

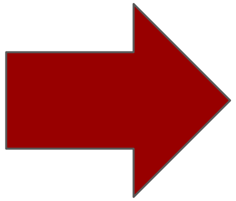
Customer103: (time=tn)

Years of credit: 9
Loan balance: $4,500
Income: ?
Own House: Yes
Other delinquent accts: 3
Max billing cycles late: 6
Profitable customer?: No

- Learned Rules
  - Other-Delinquent Account > 2 and Number Delinquent billing cycles > 1 → No Profitable
  - Other-Delinquent Account = 0 and (Income > $30k or Years-of-Credit > 3) → Profitable

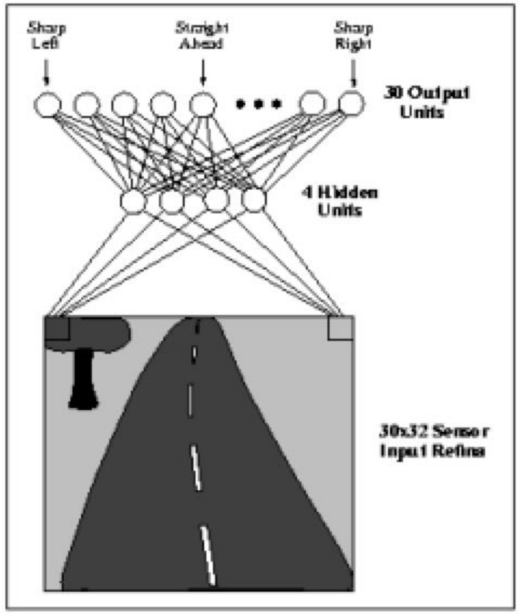
Speech Recognition

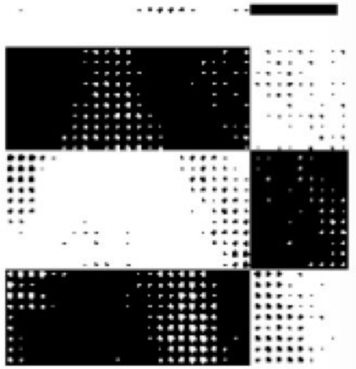




This is Friday

Self-Driving Car





ALVINN: an autonomous land vehicle in a neural network (1989)

Overview of Machine Learning Concepts

Basic Paradigm

- Define the **T**asks (what should be learned)
- Find the training **E**xperiences(datasets)
- Quantify the **P**erformance via a measure
- Choose a machine learning model to complete the **T** and improve the **P** via the **E**

Machine Learning in a nutshell

- Ten of thousands of machine learning algorithms

- Hundreds New per month

https://www.microsoft.com/en-us/research/project/academic/articles/aaai-conference-analytics/ AAAI Conference

- Each ML algorithm can be decomposed into:
  - **Representation**
  - **Evaluation**
  - **Optimization**

Representation

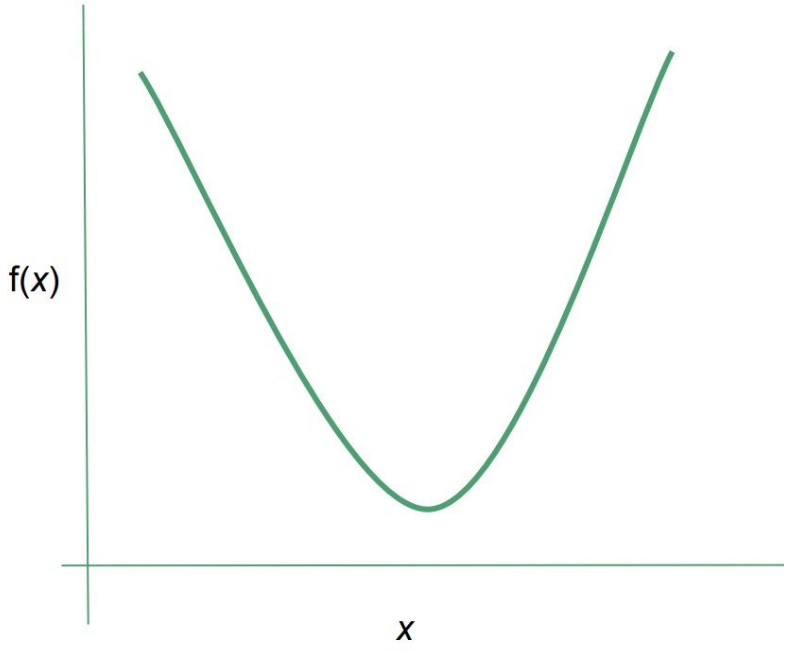
- Decision Trees
- Support Vector Machine
- Set of rules
- Instances-based Learning (K Nearest Neighbor)
- Probabilistic Graph Models (Naive Bayes and Hidden Markov Models)
- Neural Networks and Deep Learning
- Ensemble
- Others

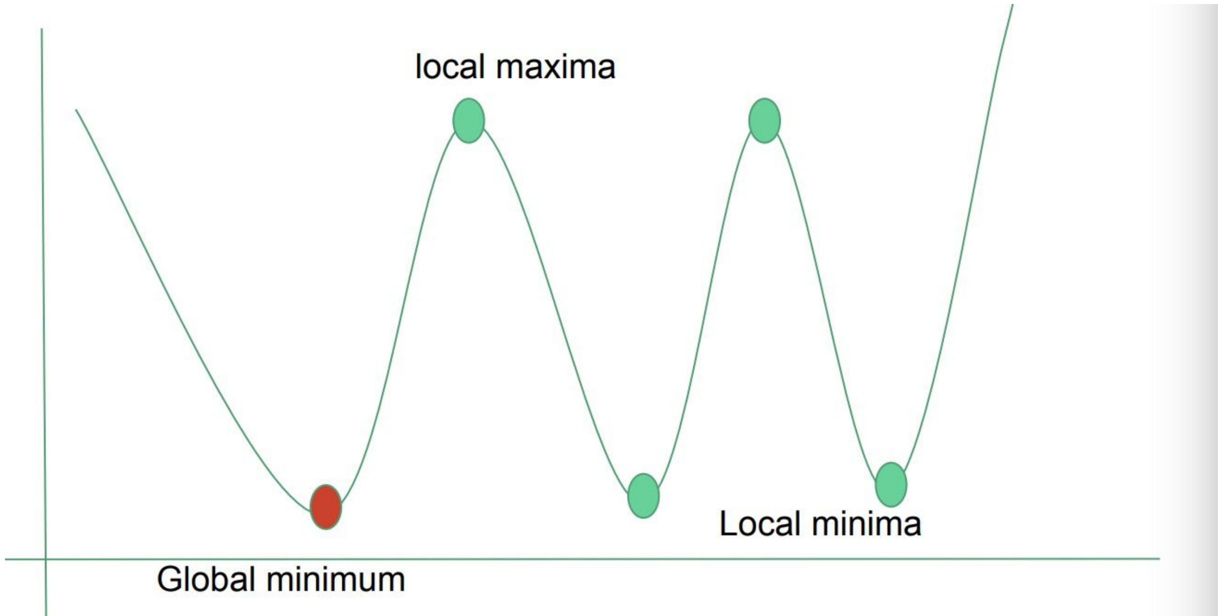
Evaluation

- Confusion matrix
- Accuracy
- Precision and recall
- Mean Squared Error
- Likelihood
- Posterior probability
- Margin
- Entropy
- K-L Divergence
- Etc

Optimization

- Combinatorial Optimization
  - Grid search
- Convex Optimization
  - Least Squares
  - Linear Programming (with constraints)
  - Semidefinite Programming
  - Etc
- Non-convex Optimization
  - Gradient descent algorithm
  - Bayesian Optimization
  - Etc





Types of Machine Learning Models

- Supervised Learning
  - Training data contain the desired outputs (labels)
- Unsupervised Learning
  - Training data do not contain labels
- Reinforcement Learning
  - Rewards from **sequence actions**
- Semi-supervised Learning
  - Training data include a few labels

Supervised Learning

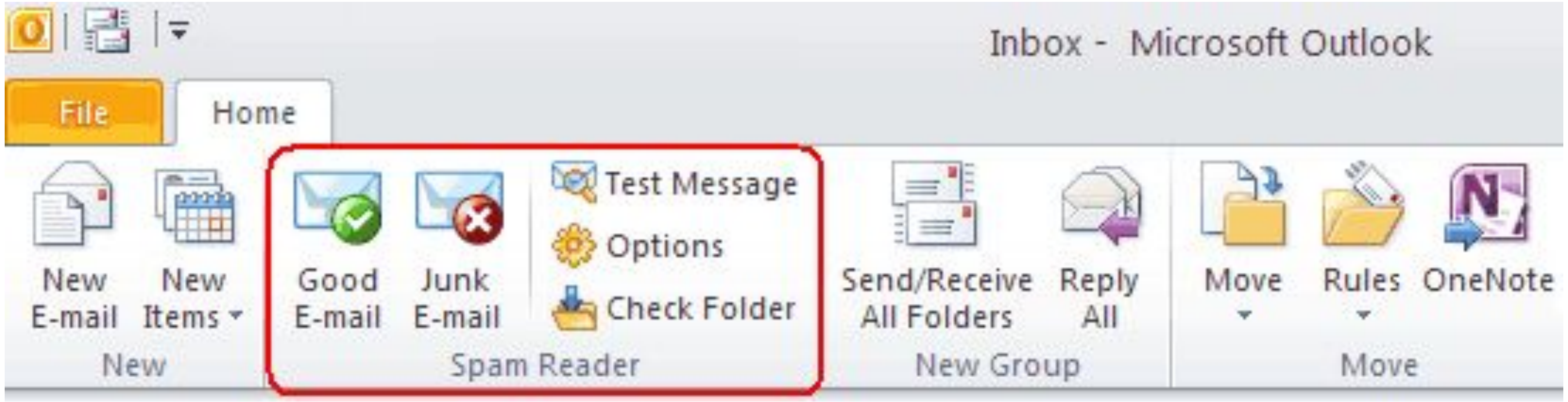
- Given (training data x, training label y), predict (new data, **?**)

$$h(x) \approx f(x)$$

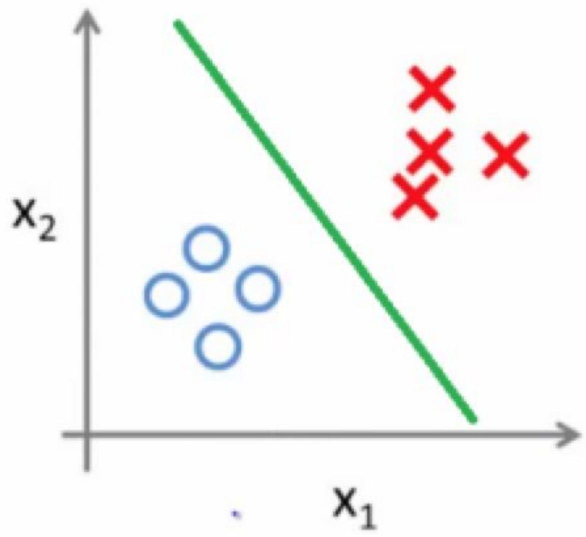
- Classification: **discrete** label
  - Binary Classification: label y in {0, 1}
  - Multi-class Classification: label y in {0, 1, 2, 3, …, k-1}
- Regression: **continuous** label
  - y is real-valued space

Binary Classification

- Junk Email Filter

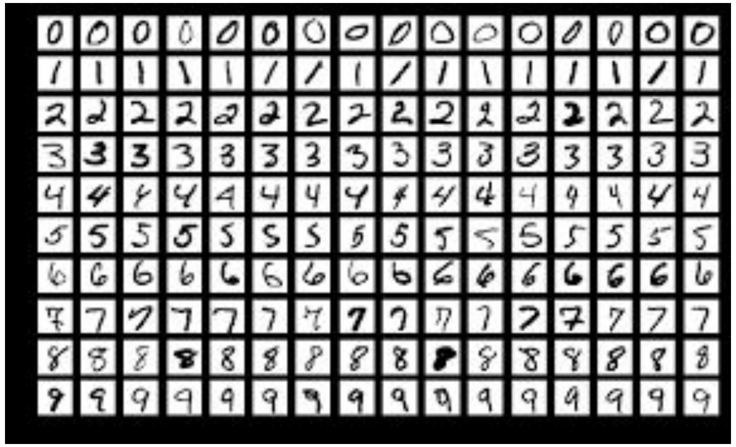


- Two classes
    - 1 Normal emails
    - 0 Spam emails

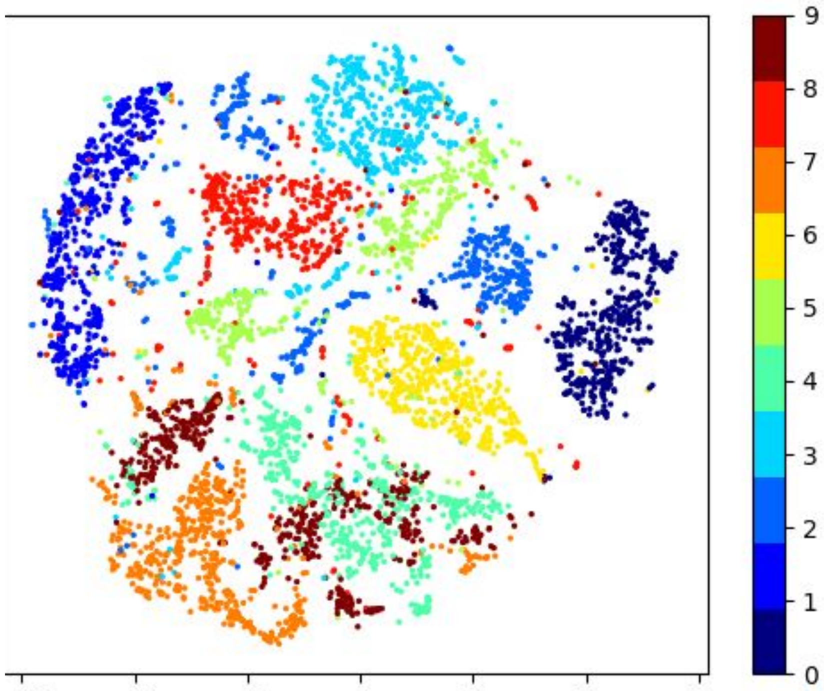


Multi-class Classification

- Handwritten digits recognition

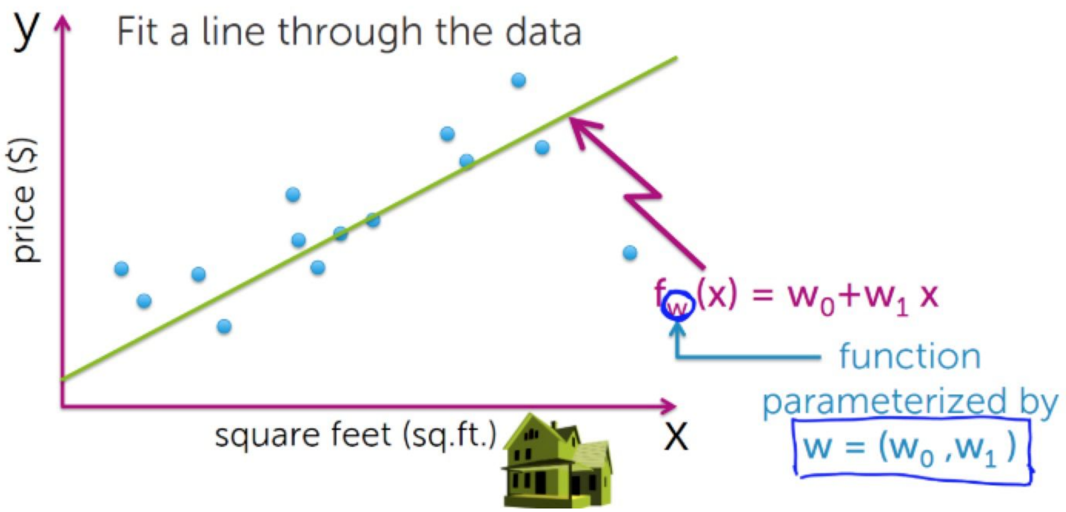


- Ten classes
  - Each number is one class from 0 to 9

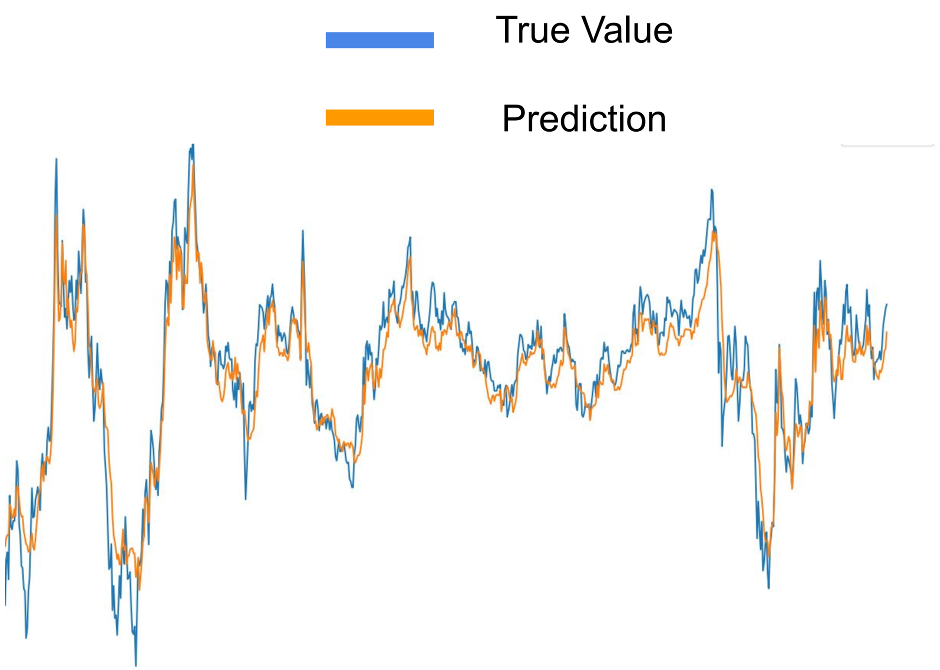


Regression

- Linear Regression



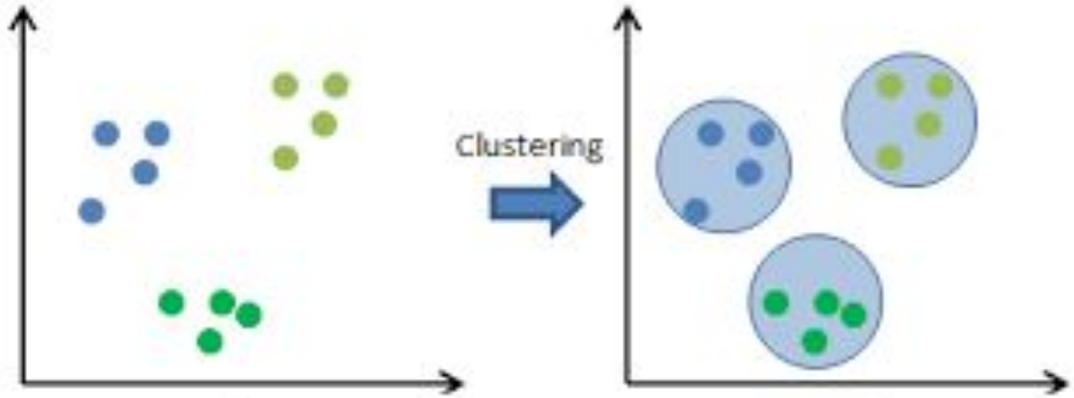
- Non-linear Regression
    - Time series prediction
    - Based on previous k time steps, predict the current value



Unsupervised Learning

- No training labels
- Clustering
  - Divide data into a number of groups
- Dimension Reduction
  - Find a sub feature space for the data representation
- Novelty/Anomaly detection
  - Find the odd one out
- Etc

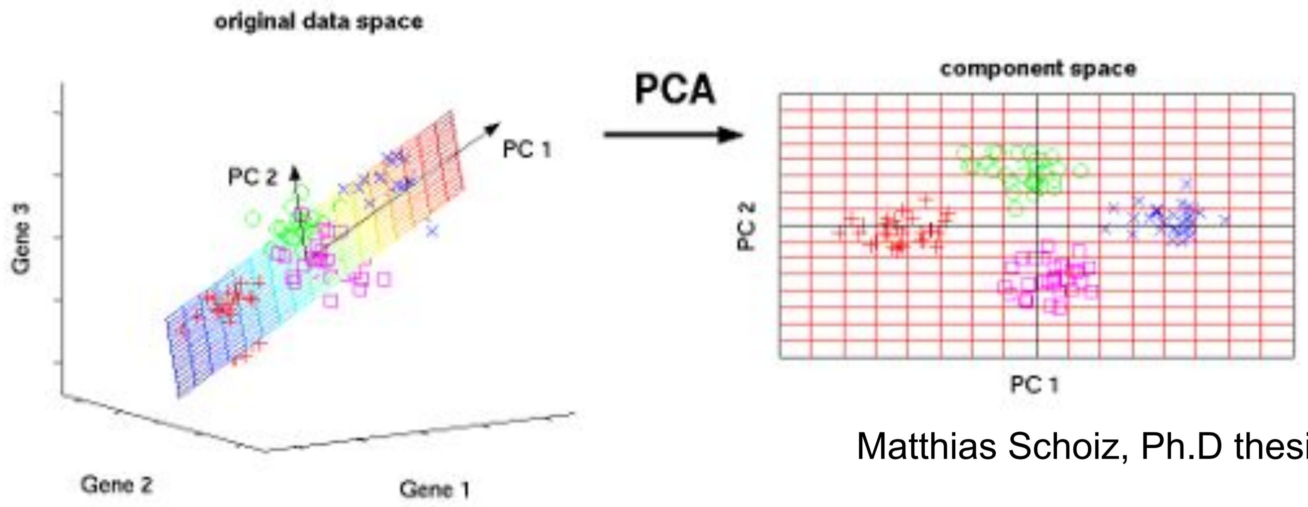
Clustering



- Customer/Marketing segmentation
- Clustering of news, documents, pictures, ..

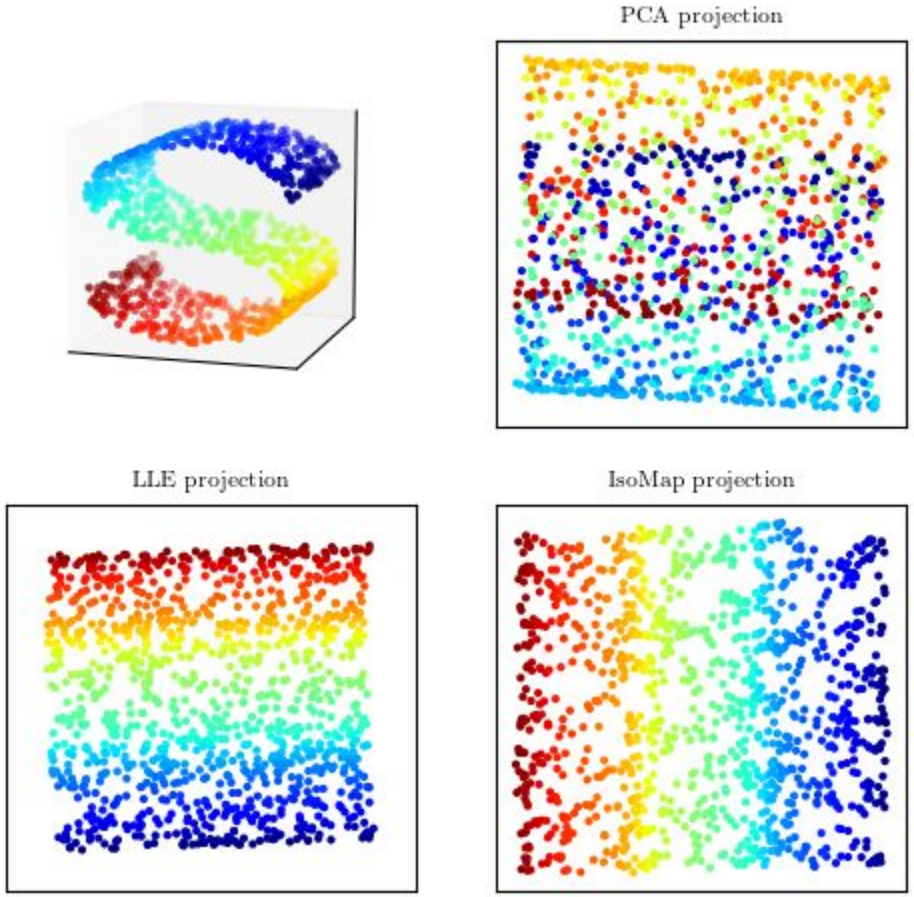
Dimension Reduction

- Principal Component Analysis



Matthias Schoiz, Ph.D thesis

- Manifold Learning
    - Find nonlinear subspace/embedding



Novelty / Anomaly Detection

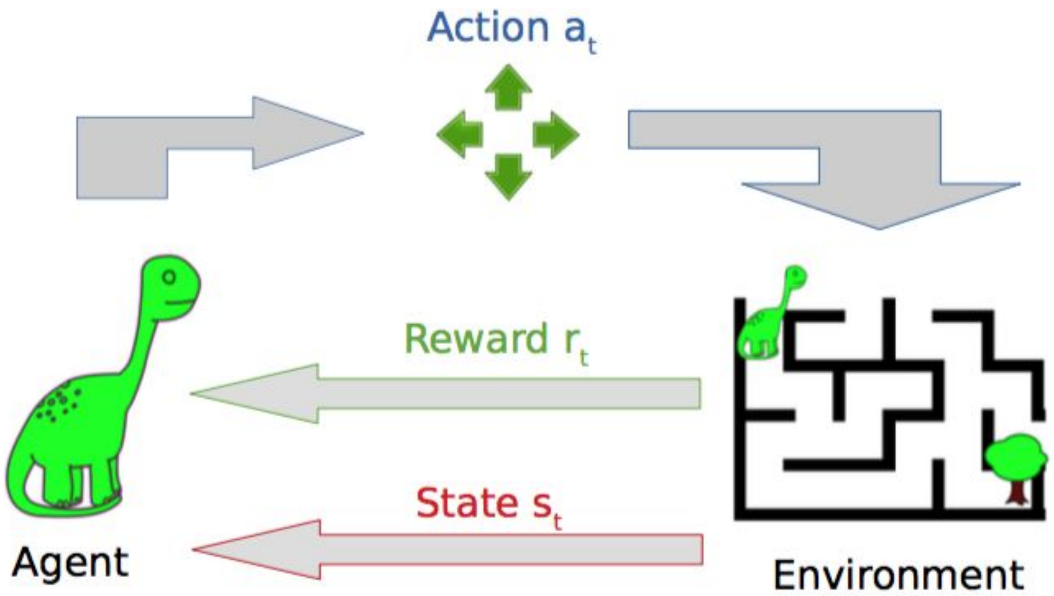
- Identify new/unknown patterns

Interacting with Environment

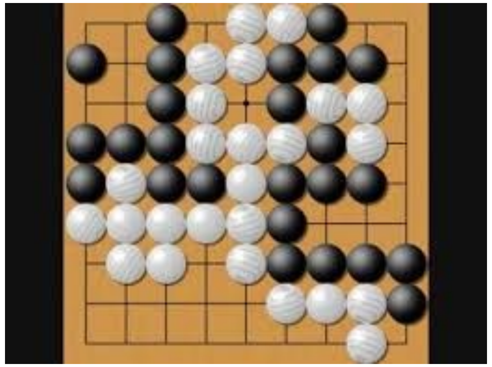
- How to get experience from Environment
- Batch Learning
  - Observe a **batch** of training data (x1, y1), …(xk, yk), then train and used for prediction
- Online Learning
  - **Sequential**: Observe x1, predict f(x1), train with (x1, y1), observe x2
- Active Learning
  - **interactively** query the user/database to obtain the desired outputs
  - Reduce the amount of labelled data that is needed
- Reinforcement Learning
  - Take action, environment responds, take new actions
  - Play Go, Autonomous Driving

Reinforcement Learning

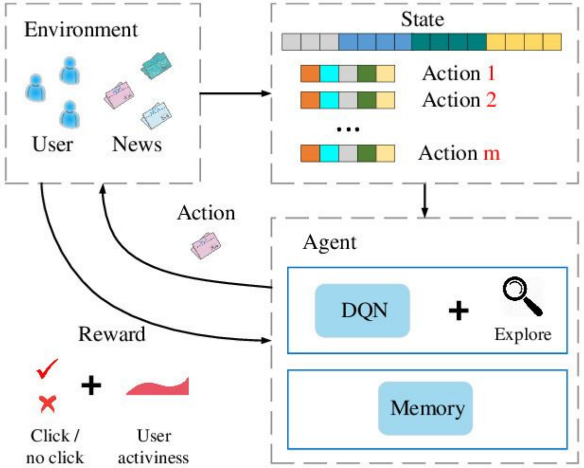
- Do not have known-correct answers
- Repeat
  - Take action
  - Environment reacts
  - Reward/Penalty
  - Update model
- Application



Play Dota2



Play Go



Recommendation Sys.

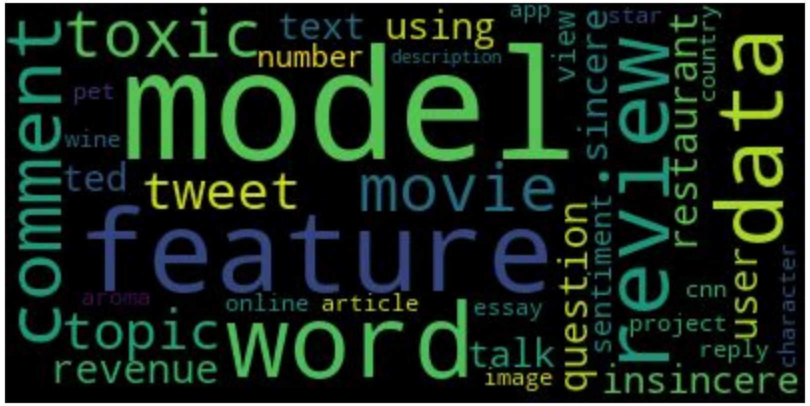
Self-driving Car.

Key Issues in Machine Learning

- Obtaining experience
  - How to obtain training data?
    - Supervised or Unsupervised
  - How many examples are enough?
    - PAC learning theory
- Learning algorithms
  - Which kind of machine learning model can approximate function well, when?
  - How does the complexity of learning algorithms impact the learning accuracy?
  - Whether the objective function is learnable?
- Representing inputs
  - How to represent the inputs?
  - How to remove the irrelevant information from the input representation?
  - How to reduce the redundancy of the input representation?

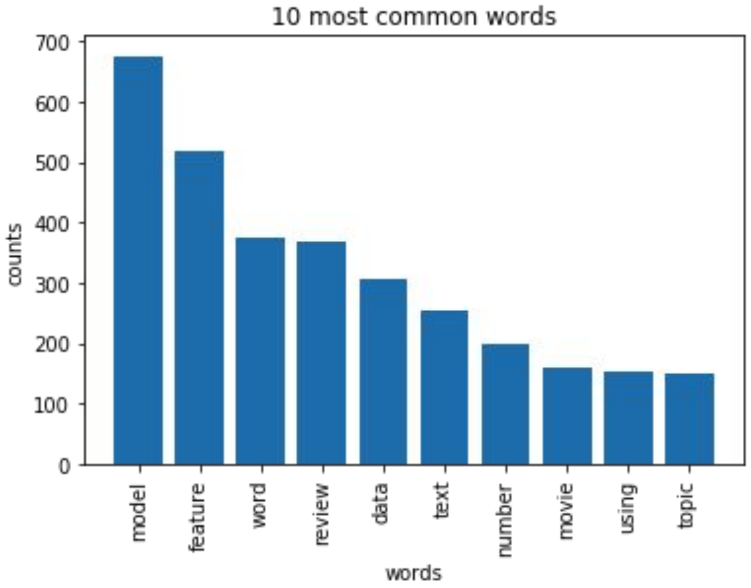
Group Projects

From Last Year



Word Cloud of high-frequent words

https://nusmsba.github.io/project/2019fyp.html




```
Topics found via LDA:

Topic #0:
model word feature project tweet movie

Topic #1:
feature model review text data using

Topic #2:
restaurant user review model feature text

Topic #3:
comment feature model character article editor

Topic #4:
review model movie reply star data

Topic #5:
word model data wine tweet question
```

Project Hint 1

- Find a new problem which can be solved by machine learning technique
  - **Visualize the impact of climate change**

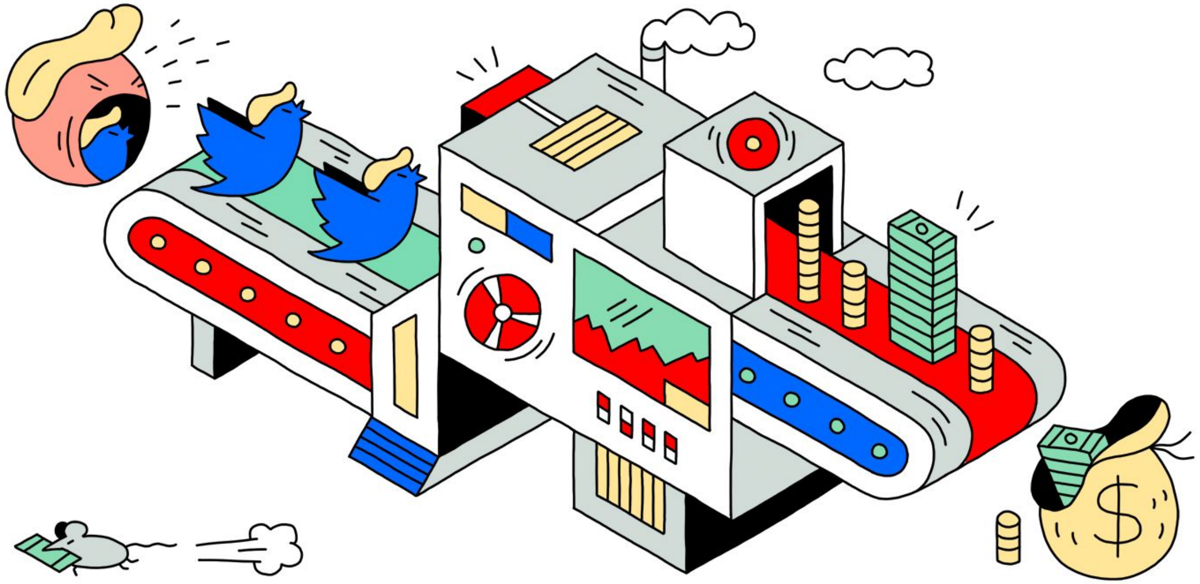
Applying generative models to create personalized images of an extreme climate event, flooding

Source: https://arxiv.org/pdf/1905.03709.pdf

Project Hint 2

- **Trump2Cash**

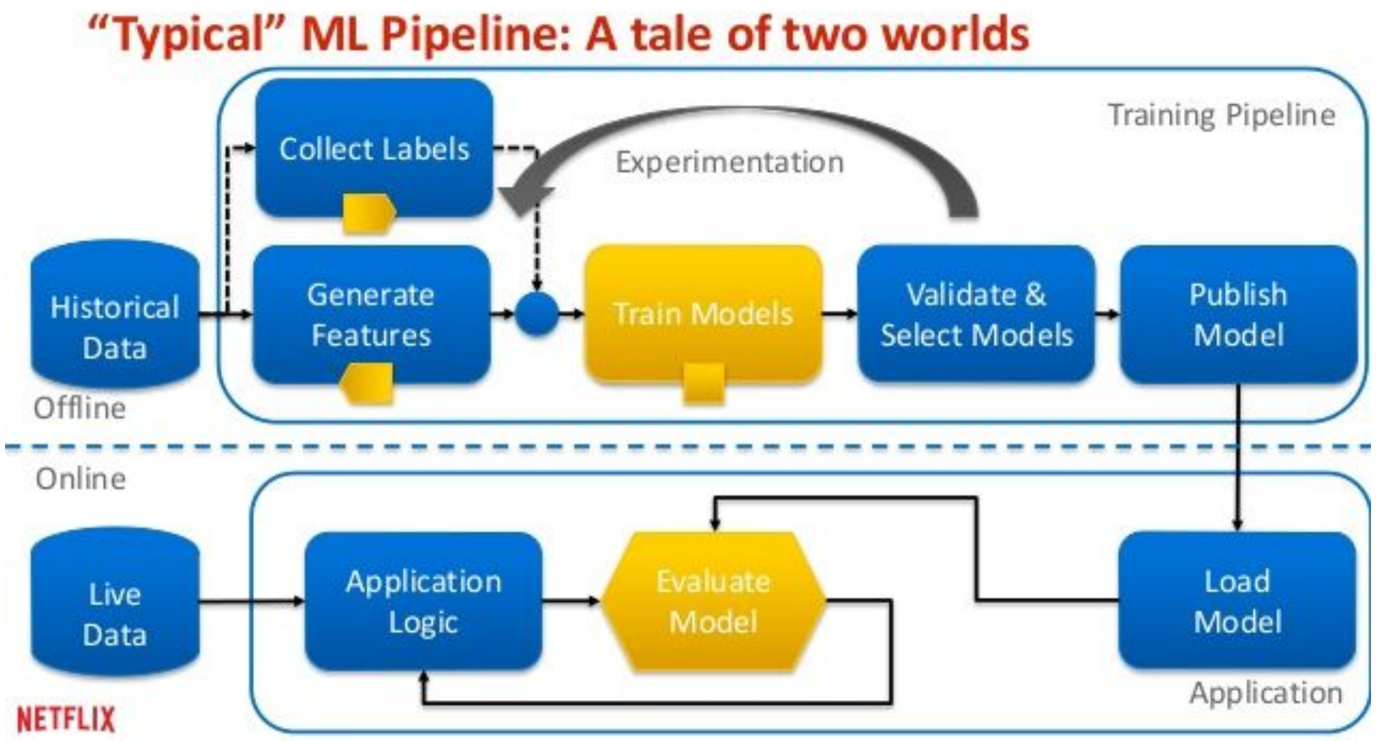
1. Monitor Trump's twitter feed
2. Analyze the twitter
   If it mentions of any publicly traded stocks and compute its sentiment
   a. Long it if the sentiment is positive
   b. Short it if the sentiment is negative



Source: https://github.com/maxbbraun/trump2cash

Project Hint 3

- Build a whole pipeline ML system (real-life one)



Project Hints 4

- In-depth analysis of machine learning algorithms on one specific application
- **Try to explain the findings**

Model	MR	SST-1	SST-2	Subj	TREC	CR	MPQA
CNN-rand	76.1	45.0	82.7	89.6	91.2	79.8	83.4
CNN-static	81.0	45.5	86.8	93.0	92.8	84.7	**89.6**
CNN-non-static	**81.5**	48.0	87.2	93.4	93.6	84.3	89.5
CNN-multichannel	81.1	47.4	**88.1**	93.2	92.2	**85.0**	89.4
RAE (Socher et al., 2011)	77.7	43.2	82.4	–	–	–	86.4
MV-RNN (Socher et al., 2012)	79.0	44.4	82.9	–	–	–	–
RNTN (Socher et al., 2013)	–	45.7	85.4	–	–	–	–
DCNN (Kalchbrenner et al., 2014)	–	48.5	86.8	–	93.0	–	–
Paragraph-Vec (Le and Mikolov, 2014)	–	**48.7**	87.8	–	–	–	–
CCAE (Hermann and Blunsom, 2013)	77.8	–	–	–	–	–	87.2
Sent-Parser (Dong et al., 2014)	79.5	–	–	–	–	–	86.3
NBSVM (Wang and Manning, 2012)	79.4	–	–	93.2	–	81.8	86.3
MNB (Wang and Manning, 2012)	79.0	–	–	**93.6**	–	80.0	86.3
G-Dropout (Wang and Manning, 2013)	79.0	–	–	93.4	–	82.1	86.1
F-Dropout (Wang and Manning, 2013)	79.1	–	–	**93.6**	–	81.9	86.3
Tree-CRF (Nakagawa et al., 2010)	77.3	–	–	–	–	81.4	86.1
CRF-PR (Yang and Cardie, 2014)	–	–	–	–	–	82.7	–
SVM_S (Silva et al., 2011)	–	–	–	–	**95.0**	–	–

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