Day 1: Introduction to Machine Learning

Summer STEM: Machine Learning

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Brooklyn, New York

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Learning Objectives

- What is Machine Learning?
- What is Regression?
- What is Classification?
- Why is Machine Learning gaining so much importance?
- Where do I import data in Python; how is it represented?
- How do we use vectors and matrices?
- How do we use Python to manipulate and visualize data?
- How do we plot functions; how do computers understand continuous data?

Outline

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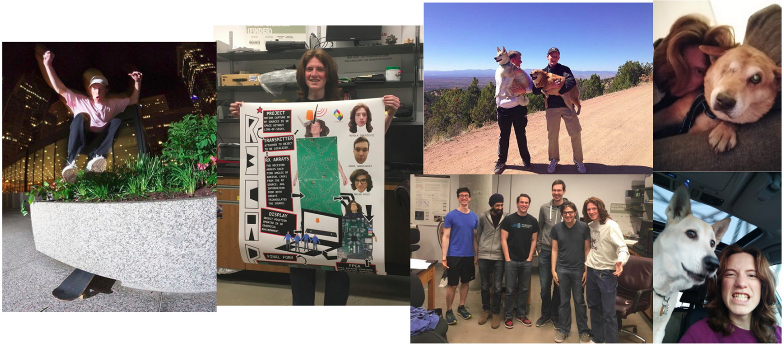
Nikola



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Akshaj

Aishwarya

Jacky

Tell the class about yourself

- Write down the following pieces of information on your notecard:
  - Name
  - Grade
  - Where are you from?
  - What do you want to get out of this class?
  - What time did you wake up this morning?
  - Where did you travel from?
  - What mode of transport did you take?
  - How long did it take you? (use Google Maps if unsure)
  - One rule you'd like to propose for the classroom
- Stand in front of the class and present what you've written down
- We'll visualize this data in python later today
  - Link to excel sheet here

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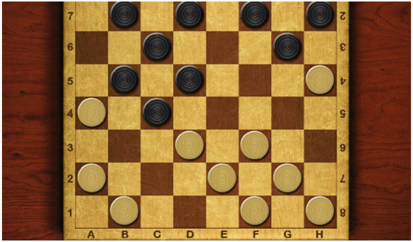
- Machine Learning is an important component to achieve the big AI dream
- Practice is the key to learn machine learning

Definition

- Machine Learning is a field of study that gives computers the ability to learn without being explicitly programmed.



Example: Digit Recognition

- Challenges with expert approach
  - Simple expert rule breaks down in practice
  - Difficult to translate our knowledge into code
- Machine Learning approach
  - Learned systems do very well on image recognition problems

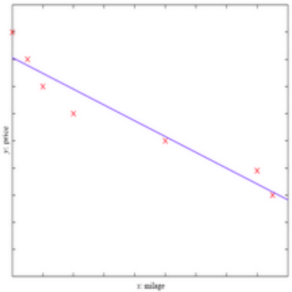
```
def classify(image):
    ...
    nv = count_vert_lines(image)
    nh = count_horiz_lines(image)
    ...

    if (nv == 1) and (nh == 1):
        digit = 7
    ...

    return digit
```

Types of Machine Learning Problems?

- There are many types of machine learning problems
  - Supervised Learning
  - Unsupervised learning
  - Reinforcement learning etc.
- In this class, we will go through two important classes of supervised learning
  - Regression
  - Classification

What is Regression?

- Target variable is continuous-valued
- Example
  - Predict y = price of a car
  - From x = mileage, size, horsepower
  - Can use multiple predictors
- Assume some form of mapping
  - Ex: Linear mapping: $y = \beta_0 + \beta_1 x$
  - Find parameter β_0, β_1 from data
- Use target-feature pairings as examples to form model



What is Classification?

- Determine what class a target belongs to based on its features
- Example:
  - Predict y = what type of object is in a photo
  - From x = the pixels of the image
- Learn a model/function from features to target
- Use target-feature pairings as examples to form model

Areas Machine Learning is being applied to

- Semantic Segmentation, Image Classification, Object Detection, Image Generation
- Machine Translation
- Speech Recognition and Synthesis
- Robotics Control Systems
- Stock Market Forecasting
- And many more ...

State of Art Examples

- Learning To See in the Dark (2018)
- Latest Deep Fakes Model (2019)
- Robots Learning to Toss (2019)
- Ted Talk on Machine Learning (2014)
  - Slightly outdated
- You'll learn the fundamental concepts behind these projects

Outline

Course Outline

- Day 1: Intro to ML
- Day 2: Linear Regression
- Day 3: Generalization Error
- Day 4: Linear Classification
- Day 5: Mini-Project Competition & Presentations
- Day 6: Neural Networks
- Day 7: Deep Learning & Convolutional Neural Networks
- Day 8: Applications of CNNs
- Day 9: Final Projects
- Day 10: Final Projects & Presentations

Course Format, Website, Resources

- Course Website: github.com/nikopj/SummerML
  - Contains lecture slides, code notebooks, and datasets
  - Slides posted after lecture, student code notebooks and datasets the morning of
- We're programming in Python via Google Colab
  - No installation required
- We'll give additional resources at the end of each day based on student interest

Github & Colab

- Github is an online service for sharing code repositories and collaborating on projects
- Google Colab runs Python code on a server or your local machine
  - Works just like Jupyter Notebook
  - Write separate code blocks and markdown blocks

Outline

Looking at our "ice-breaker" data in spreadsheets

- Columns have labels in the first row
- Collected data (numbers, words) follow below
- Let's export it to a Comma-Separated Values (CSV) file and open it
- Demo on Github.

Ice-Breaker Data Gathering

Name	Prefered Name	Grade	Country	Wake Up Time	Travel Time (mins)	Mode of transportation
Nikola	Nikola	17	Hong Kong	8.5	20	Train
Student's T	Distribution	25	England	1937	50	Concord
Akshaj	Akshaj	19	India	6:30	25	Train

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  - What do we mean by **dimension**?

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  - Ex: $aB = \begin{bmatrix} 0 & 8a \\ 7a & 11a \end{bmatrix}$, where a is a scalar

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  - σ_x^2 is the average of the *deviations from the mean weighted by the size of the deviation*

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- What is the average GPA of our students?
  - **mean**: $\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i = 3.80$
- How are the student GPA's spread around the average?
  - **variance**: $\sigma_x^2 = \frac{1}{N}\sum_{i=1}^{N}(\bar{x} - x_i)^2 = 0.02$
  - σ_x^2 is the average of the *deviations from the mean weighted by the size of the deviation*
  - **standard deviation**: σ_x

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Mean and Variance

- Two fundamental ideas we'll use throughout this class
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  - **standard deviation**: σ_x
- Demo on Github.

Outline

Lab: Plotting Functions

- Generate and plot the following functions in Python:

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  - Sine-wave, Polynomial, Bell-Curve

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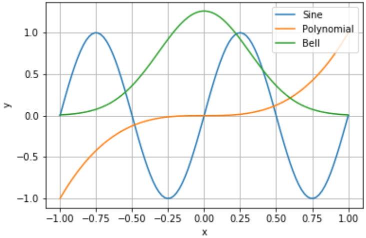
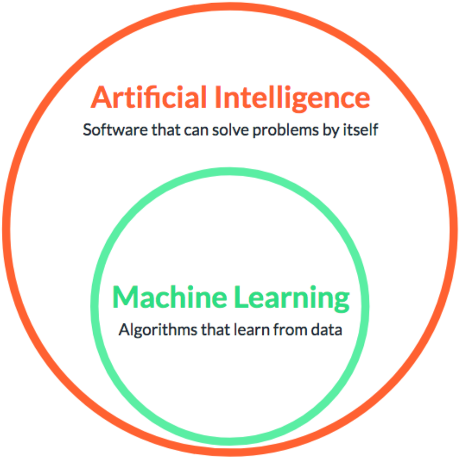


Outline

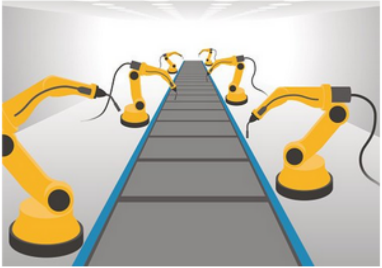
Artificial Intelligence

- Search
- Reasoning and Problem Solving
- Knowledge Representation
- Planning
- Learning
- Perception
- Natural Language Processing
- Motion and Manipulation
- Social and General Intelligence

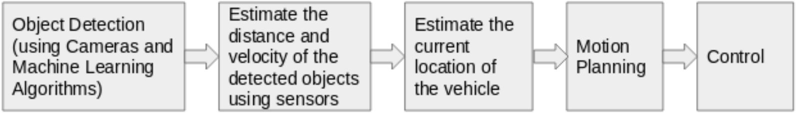
Machine Learning



Autonomous vs. Automated



Autonomous Example: Driver-less Cars



Outline

Why is Machine Learning so Prevalent?

- Database mining
- Medical records
- Computational biology
- Engineering
- Recommendation systems
- Understanding the human brain

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Why Now?

- Big Data
  - Massive storage. Large data centers
  - Massive connectivity
  - Sources of data from internet and elsewhere
- Computational advances
  - Distributed machines, clusters
  - GPUs and hardware

Learning Objectives

- What is Machine Learning?
- What is Regression?
- What is Classification?
- Why is Machine Learning gaining so much importance?
- Where do I import data in Python; how is it represented?
- How do we use vectors and matrices?
- How do we use Python to manipulate and visualize data?
- How do we plot functions; how do computers understand continuous data?

Thank You!

- Next Class: Linear Regression
- The real machine learning will begin!