

Day 1: Introduction to Machine Learning

Summer STEM: Machine Learning

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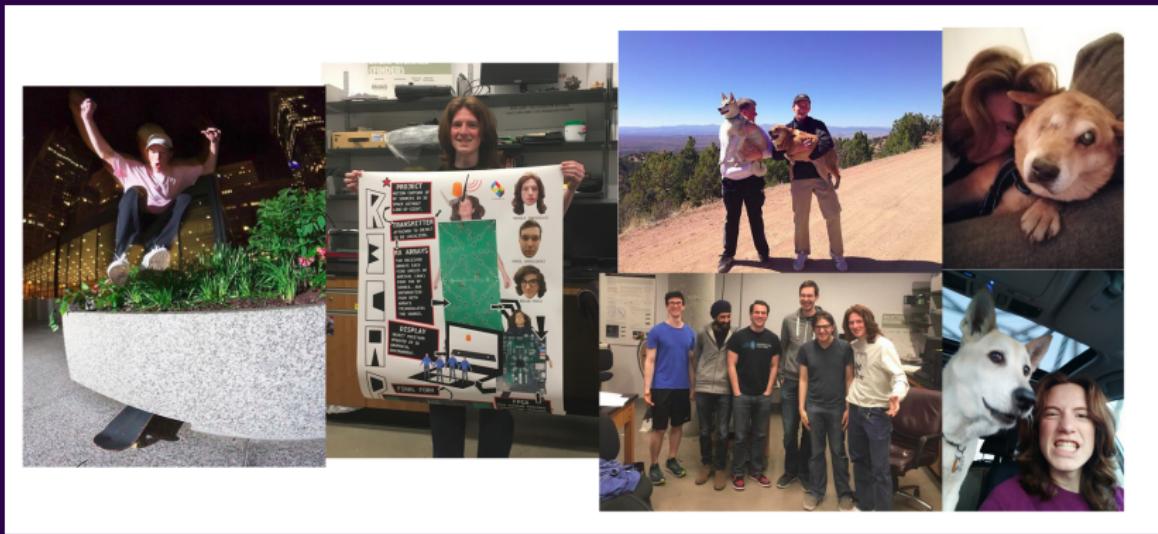
Learning Objectives

- 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

- 1 Teacher and Student Introductions
- 2 What is Machine Learning?
- 3 Course Outline
- 4 Dealing with Data
- 5 Vectors and Matrices
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- 7 Lab: Plotting Functions
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- 9 Why the Hype?

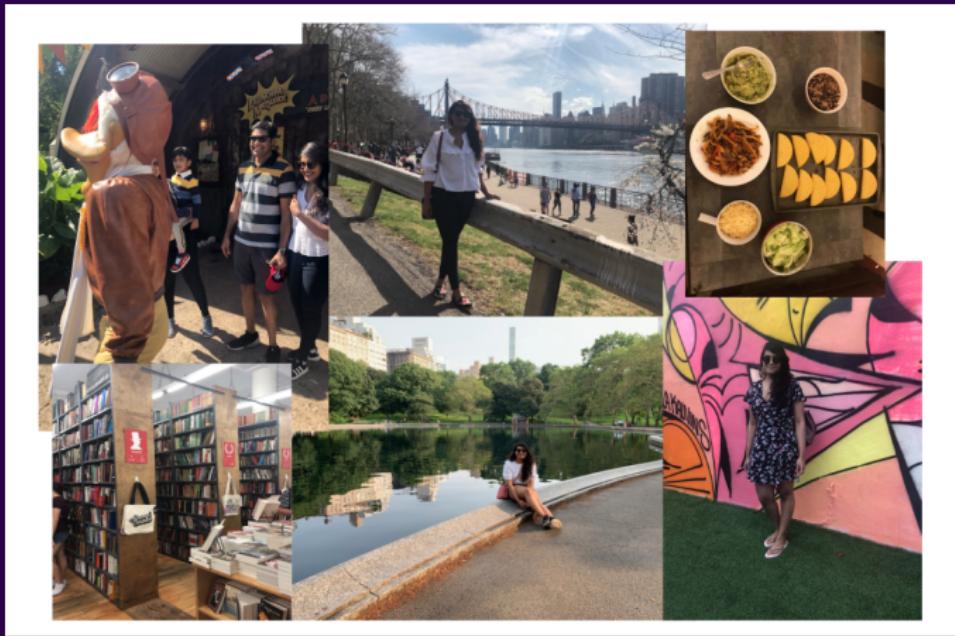
Nikola



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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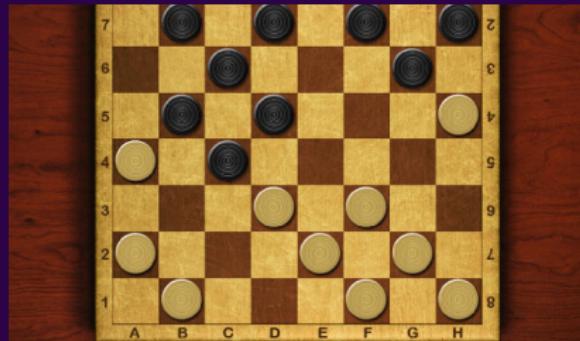
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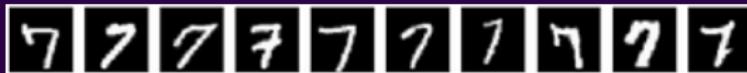
- Most recent exciting technology
- We use these algorithms dozens of times a day
 - Web search engine
 - Face detection
- Machine Learning is an important component to achieve the big AI dream
- Practice is the key to learn machine learning

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
    ...

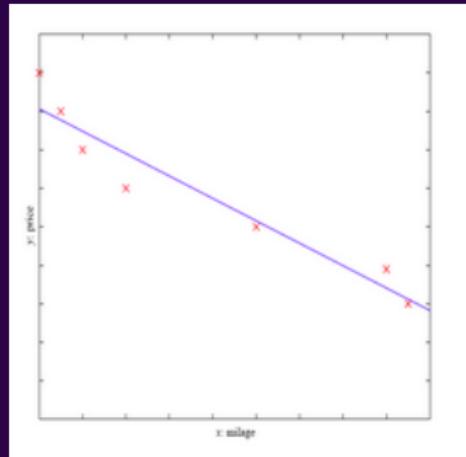
    return digit
```

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

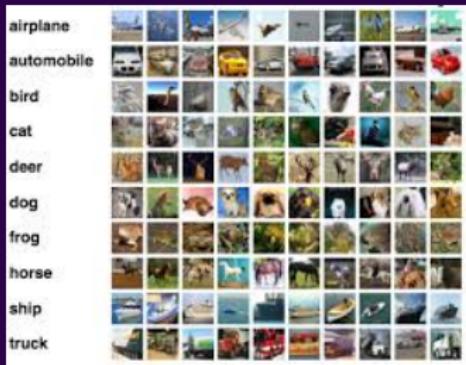
What is Regression?

- Target variable is continuous-valued
- Example
 - Predict $y = \text{price}$ of a car
 - From $x = \text{mileage, size, horsepower}$
 - 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

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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

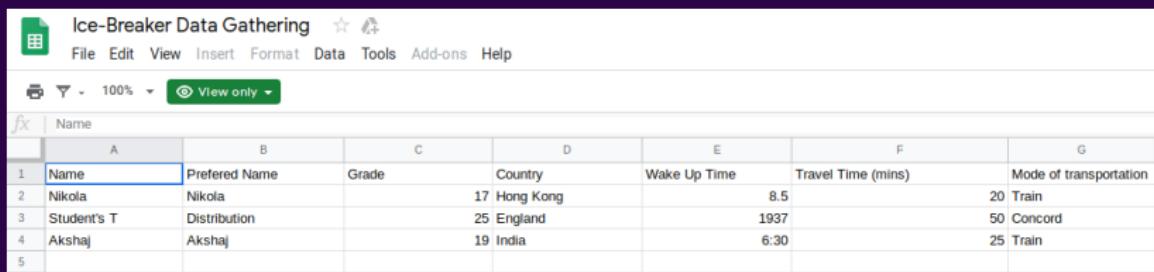
- Github is an online service for sharing code repositories and collaborating on projects
- Google Colab runs Python code on a server or your local machine
 - Works just like Jupyter Notebook
 - Write separate code blocks and markdown blocks

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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.



The screenshot shows a Google Sheets document with the title "Ice-Breaker Data Gathering". The table has the following data:

| | Name | Preferred Name | Grade | Country | Wake Up Time | Travel Time (mins) | Mode of transportation |
|---|-------------|----------------|-------|--------------|--------------|--------------------|------------------------|
| 1 | Nikola | Nikola | | 17 Hong Kong | | 8.5 | 20 Train |
| 2 | Student's T | Distribution | | 25 England | | 1937 | 50 Concord |
| 3 | Akshaj | Akshaj | | 19 India | | 6:30 | 25 Train |
| 4 | | | | | | | |
| 5 | | | | | | | |

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

Matrices

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- Ex: $A = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix}, B = \begin{bmatrix} 0 & 8 \\ 7 & 11 \end{bmatrix}, A + B = \begin{bmatrix} 1 & 9 \\ 9 & 12 \end{bmatrix}$

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

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 - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$

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 - **mean:** $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$

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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?

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 - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?
 - **mean:** $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$
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Outline

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- 2 What is Machine Learning?
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- 4 Dealing with Data
- 5 Vectors and Matrices
- 6 Mean and Variance
- 7 Lab: Plotting Functions
- 8 Artificial Intelligence and Machine Learning
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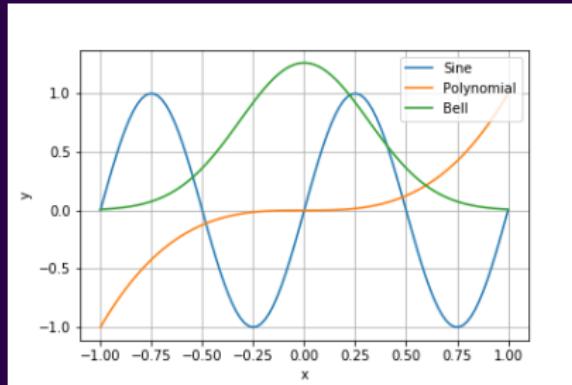
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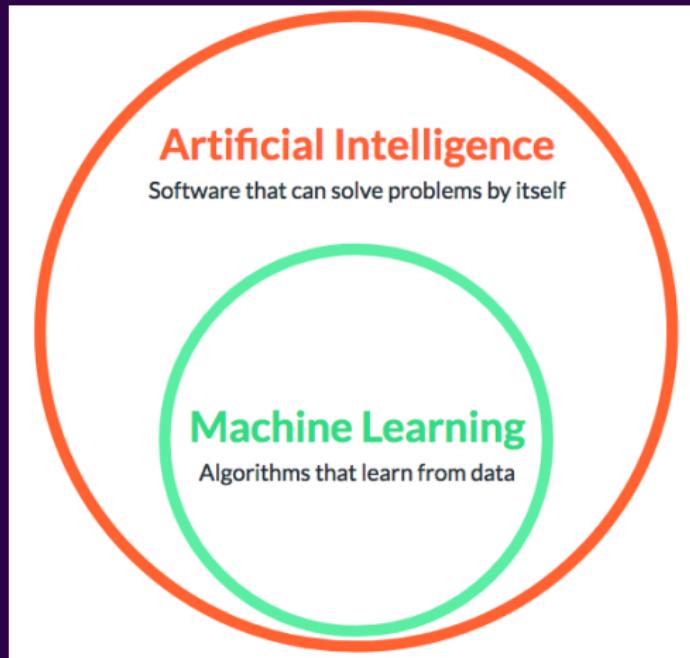
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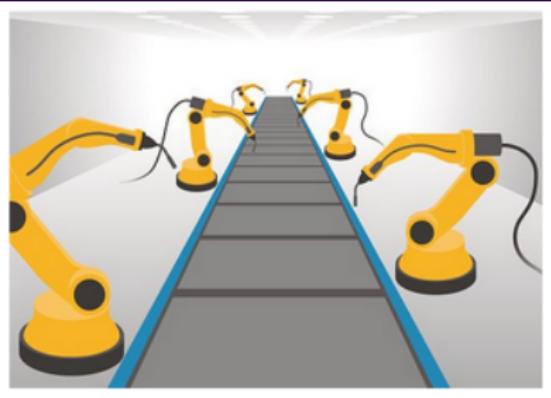
Artificial Intelligence

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

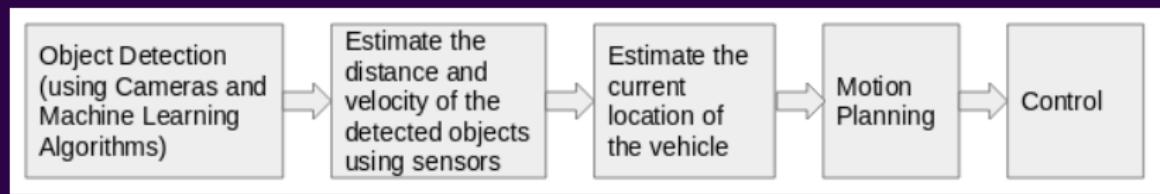
Machine Learning



Autonomous vs. Automated



Autonomous Example: Driver-less Cars



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Why is Machine Learning so Prevalent?

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

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!