

# Day 1: Introduction to Machine Learning

## Summer STEM: Machine Learning

Nikola Janjušević, Akshaj Kumar Veldanda, Jacky Yuan,  
Tejaishwarya Gagadam

NYU Tandon School of Engineering

June 15, 2019

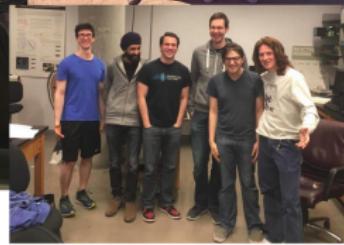
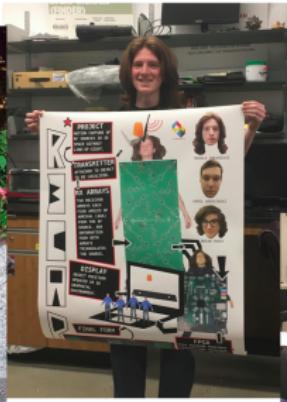
# Learning Objectives

- 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
- 6 Mean and Variance
- 7 Lab: Plotting Functions
- 8 Artificial Intelligence and Machine Learning
- 9 Why the Hype?

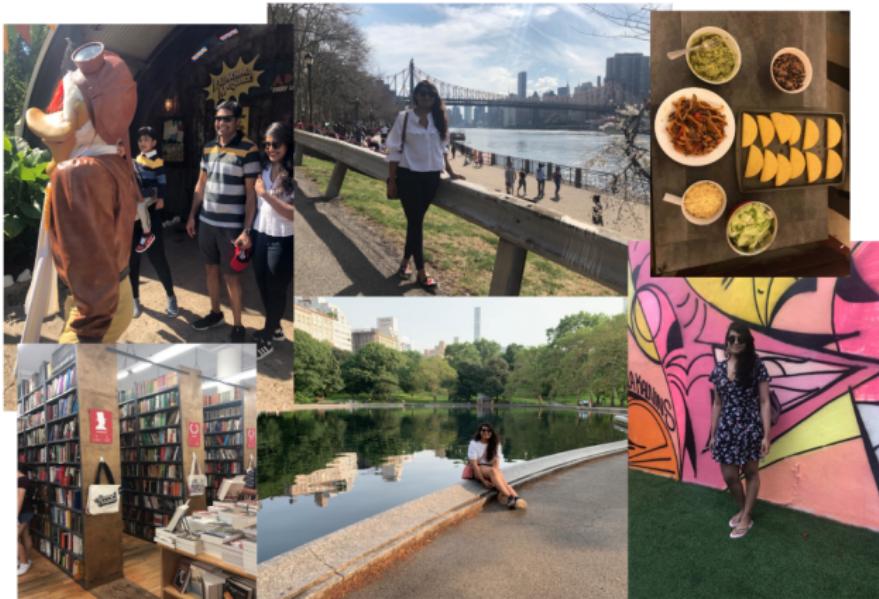
# Nikola



# Akshaj



# Aishwarya



# Jacky



# Tell the class about yourself

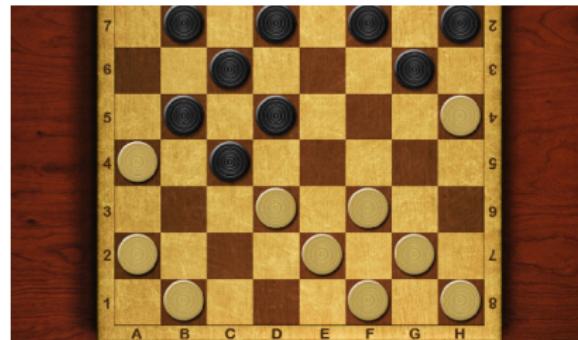
- Write down the following pieces of information on your notecard:
  - Name
  - Grade
  - Where are you from?
  - What do you want to get out of this class?
  - What time did you wake up this morning?
  - Where did you travel from?
  - What mode of transport did you take?
  - How long did it take you? (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

# Outline

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

# Definition

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



# Another 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
  - This is what you will learn in this course

```
def classify(image):  
    ...  
    nv = count_vert_lines(image)  
    nh = count_horiz_lines(image)  
    ...  
  
    if (nv == 1) and (nh == 1):  
        digit = 7  
    ...  
  
    return digit
```

# Modern Definition

Tom Mitchell provides a more modern definition: “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.”

Example: playing checkers.

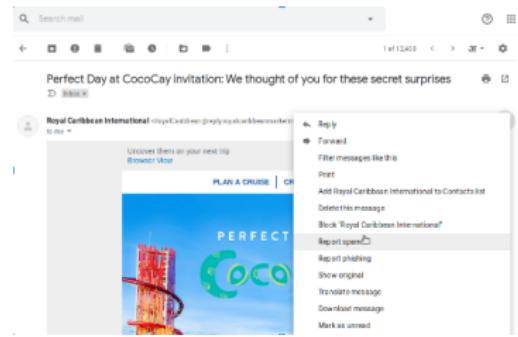
- E = the experience of playing many games of checkers
- T = the task of playing checkers.
- P = the probability that the program will win the next game.

# Question

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam.

What is the task, experience and performance in this setting?

- a) Classifying emails as spam or not spam
- b) Watching you label emails spam or not spam
- c) The number of emails correctly classified as spam or not spam

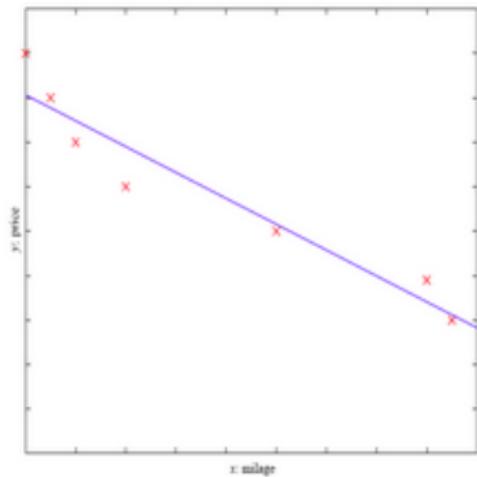


# Types of Machine Learning Problems?

- 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  $\beta_0, \beta_1$  from data



## What is Classification?

- Object classification from images
  - Determine what objects are in an image
  - Features
    - Pixels of the image
  - Target
    - Classification label
  - Learn a model / function from features to target
    - Use examples of labeled images



# Outline

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

# 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](https://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

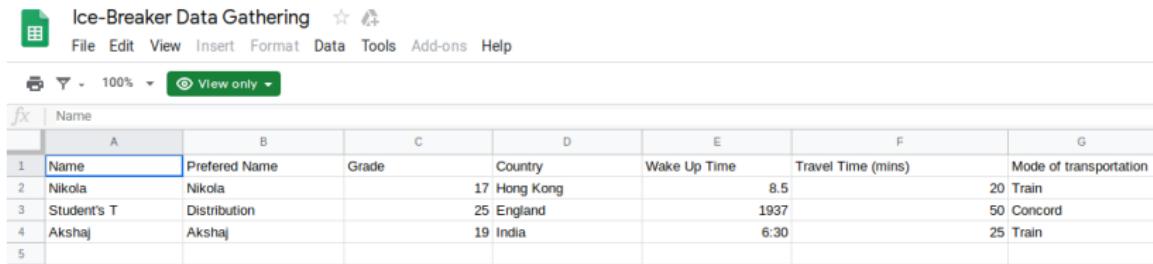
- Github is an online service for sharing code repositories and collaborating on projects
- Google Colab runs Python code on a server or your local machine
  - Works just like Jupyter Notebook
  - Write separate code blocks and markdown blocks

# Outline

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

# 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 menu bar includes File, Edit, View, Insert, Format, Data, Tools, Add-ons, and Help. The toolbar includes print, zoom (100%), and view only mode. The spreadsheet contains a table with columns labeled A through G. The data rows are as follows:

	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							

# Outline

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

# Vectors

- A **vector** is an n-tuple of numbers or symbols

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$   
 $\mathbf{v} + \mathbf{u} = (1 + 3, 5 + 6, 2 + 0, 9 + (-5)) = (4, 11, 2, 4)$

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$   
 $\mathbf{v} + \mathbf{u} = (1 + 3, 5 + 6, 2 + 0, 9 + (-5)) = (4, 11, 2, 4)$
- Vectors may be scaled by a number, element-wise

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$   
 $\mathbf{v} + \mathbf{u} = (1 + 3, 5 + 6, 2 + 0, 9 + (-5)) = (4, 11, 2, 4)$
- Vectors may be scaled by a number, element-wise
  - Ex:  $3\mathbf{v} = (3 \times 1, 3 \times 5, 3 \times 2, 3 \times 9) = (3, 15, 6, 27)$

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$   
 $\mathbf{v} + \mathbf{u} = (1 + 3, 5 + 6, 2 + 0, 9 + (-5)) = (4, 11, 2, 4)$
- Vectors may be scaled by a number, element-wise
  - Ex:  $3\mathbf{v} = (3 \times 1, 3 \times 5, 3 \times 2, 3 \times 9) = (3, 15, 6, 27)$
- **Dot-Product:** sum of element-wise products of two vectors

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$   
 $\mathbf{v} + \mathbf{u} = (1 + 3, 5 + 6, 2 + 0, 9 + (-5)) = (4, 11, 2, 4)$
- Vectors may be scaled by a number, element-wise
  - Ex:  $3\mathbf{v} = (3 \times 1, 3 \times 5, 3 \times 2, 3 \times 9) = (3, 15, 6, 27)$
- **Dot-Product:** sum of element-wise products of two vectors
  - Ex:  
$$\mathbf{u} \cdot \mathbf{v} = 3 \times 1 + 6 \times 5 + 0 \times 2 + (-5) \times 9 = 3 + 30 - 45 = -12$$

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$   
 $\mathbf{v} + \mathbf{u} = (1 + 3, 5 + 6, 2 + 0, 9 + (-5)) = (4, 11, 2, 4)$
- Vectors may be scaled by a number, element-wise
  - Ex:  $3\mathbf{v} = (3 \times 1, 3 \times 5, 3 \times 2, 3 \times 9) = (3, 15, 6, 27)$
- **Dot-Product:** sum of element-wise products of two vectors
  - Ex:  
$$\mathbf{u} \cdot \mathbf{v} = 3 \times 1 + 6 \times 5 + 0 \times 2 + (-5) \times 9 = 3 + 30 - 45 = -12$$
- Length of a Vector <sub>(L2 Norm)</sub>:  $\|\mathbf{x}\| = \sqrt{\mathbf{x} \cdot \mathbf{x}}$

# Vectors

- A **vector** is an n-tuple of numbers or symbols
  - Ex: integer 4-tuple:  $\mathbf{v} = (1, 5, 2, 9)$
- Vectors of the same size may be added together, element-wise
  - Ex:  $\mathbf{u} = (3, 6, 0, -5)$   
 $\mathbf{v} + \mathbf{u} = (1 + 3, 5 + 6, 2 + 0, 9 + (-5)) = (4, 11, 2, 4)$
- Vectors may be scaled by a number, element-wise
  - Ex:  $3\mathbf{v} = (3 \times 1, 3 \times 5, 3 \times 2, 3 \times 9) = (3, 15, 6, 27)$
- **Dot-Product:** sum of element-wise products of two vectors
  - Ex:  
$$\mathbf{u} \cdot \mathbf{v} = 3 \times 1 + 6 \times 5 + 0 \times 2 + (-5) \times 9 = 3 + 30 - 45 = -12$$
- Length of a Vector (L<sub>2</sub> Norm):  $||\mathbf{x}|| = \sqrt{\mathbf{x} \cdot \mathbf{x}}$ 
  - Ex:  $|\mathbf{v}| = \sqrt{1 + 25 + 4 + 81} = \sqrt{111}$

# Matrices

- A **matrix** is a rectangular array of numbers or symbols arranged in rows and columns

# Matrices

- A **matrix** is a rectangular array of numbers or symbols arranged in rows and columns
  - Ex: 2 by 3 matrix,  $M = \begin{bmatrix} 1 & 9 & -12 \\ 15 & -2 & 0 \end{bmatrix}$

# Matrices

- A **matrix** is a rectangular array of numbers or symbols arranged in rows and columns
  - Ex: 2 by 3 matrix,  $M = \begin{bmatrix} 1 & 9 & -12 \\ 15 & -2 & 0 \end{bmatrix}$
- Matrices of the same shape may be added together, element-wise

# Matrices

- A **matrix** is a rectangular array of numbers or symbols arranged in rows and columns

- Ex: 2 by 3 matrix,  $M = \begin{bmatrix} 1 & 9 & -12 \\ 15 & -2 & 0 \end{bmatrix}$

- Matrices of the same shape may be added together, element-wise

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

# Matrices

- A **matrix** is a rectangular array of numbers or symbols arranged in rows and columns
  - Ex: 2 by 3 matrix,  $M = \begin{bmatrix} 1 & 9 & -12 \\ 15 & -2 & 0 \end{bmatrix}$
- Matrices of the same shape may be added together, element-wise
  - Ex:  $A = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix}, B = \begin{bmatrix} 0 & 8 \\ 7 & 11 \end{bmatrix}, A + B = \begin{bmatrix} 1 & 9 \\ 9 & 12 \end{bmatrix}$
- Matrices may be scaled, element-wise

# Matrices

- A **matrix** is a rectangular array of numbers or symbols arranged in rows and columns
  - Ex: 2 by 3 matrix,  $M = \begin{bmatrix} 1 & 9 & -12 \\ 15 & -2 & 0 \end{bmatrix}$
- Matrices of the same shape may be added together, element-wise
  - Ex:  $A = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix}, B = \begin{bmatrix} 0 & 8 \\ 7 & 11 \end{bmatrix}, A + B = \begin{bmatrix} 1 & 9 \\ 9 & 12 \end{bmatrix}$
- Matrices may be scaled, element-wise
  - Ex:  $aB = \begin{bmatrix} 0 & 8a \\ 7a & 11a \end{bmatrix}$ , where  $a$  is a scalar

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria
  - Criteria: for  $AB$  to be valid, # cols of  $A$  must equal the # rows of  $B$

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria
  - Criteria: for  $AB$  to be valid, # cols of  $A$  must equal the # rows of  $B$
  - Result is a matrix with shape (# rows A, # cols B)

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria
  - Criteria: for  $AB$  to be valid, # cols of  $A$  must equal the # rows of  $B$
  - Result is a matrix with shape (# rows A, # cols B)
  - Ex:  $A$  is  $(2 \times 3)$  and  $B$  is  $(3 \times 5)$ ,  $C = AB$  is  $(2 \times 5)$

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria
  - Criteria: for  $AB$  to be valid, # cols of  $A$  must equal the # rows of  $B$
  - Result is a matrix with shape (# rows A, # cols B)
  - Ex:  $A$  is  $(2 \times 3)$  and  $B$  is  $(3 \times 5)$ ,  $C = AB$  is  $(2 \times 5)$
  - Example on board

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria
  - Criteria: for  $AB$  to be valid, # cols of  $A$  must equal the # rows of  $B$
  - Result is a matrix with shape (# rows A, # cols B)
  - Ex:  $A$  is  $(2 \times 3)$  and  $B$  is  $(3 \times 5)$ ,  $C = AB$  is  $(2 \times 5)$
  - Example on board
- **Transpose:**  $A^T$  swaps the rows and columns of matrix  $A$

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria
  - Criteria: for  $AB$  to be valid, # cols of  $A$  must equal the # rows of  $B$
  - Result is a matrix with shape (# rows A, # cols B)
  - Ex:  $A$  is  $(2 \times 3)$  and  $B$  is  $(3 \times 5)$ ,  $C = AB$  is  $(2 \times 5)$
  - Example on board
- **Transpose:**  $A^T$  swaps the rows and columns of matrix  $A$
- **Inverse:**  $A^{-1}$  satisfies the equation  $AA^{-1} = A^{-1}A = \mathbb{I}$

# More About Matrices

- Matrices may be multiplied together provided their shapes meet the criteria
  - Criteria: for  $AB$  to be valid, # cols of  $A$  must equal the # rows of  $B$
  - Result is a matrix with shape (# rows A, # cols B)
  - Ex:  $A$  is  $(2 \times 3)$  and  $B$  is  $(3 \times 5)$ ,  $C = AB$  is  $(2 \times 5)$
  - Example on board
- **Transpose:**  $A^T$  swaps the rows and columns of matrix  $A$
- **Inverse:**  $A^{-1}$  satisfies the equation  $AA^{-1} = A^{-1}A = \mathbb{I}$ 
  - Square matrices only!

# Vectors and Matrices

- We may consider a vector as a matrix

# Vectors and Matrices

- We may consider a vector as a matrix
  - **Row Vector:** shape  $(1 \times N)$

# Vectors and Matrices

- We may consider a vector as a matrix
  - **Row Vector:** shape  $(1 \times N)$   
Ex:  $\mathbf{v} = [1 \ 5 \ 2 \ 9]$

# Vectors and Matrices

- We may consider a vector as a matrix
  - **Row Vector:** shape  $(1 \times N)$   
Ex:  $v = [1 \ 5 \ 2 \ 9]$
  - **Column Vector:** shape  $(N \times 1)$

# Vectors and Matrices

- We may consider a vector as a matrix

- **Row Vector:** shape  $(1 \times N)$

Ex:  $\mathbf{v} = [1 \ 5 \ 2 \ 9]$

- **Column Vector:** shape  $(N \times 1)$

$$\text{Ex: } \mathbf{v} = \begin{bmatrix} 1 \\ 5 \\ 2 \\ 9 \end{bmatrix} = [1 \ 5 \ 2 \ 9]^T$$

# Vectors and Matrices

- We may consider a vector as a matrix

- **Row Vector:** shape  $(1 \times N)$

Ex:  $\mathbf{v} = [1 \ 5 \ 2 \ 9]$

- **Column Vector:** shape  $(N \times 1)$

$$\text{Ex: } \mathbf{v} = \begin{bmatrix} 1 \\ 5 \\ 2 \\ 9 \end{bmatrix} = [1 \ 5 \ 2 \ 9]^T$$

- We'll consider vectors as column vectors by default

# Vectors and Matrices

- We may consider a vector as a matrix

- **Row Vector:** shape  $(1 \times N)$

Ex:  $\mathbf{v} = [1 \ 5 \ 2 \ 9]$

- **Column Vector:** shape  $(N \times 1)$

$$\text{Ex: } \mathbf{v} = \begin{bmatrix} 1 \\ 5 \\ 2 \\ 9 \end{bmatrix} = [1 \ 5 \ 2 \ 9]^T$$

- We'll consider vectors as column vectors by default

- Vector-Matrix Multiplication: on board

# Vectors and Matrices

- We may consider a vector as a matrix

- **Row Vector:** shape  $(1 \times N)$

Ex:  $\mathbf{v} = [1 \ 5 \ 2 \ 9]$

- **Column Vector:** shape  $(N \times 1)$

$$\text{Ex: } \mathbf{v} = \begin{bmatrix} 1 \\ 5 \\ 2 \\ 9 \end{bmatrix} = [1 \ 5 \ 2 \ 9]^T$$

- We'll consider vectors as column vectors by default

- Vector-Matrix Multiplication: on board

- Dot Product:

# Vectors and Matrices

- We may consider a vector as a matrix

- **Row Vector:** shape  $(1 \times N)$

Ex:  $\mathbf{v} = [1 \ 5 \ 2 \ 9]$

- **Column Vector:** shape  $(N \times 1)$

$$\text{Ex: } \mathbf{v} = \begin{bmatrix} 1 \\ 5 \\ 2 \\ 9 \end{bmatrix} = [1 \ 5 \ 2 \ 9]^T$$

- We'll consider vectors as column vectors by default

- Vector-Matrix Multiplication: on board

- Dot Product:

# Vectors and Matrices

- We may consider a vector as a matrix

- **Row Vector:** shape  $(1 \times N)$

Ex:  $\mathbf{v} = [1 \ 5 \ 2 \ 9]$

- **Column Vector:** shape  $(N \times 1)$

$$\text{Ex: } \mathbf{v} = \begin{bmatrix} 1 \\ 5 \\ 2 \\ 9 \end{bmatrix} = [1 \ 5 \ 2 \ 9]^T$$

- We'll consider vectors as column vectors by default

- Vector-Matrix Multiplication: on board

- Dot Product:  $\mathbf{v}^T \mathbf{v}$

# Outline

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

# Mean and Variance

- Two fundamental ideas we'll use throughout this class

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?
  - **mean:**  $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?
  - **mean:**  $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$
- How are the student GPA's spread around the average?

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?
  - **mean:**  $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$
- How are the student GPA's spread around the average?
  - **variance:**  $\sigma_x^2 = \frac{1}{N} \sum_{i=1}^N (\bar{x} - x_i)^2 = 0.02$

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?
  - **mean:**  $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$
- How are the student GPA's spread around the average?
  - **variance:**  $\sigma_x^2 = \frac{1}{N} \sum_{i=1}^N (\bar{x} - x_i)^2 = 0.02$
  - $\sigma_x^2$  is the average of the *deviations from the mean weighted by the size of the deviation*

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?
  - **mean:**  $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$
- How are the student GPA's spread around the average?
  - **variance:**  $\sigma_x^2 = \frac{1}{N} \sum_{i=1}^N (\bar{x} - x_i)^2 = 0.02$
  - $\sigma_x^2$  is the average of the *deviations from the mean weighted by the size of the deviation*
  - **standard deviation:**  $\sigma_x$

# Mean and Variance

- Two fundamental ideas we'll use throughout this class
- Suppose we have a dataset of the GPA of 7 students
  - $\mathbf{x} = (3.6, 4.0, 3.7, 3.75, 3.9, 4.0, 3.65)$
- What is the average GPA of our students?
  - **mean:**  $\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i = 3.80$
- How are the student GPA's spread around the average?
  - **variance:**  $\sigma_x^2 = \frac{1}{N} \sum_{i=1}^N (\bar{x} - x_i)^2 = 0.02$
  - $\sigma_x^2$  is the average of the *deviations from the mean weighted by the size of the deviation*
  - **standard deviation:**  $\sigma_x$
- Demo on Github.

# Outline

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

# Lab: Plotting Functions

- Generate and plot the following functions in Python:

# Lab: Plotting Functions

- Generate and plot the following functions in Python:
  - Sine-wave, Polynomial, Bell-Curve

# Lab: Plotting Functions

- Generate and plot the following functions in Python:
  - Sine-wave, Polynomial, Bell-Curve
- Compute the mean and variance of your functions

# Lab: Plotting Functions

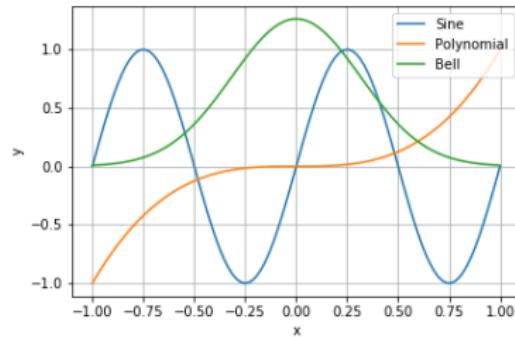
- Generate and plot the following functions in Python:
  - Sine-wave, Polynomial, Bell-Curve
- Compute the mean and variance of your functions
- Use Wikipedia and Numpy Documentation to search for mathematical formulas and python functions

# Lab: Plotting Functions

- Generate and plot the following functions in Python:
  - Sine-wave, Polynomial, Bell-Curve
- Compute the mean and variance of your functions
- Use Wikipedia and Numpy Documentation to search for mathematical formulas and python functions
- Github: Day1/Day1.ipynb, open in Colab

# Lab: Plotting Functions

- Generate and plot the following functions in Python:
  - Sine-wave, Polynomial, Bell-Curve
- Compute the mean and variance of your functions
- Use Wikipedia and Numpy Documentation to search for mathematical formulas and python functions
- Github: Day1/Day1.ipynb, open in Colab



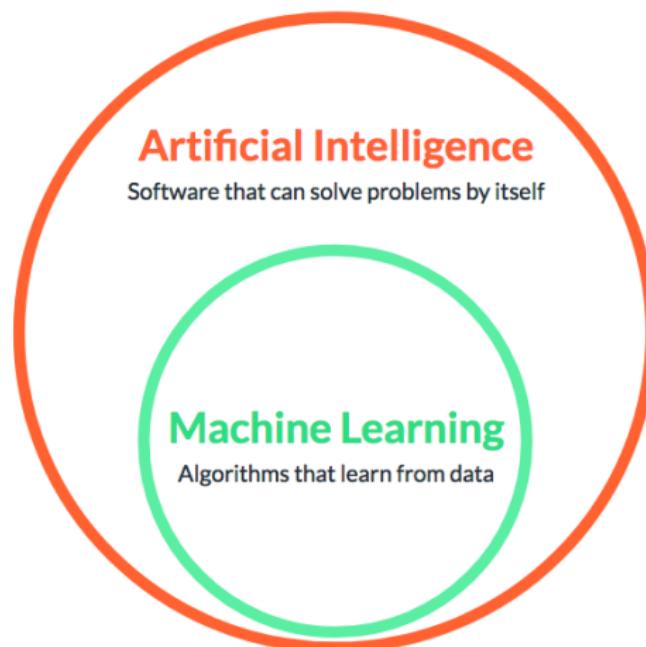
# Outline

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

# Artificial Intelligence

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

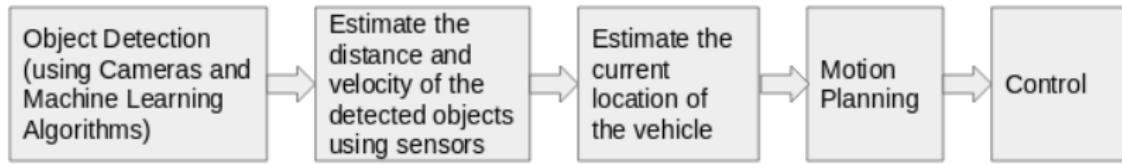
# Machine Learning



# Autonomous vs. Automated



# Autonomous Example: Driver-less Cars



# Outline

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

# 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!