COMPUTER VISION: SELF DRIVING CARS

Annie Zhou
Arsh Banerjee
Bryanna Mendez
Kishan Vyas
Nina Austria
Sakhi Shah
Widnie Pierre-Louis
William Zimmerman

Some slides & images adapted from
Julienne LaChance

What Are Autonomous Vehicles?

- Autonomous vehicles (AVs) are self-driving vehicles that do not require human intervention to safely operate.

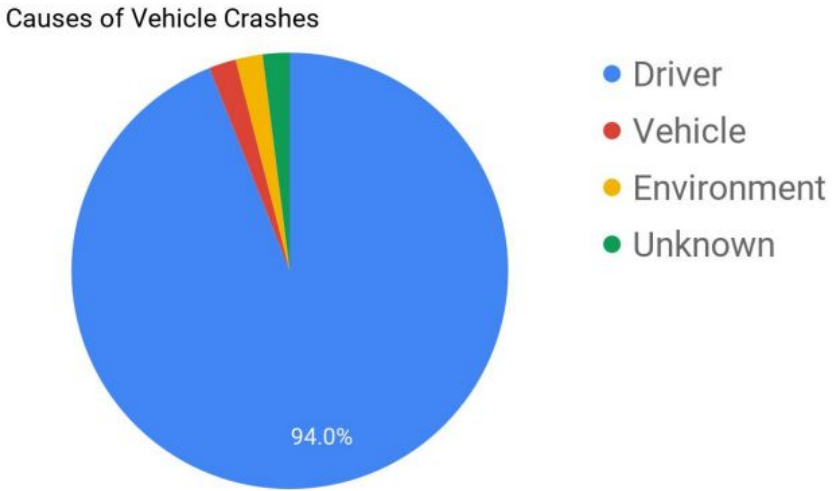
Waymo (Google)

Uber

Tesla

Benefits of Autonomous Vehicles

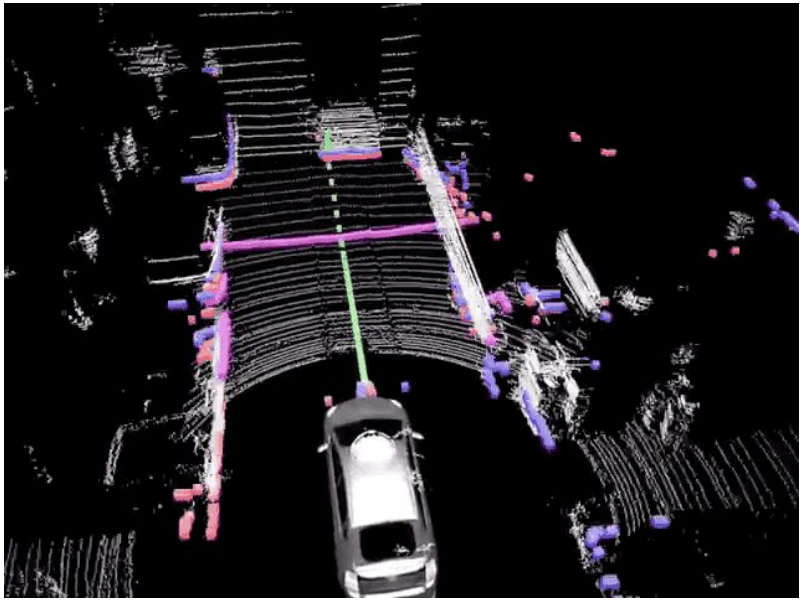
- Greater accessibility for children, the elderly, and the disabled
- Improved traffic flow
- Increased productivity during commute
- Safety
    - Deaths: About 1.3 million per year
        - About 3,287 deaths a day.
    - Injuries: Additional 20-50 million



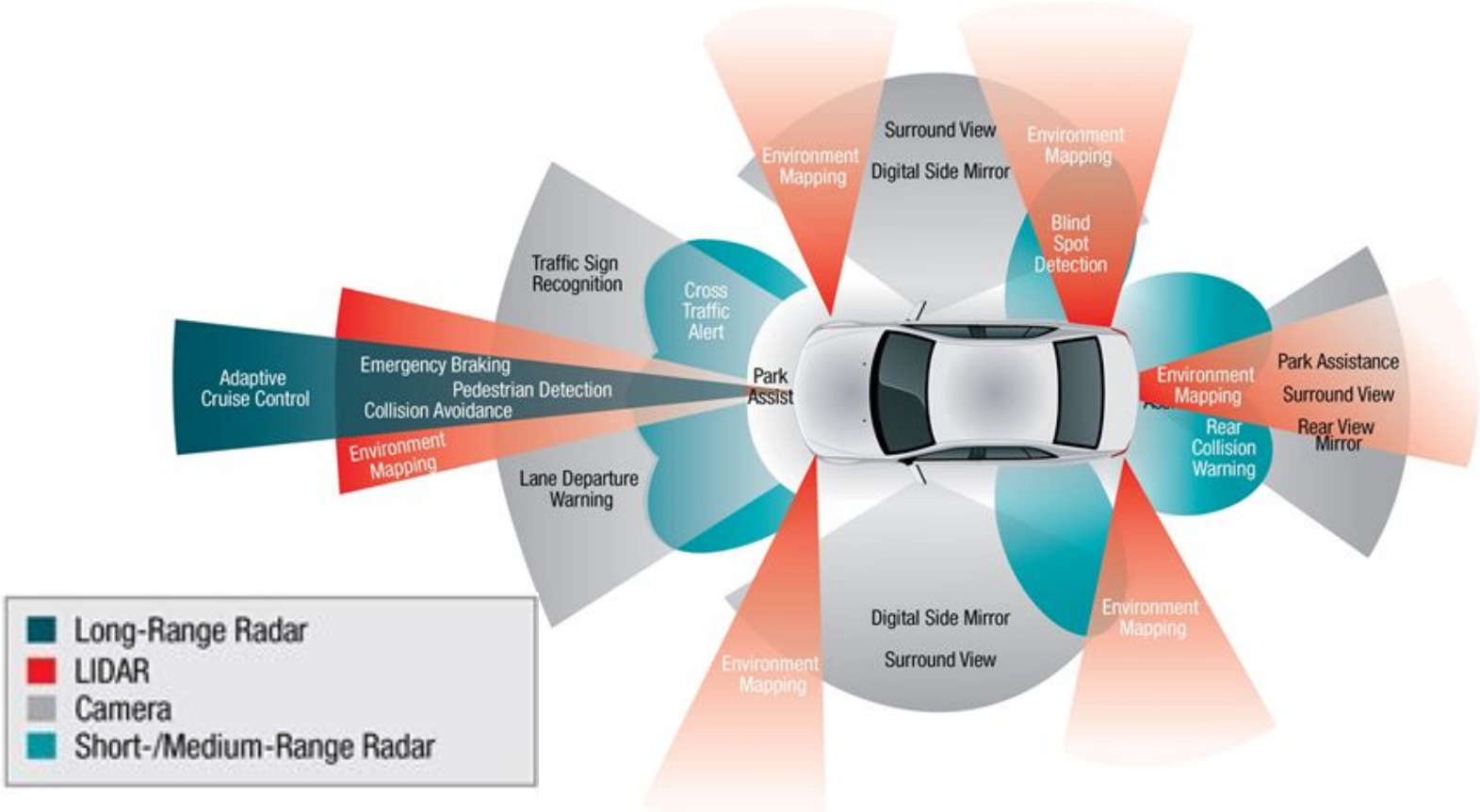
How do Autonomous Vehicles Work?

- Driverless cars use an array of sensors, cameras, radars, real-time 3D maps, and gigabytes of specialized software to “see” the road in front of it, behind it, and around every corner.

- By incorporating what the car can see into one coherent image of the road, self-driving vehicles are able to navigate the terrain



How do Autonomous Vehicles Work?



Types of Autonomous Vehicles

AUTOMATION LEVELS OF AUTONOMOUS CARS

LEVEL 0

There are no autonomous features.

LEVEL 1

These cars can handle one task at a time, like automatic braking.

LEVEL 2

These cars would have at least two automated functions.

LEVEL 3

These cars handle "dynamic driving tasks" but might still need intervention.

LEVEL 4

These cars are officially driverless in certain environments.

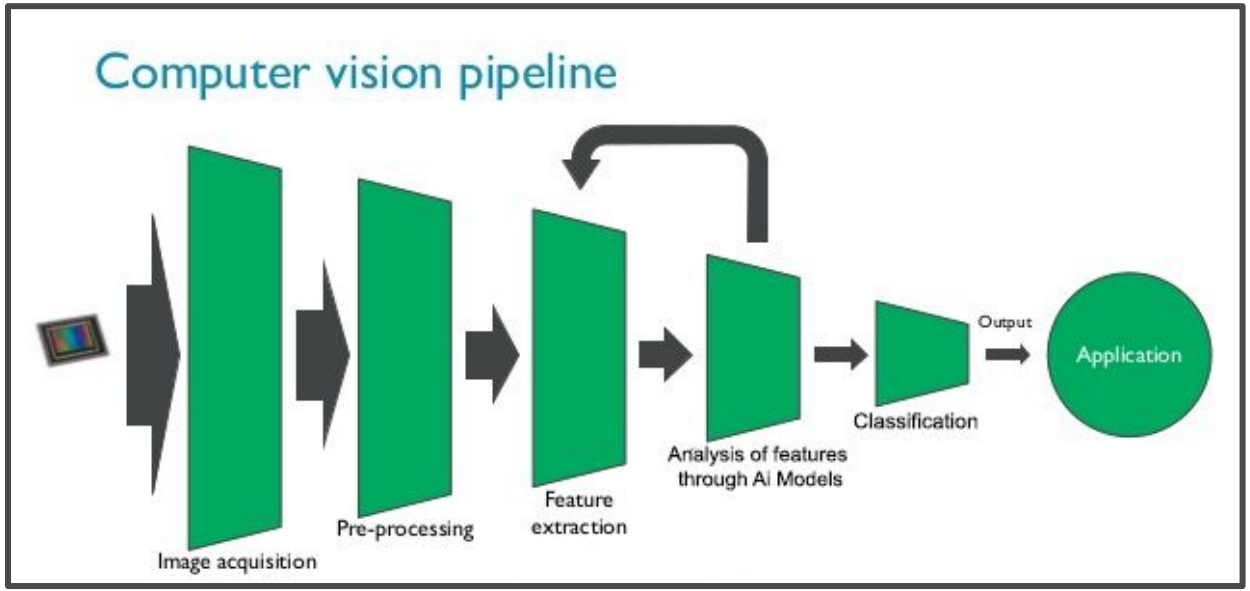
LEVEL 5

These cars can operate entirely on their own without any driver presence.

SOURCE: SAE International

BUSINESS INSIDER

Computer Vision for Self Driving Cars



- Within this project, we applied computer vision to recognize traffic signs which AVs would come accross frequently.

- This projected entailed numerous aspects, such as developing a computer vision pipeline, including exploring and visualizing data, creating a machine learning classifier to detect the type of traffic sign presented

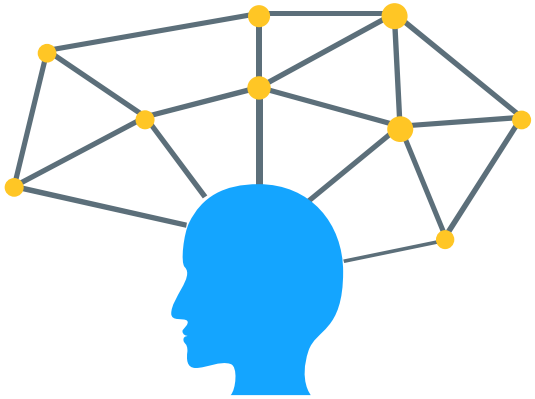


Image Processing

Image Processing in Python

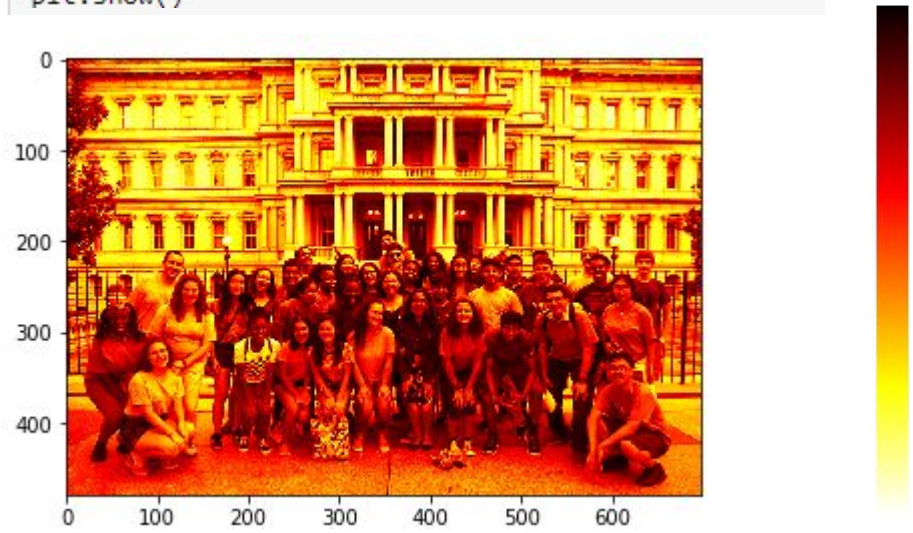
- Computers don’t look at images like we do!
- In order to display an image...

```
import numpy as np
import cv2
%matplotlib inline
img = plt.imread('aigroup2.png')
plt.imshow(img)
plt.show()
```

Changing Colors

- You can convert images to different colors.
- Converting it to grayscale compresses the image, speeding up the model's learning time.

```
hawt = cv2.cvtColor( img, cv2.COLOR_RGB2GRAY )   )
plt.imshow(hawt, cmap='hot')
plt.show()
```



Blurring

- Blurring an image reduces the amount of noise in a picture.
- Application: Lane detection

```
blur = cv2.blur(img,(9,9))
plt.imshow(blur)
plt.show()
```

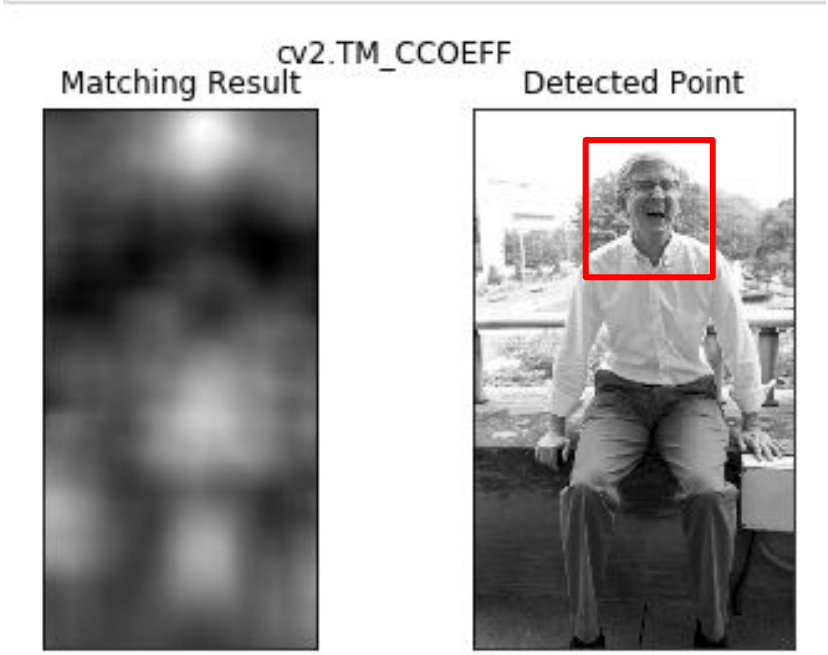
Applies a 9x9 blur filter

Template Matching

- Template matching: "method for searching and finding the location of a template image in a larger image (Open CV)”

ed

happy



Template Matching

- Can it detect someone from a sea of faces?

cv2.TM_CCOEFF

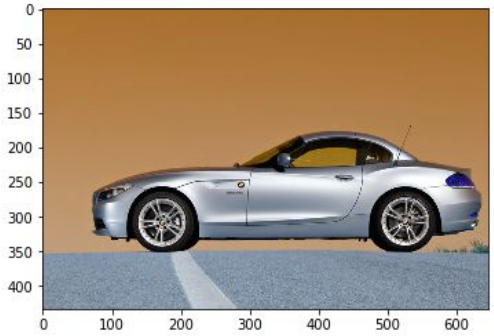
aigroup

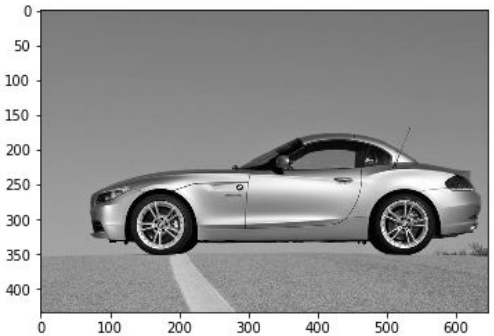
eisgruber

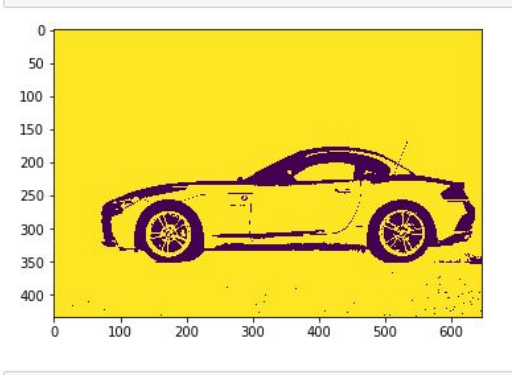
Matching Result

Detected Point

Image Processing in Python: Pre-Processing







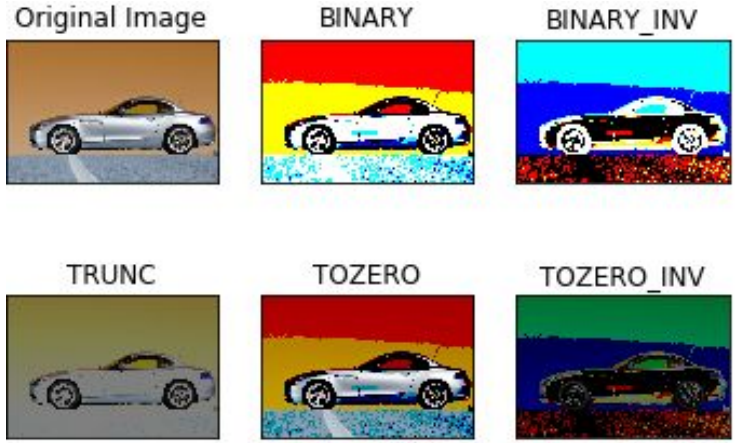

```
grey_img = cv2.cvtColor( img, cv2.COLOR_RGB2GRAY )
plt.imshow(grey_img, cmap='gray')
plt.show()
```

```
threshold_value =  110
ret,thresh1 = cv2.threshold(grey_img,threshold_value,255,cv2.THRESH_BINARY)
plt.imshow(thresh1)
plt.show()
```

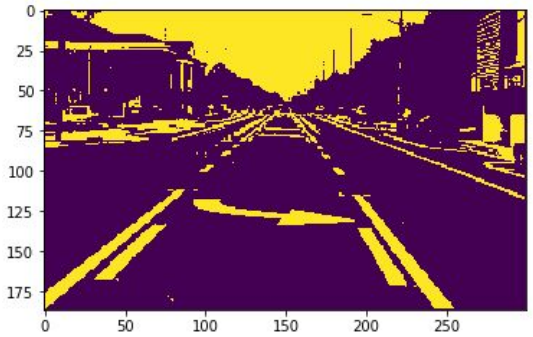
- creating a two color image out of a grayscale image and consists of setting certain pixels to one color whose value is above a given threshold, while setting the other pixels to another color

Pre-Processing: Thresholding

```
from matplotlib import pyplot as plt

ret,thresh1 = cv2.threshold(img,127,255,cv2.THRESH_BINARY)
ret,thresh2 = cv2.threshold(img,127,255,cv2.THRESH_BINARY_INV)
ret,thresh3 = cv2.threshold(img,127,255,cv2.THRESH_TRUNC)
ret,thresh4 = cv2.threshold(img,127,255,cv2.THRESH_TOZERO)
ret,thresh5 = cv2.threshold(img,127,255,cv2.THRESH_TOZERO_INV)

titles = ['Original Image','BINARY','BINARY_INV','TRUNC','TOZERO','TOZERO_INV']
images = [img, thresh1, thresh2, thresh3, thresh4, thresh5]

for i in range(6):
    plt.subplot(2,3,i+1),plt.imshow(images[i],'gray')
    plt.title(titles[i])
    plt.xticks([]),plt.yticks([])

plt.show()
```

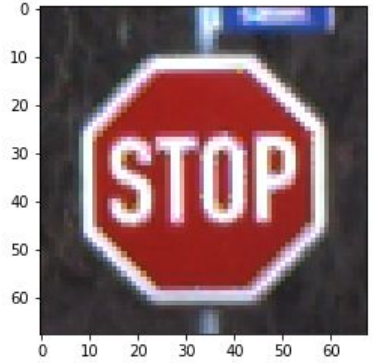


- thresholding can be used for edge detection
- can also be used for lane detection
- can be used to create binary images (easier to work with)
- can change the threshold to different values
- certain values work better for different pictures

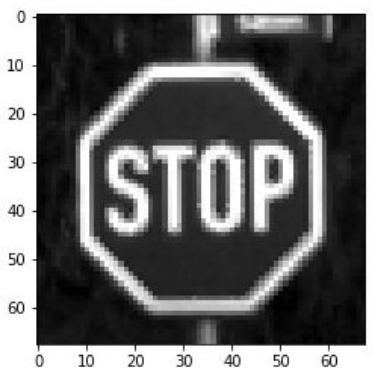


German Traffic Signs Dataset

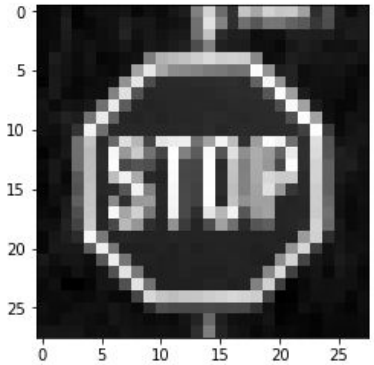
```python
def process(image):
    image_gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY )# changed each picture from colored to gray scale

    image_resize = cv2.resize(image_gray, (28,28)) #resized each picture so that they are all the same size and shape

    image_flat = image_resize.reshape(-1) # reshaped the image into one long array so they can be used by the models
    #each picture becomes one array

    return image_flat
```



Regular



Gray



Resized

```
[ 44  46  57  40  50  52  51  54  43  51
 180 217 206 209 175  76 106  60  47  58
  56  56  49  52  54 134 230 149  77 132
  59  60  45  46  60  49  46  48  52  68
  63  64  48  51  51  64  64  62  63  54
  50  57  48  58  54  60  65 102 147  65
  51  52  51  57  42  61  54  47  54  42
 222 212 215 212 154  48  50  62  59  56
```

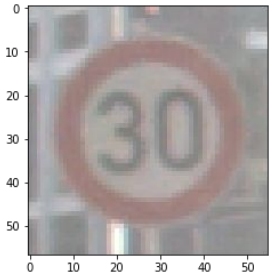
Reshaped into array

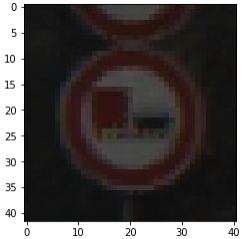
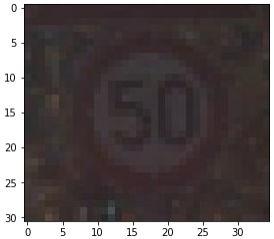
AI Models & Analysis

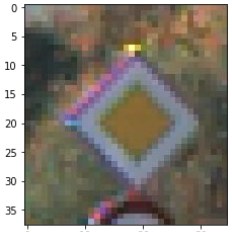
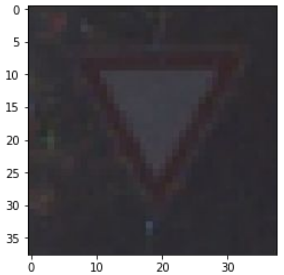
The Dataset

- Within the GTSRB Dataset, there are 42 classes of signs. However, for the purposes of testing these advanced computational models, we only utilized 6 classes. These classes were chosen based of the number of examples in each class as well as their diverse shapes and colors.

- This ensures that the model can be properly tested with sufficient examples to be trained on within a diversified test group.

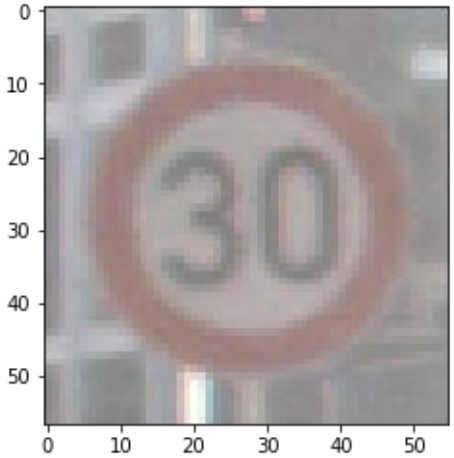


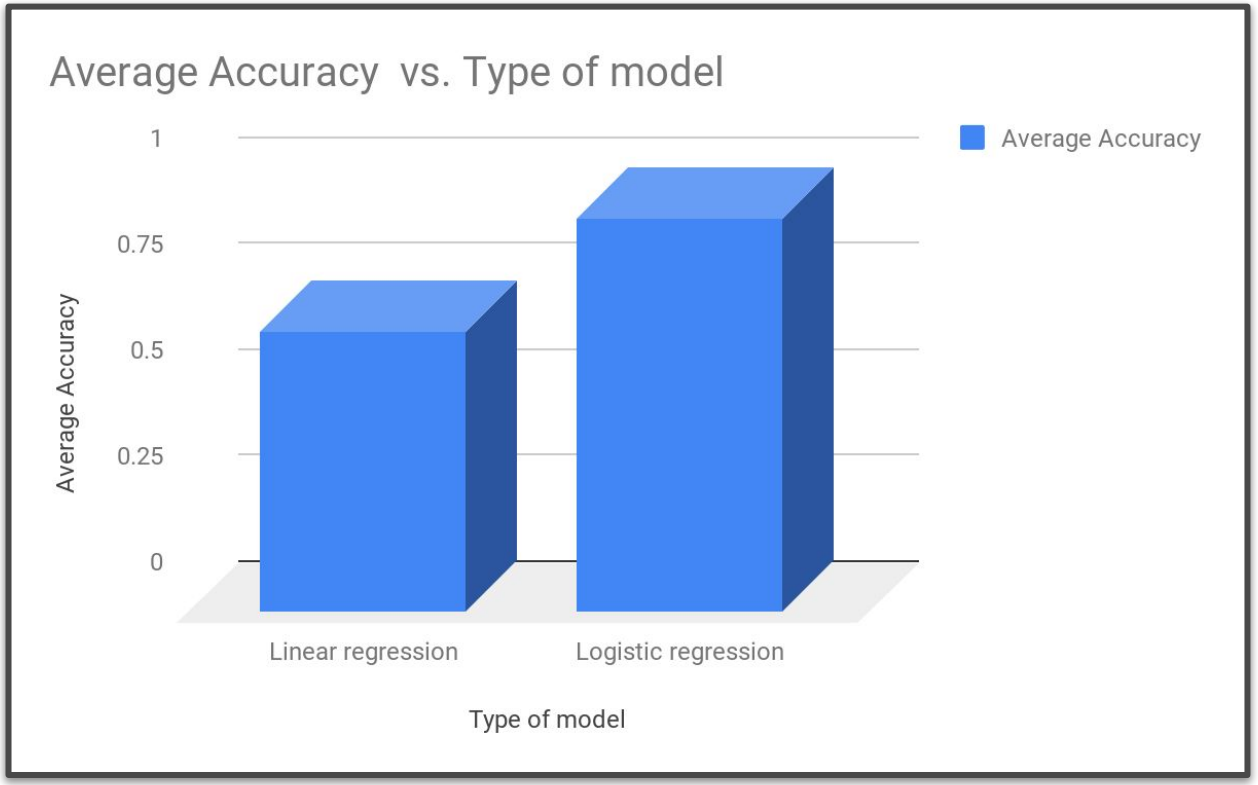




Linear/Logistic Regression

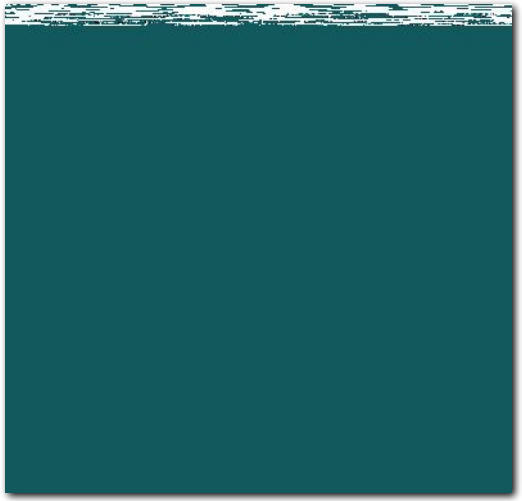
- Logistic regression can fit non linear shapes like circles and characters.

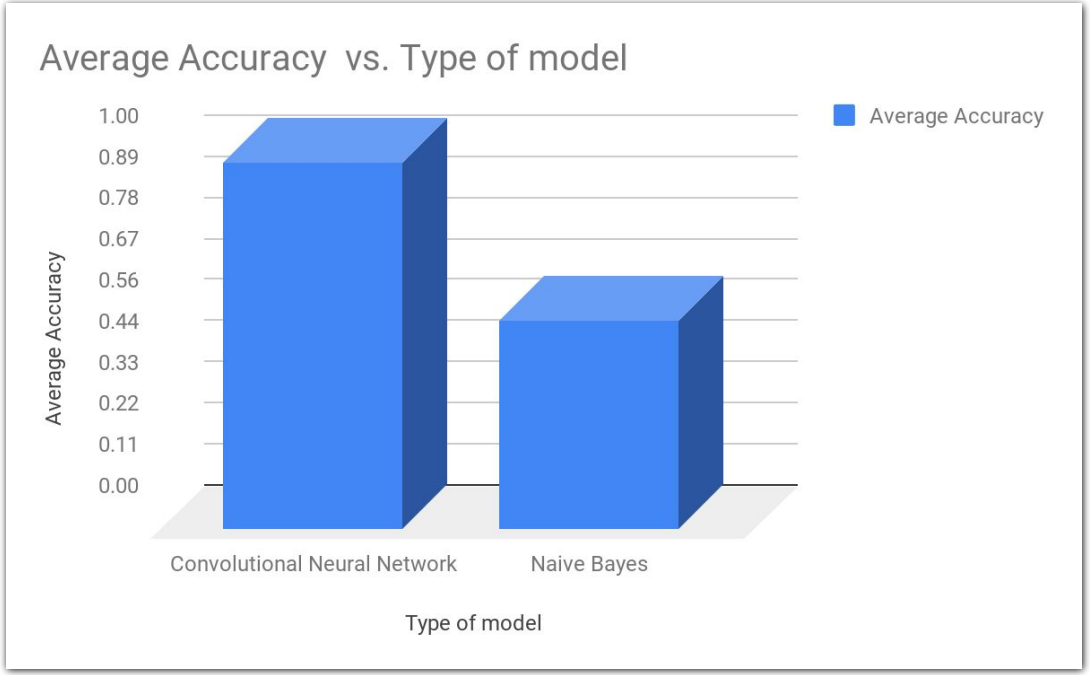




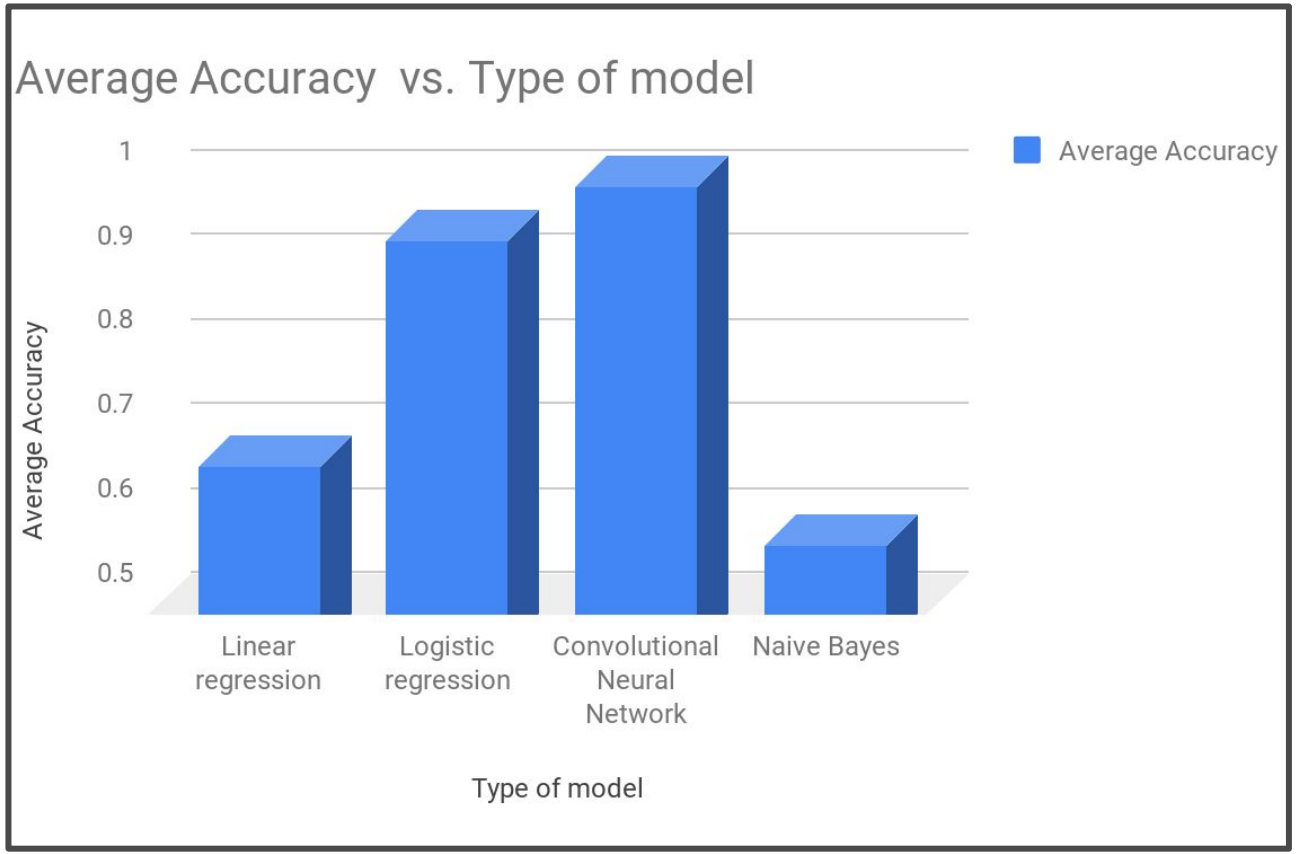
Convolutional Neural Networks/Multinomial Naive Bayes

- Naive Bayes calculates the probability that an object belongs to a class by using features.
- Convolutional Neural Networks apply filters over an image to find features.



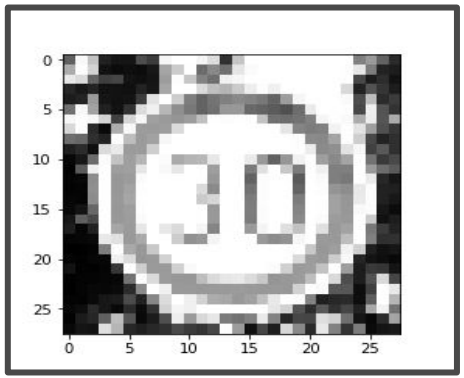


Overall Comparison



Adversarial Attacks

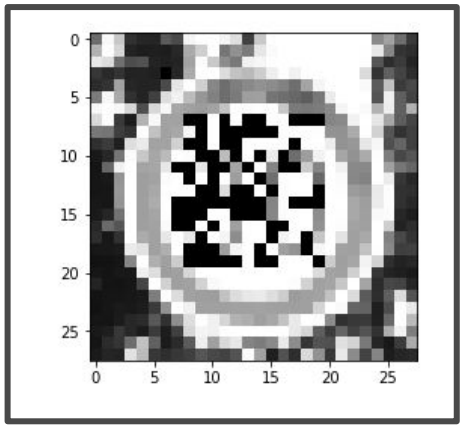
Normal image



Accuracy=.999

- We can test how robust a model is by feeding it confusing data and seeing how well it classifies it
- Can you classify the left image?

Changed image

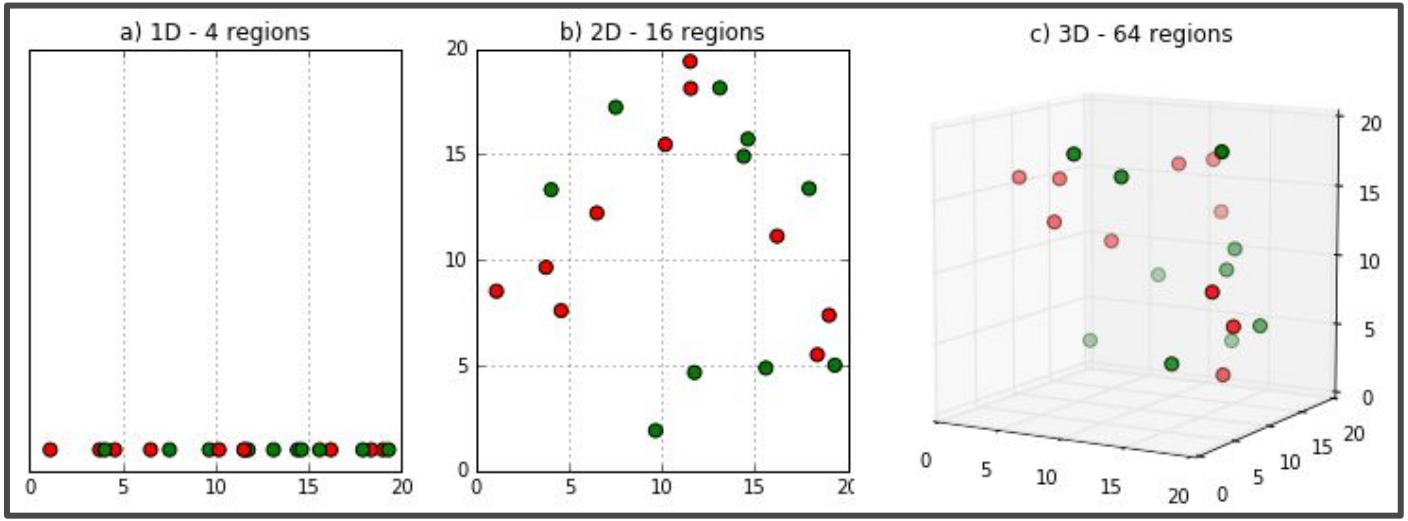


Accuracy=.945

K-Means Clustering

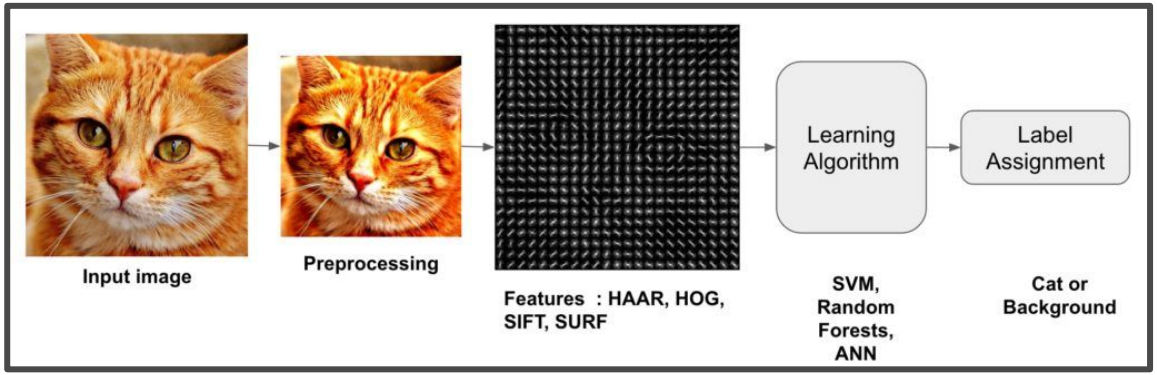
- The Curse of Dimensionality: In high dimensions reasonably well separated clusters (and not uniform random data like yours) may fail to be uncovered as successfully as it is in low dimensions.

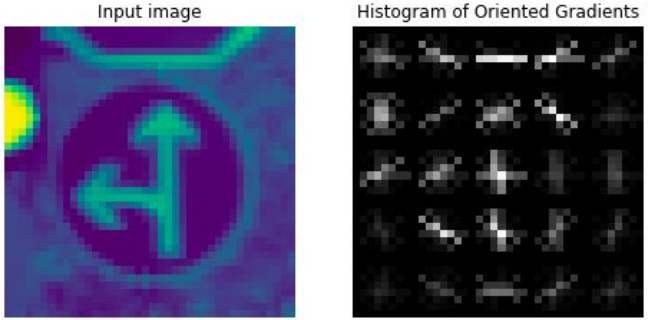
- Images which are often extremely high dimensional, with large pixel arrays with RGB values, create issues when attempting to utilize K-Means clustering

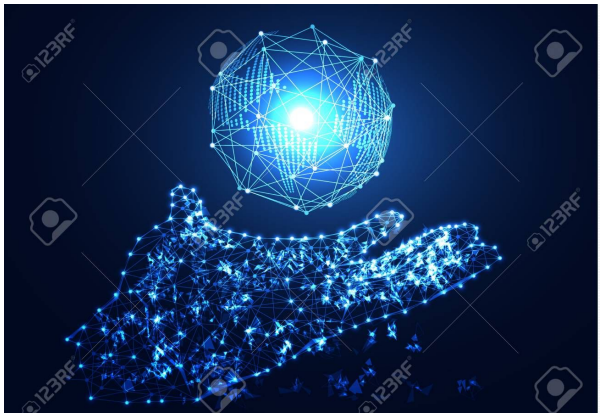


Hog Descriptor Features

- The histogram of oriented gradients (HOG) is a feature descriptor used in computer vision and image processing for the purpose of object detection. The technique counts occurrences of gradient orientation in localized portions of an image.



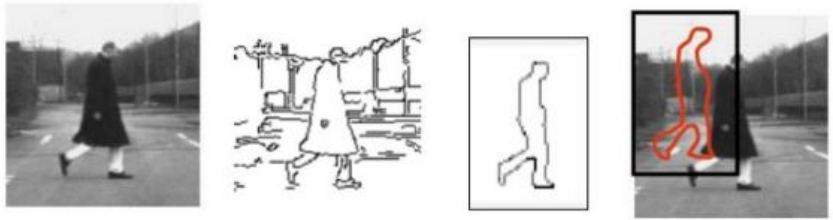




Improvements & Challenges in Image Processing

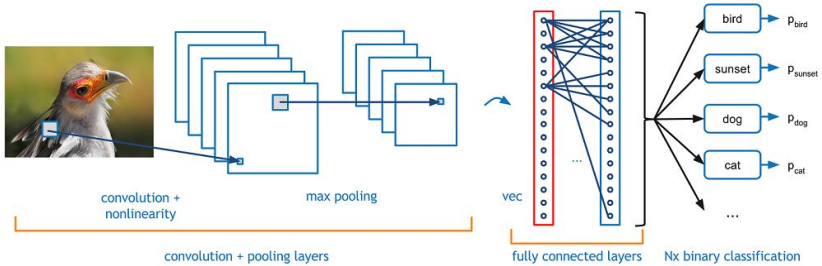
Pedestrian Detection

Old School



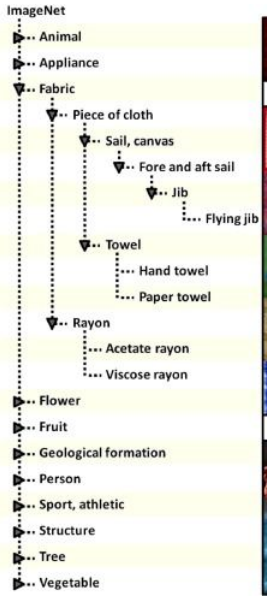
Modern

Templates VS Convolutional Neural Networks



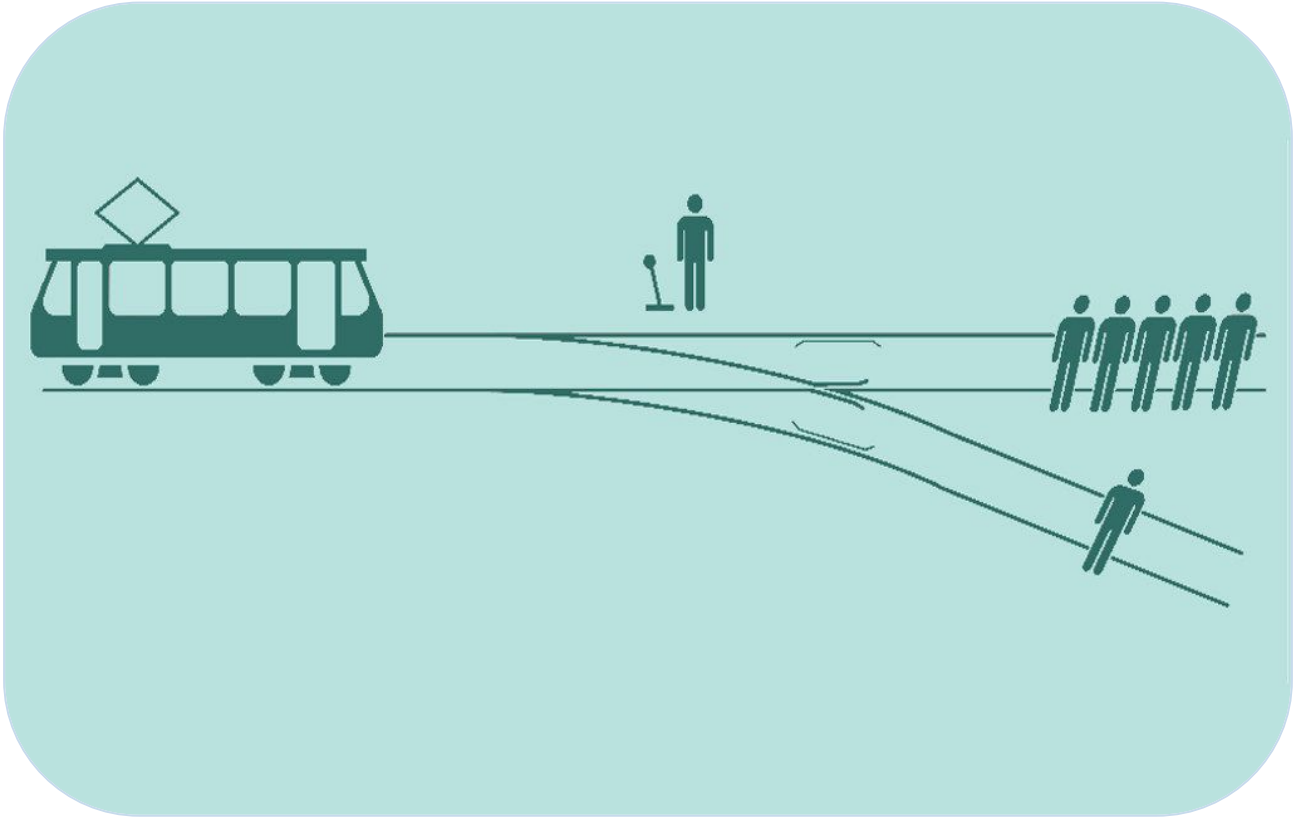
Biases in AI

- Cause of biases:
  - Limited variety in datasets
- Consequences of biases:
  - Racial biases
  - Misrepresentation in data
  - Safety risks
- Solution
  - Intraclass variation
  - More images and real life depictions of the world!
  - Diverse representation of society

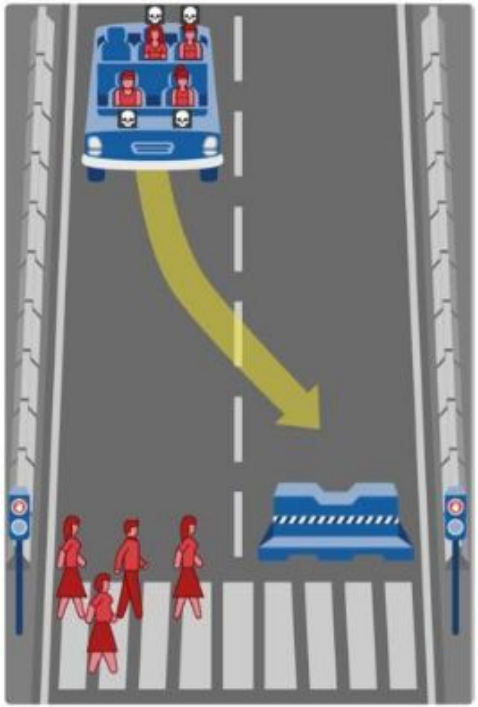


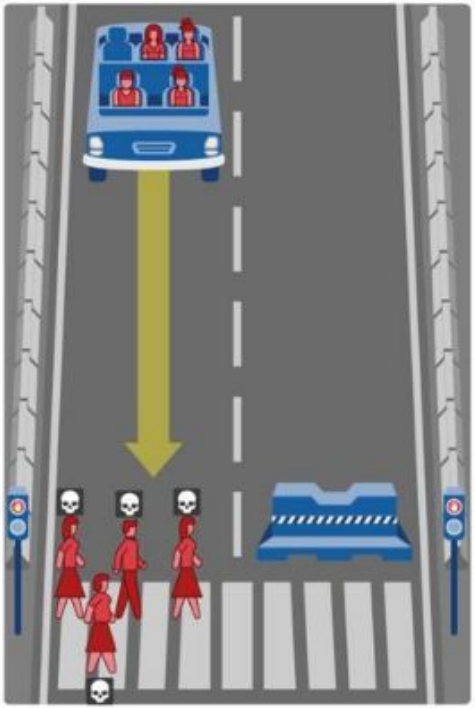
Policy and Ethics

The Trolley Question



Controversial Debate

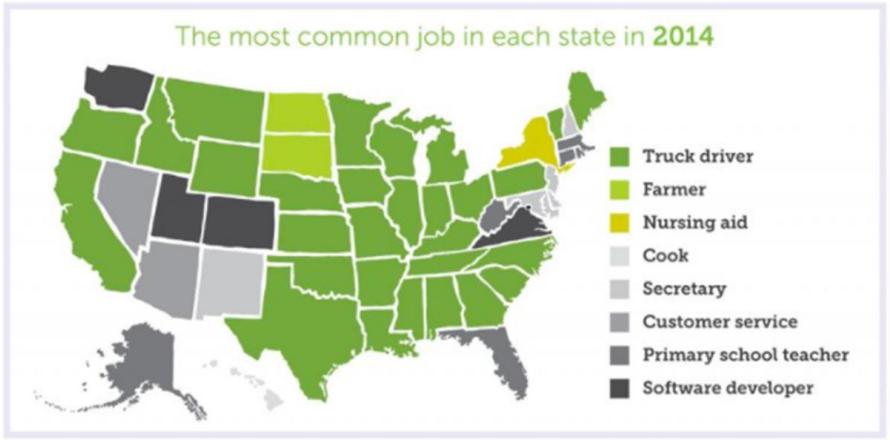




Should passengers and pedestrians be prioritized equally?

Job Loss

~3,500,000



This profession is the most popular in 29 U.S states

Economic Impact

- There are 3.5 million truck drivers in the U.S, 8.7 million in industry
  - Retailers are facing a shipping squeeze
  - Trucks were expected to handle 10.73 billion tons of goods in 2017 or about two-thirds of the nation's total
  - Truck driver shortage of 50,000
- Autonomous vehicles don't have limited hours, labor unions or claim a paycheck
- Big push from large companies to automate
  - Self check-out machines
- Over 5 million jobs would change or be gone in the next decade or two

Tesla Semi

Economic Impact

- 3.5 million truck drivers alone
    - Taxi Drivers, School Bus Drivers, Delivery Drivers (UPS, Fed-Ex), ...
    - Local Mechanics and Auto Shops
- Future of Transportation

How Are We Going To Replace All These Lost Jobs?

Policy

- There is not much knowledge of technology within policy makers
  - Both sides assume that the other would fix any arising or pre-existing problems

- What ways can regulators develop better laws and policies?
  - Legal Interfaces
    - Database
  - “Law Labs”
    - Controlled Environments
  - Structure Dialogues
    - Establish Communication

Policy Question

Should some kind of precaution like the presence of a trained human safety driver be required?

What will you do to change AI?

Bibliography

https://news.cnrs.fr/opinions/the-ethics-and-morals-of-self-driving-cars
http://www.esa.doc.gov/sites/default/files/Employment%20Impact%20Autonomous%20Vehicles_0.pdf
http://cyber.harvard.edu/sites/default/files/2018-07/2018-07_AVs04_1.pdf
https://www.nbcnews.com/business/autos/millions-professional-drivers-will-be-replaced-self-driving-vehicles-n817356
https://www.caranddriver.com/news/self-driving-mercedes-will-prioritize-occupant-safety-over-pedestrians
https://matplotlib.org/examples/color/colormaps_reference.html
https://docs.opencv.org/3.0-beta/doc/py_tutorials/py_imgproc/py_template_matching/py_template_matching.html
https://steemit.com/steem/@kevinwong/time-to-wake-up-and-fix-steem-s-voting-problem

Overview (don’t delete until we finish)

- Autonomous Vehicles (AVs) (Arsh) (Kishan) What is an AV? (3 minutes)

- Image Processing in Python (Annie) (Sakhi) (5 minutes)
  - German Traffic Signs Dataset Introduction
  - German Traffic Signs Dataset: Pre-processing

- AI Models and Analysis (Arsh)(Will) (6 minutes)
  - Compare accuracy of the models (Bring up how well they generalize)
  - Explain why these models have varying degrees of accuracy

- Difficulties:
  - Motion tracking
  - pedestrian detection & biases in AI (Bryanna & Will)

- Policy & ethics
  - AV Policy (ideas presented in articles) (Widnie)
  - the trolley question and jobs(economic impact & debate) (Kishan) (Nina)

5 Minute Presentation

- Intro
- How they operate
- Image Processing/German Traffic Data Set
- Models
- Ethics and Economy and Policy