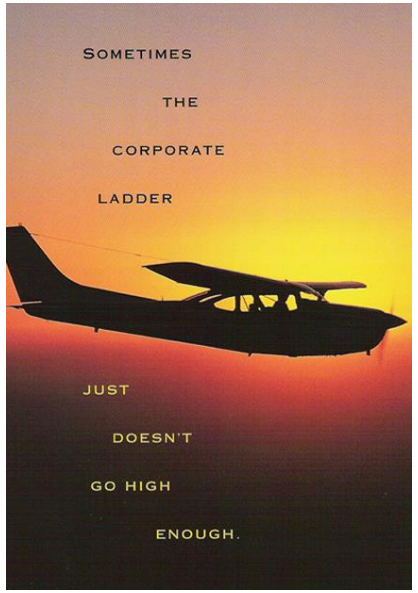
Plane and Simple: Exploration of Machine Interaction with Text Type for Visual Based Navigation Systems

OLIVER AUSTIN, TUG 2021

Education/Experience

Oak Grove High School
2018-Present

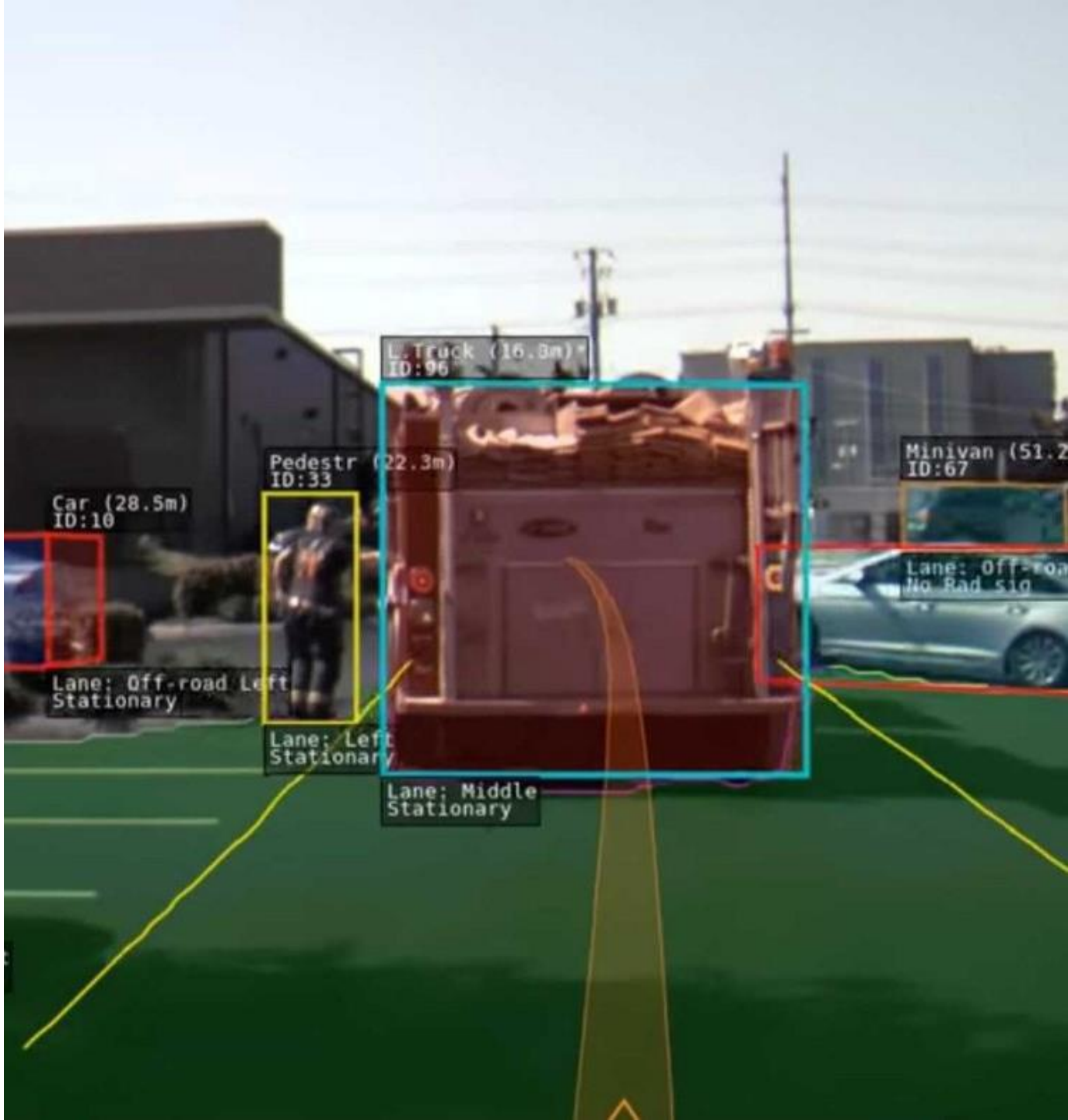
OGHS Maker Club/Makerspace Co-Founder
2019-Present



Sundance Flying Club
2019-Present

Project Introduction

- Visual-Based Navigation Systems Consist of One or More Cameras that Feed Directly into an Onboard Computer
- Use of Cameras Helps Systems Achieve Higher Precision when Controlling Vehicles
- Most Prevalent Use is with Road Vehicles (i.e. Tesla Automobiles)



Visual-Based Navigation Systems in Aviation

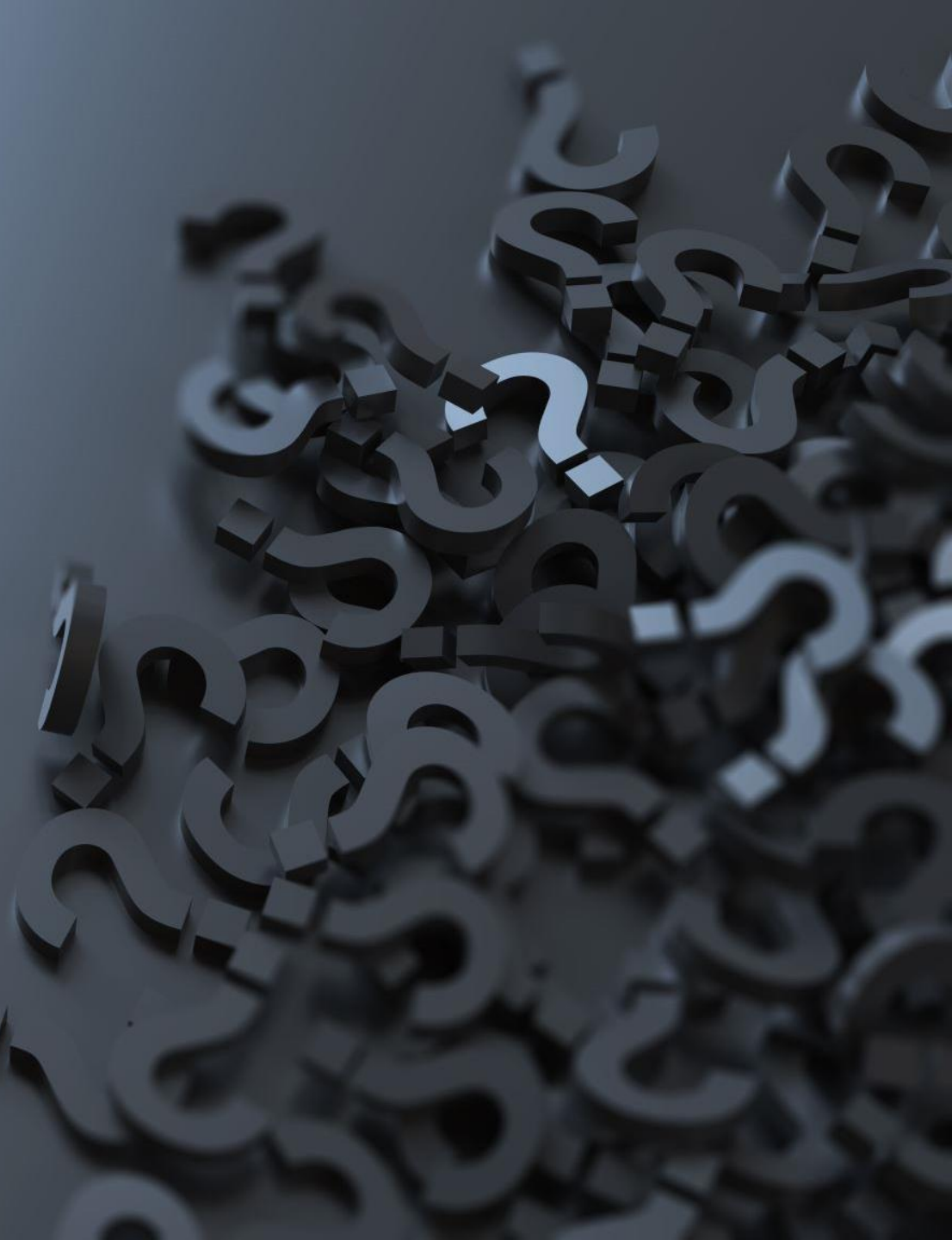
- Aviation Industry is Focusing on the Commercialization of Autonomous Unmanned Aerial Vehicles (UAVs)
- Vision-Based Navigation Systems are Most Useful for Take-Offs and Landings, the Most Critical Stages of Flight

Current Industry Applications

- Airbus' Autonomous Taxi, Take-Off & Landing (ATTOL) Project is a Major Step Towards Completely Autonomous Passenger Planes
- Airbus Helicopters' VSR700 UAV to Complete De-Risking Studies and Put Into Autonomous Operation by the End of 2021 in French Navy

Driving Question

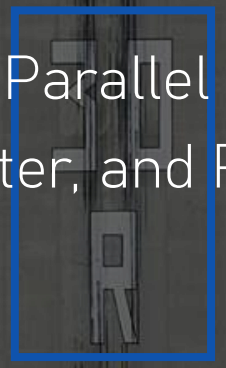
Is the current font used for runway designators suitable for visual-based navigational systems in Autonomous Aerial Vehicles (AAV)?



A Closer Look at Runway Designators

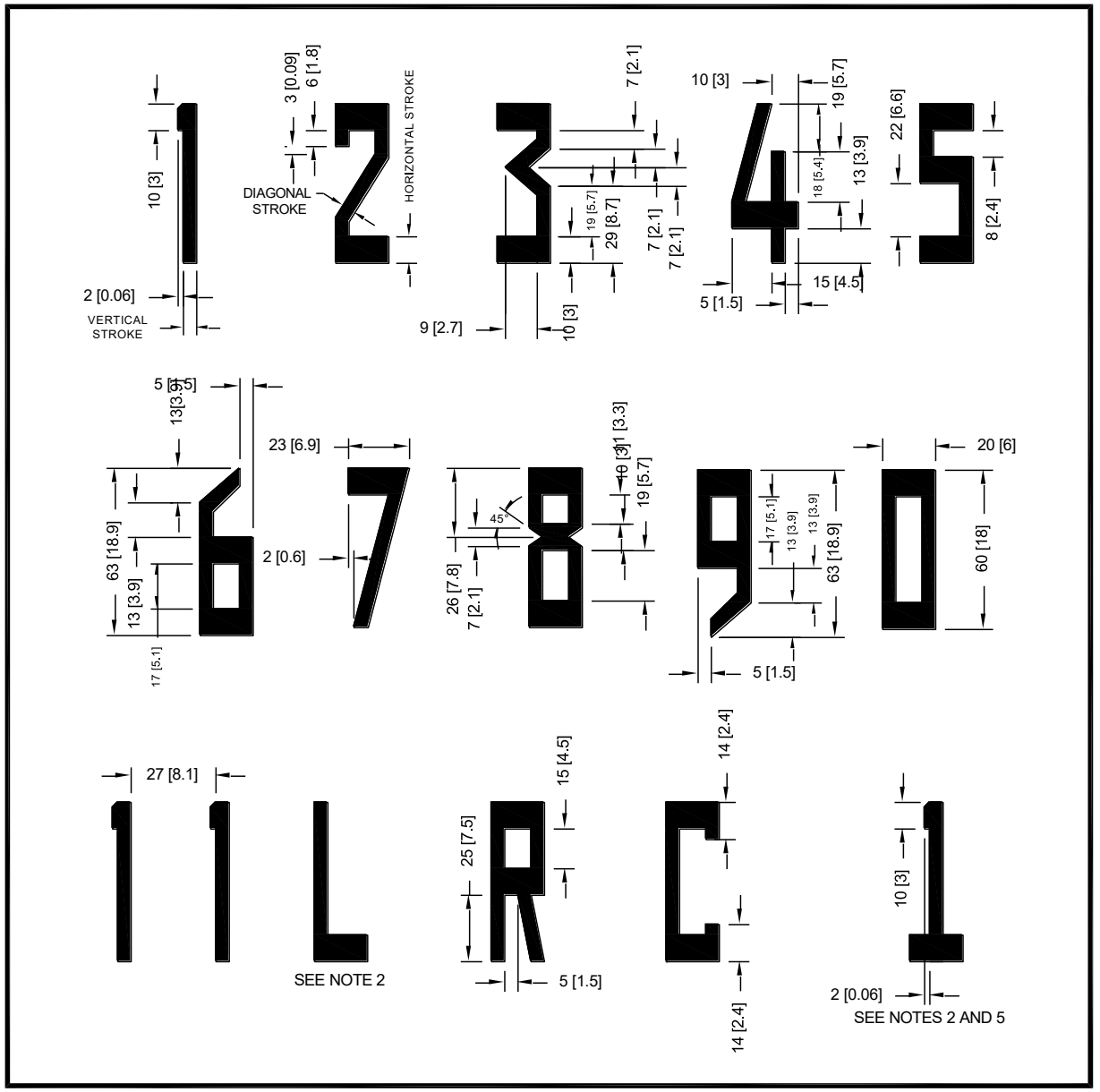
What Are Runway Designators?

- Give Runways a Unique Code
- Numbers Indicate First Two Digits of Rounded Magnetic Heading (e.g. 194° → 190° → RWY19)
- Letters Distinguish Parallel Runways (Left, Center, and Right)



Characteristics of the Font

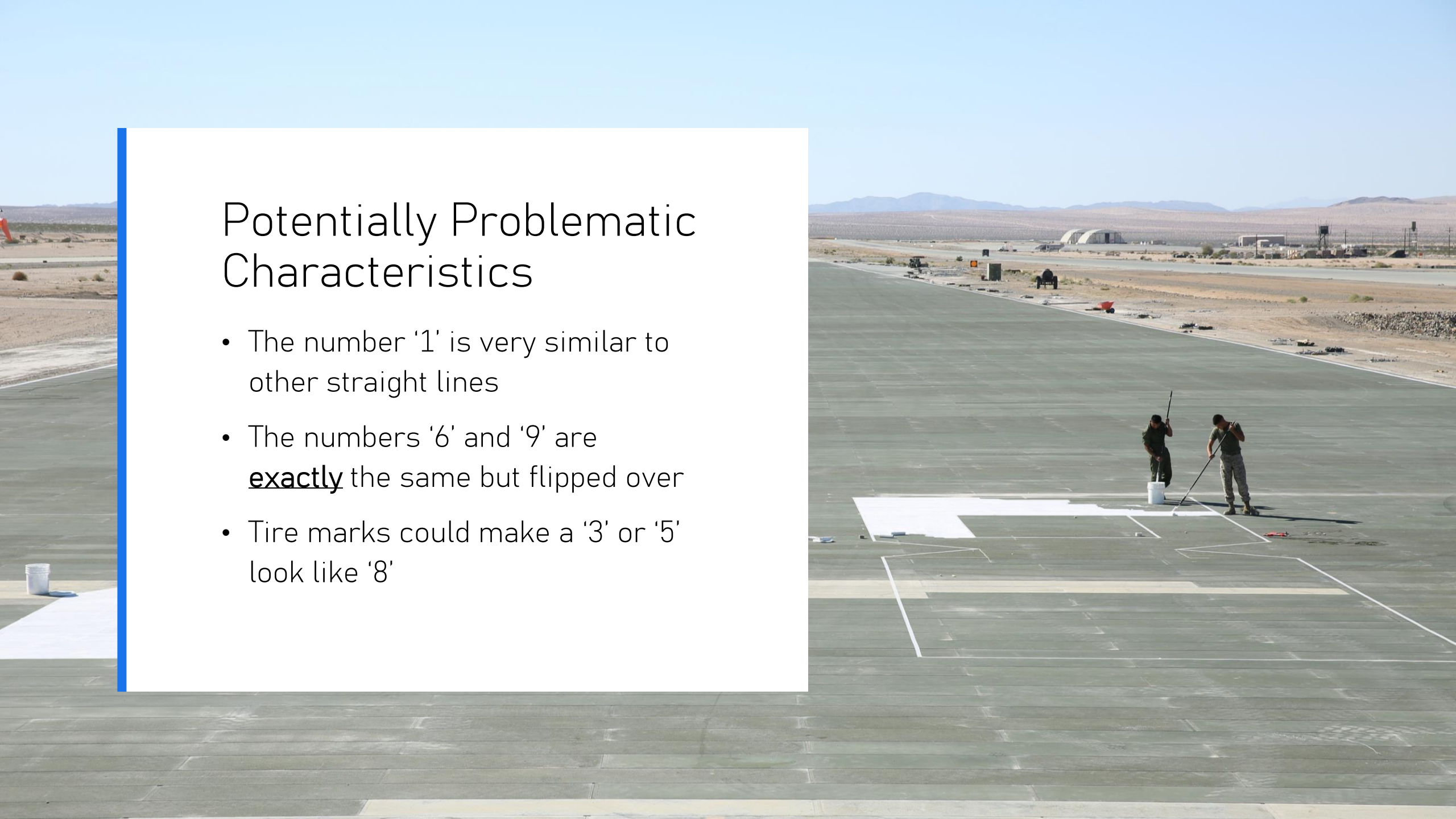
- Has No Official Name*
- Highly Geometric
- Easily Recreatable by Groundskeepers without Typographic Training
- Set as a Global Standard by the International Civil Aviation Organization (ICAO)

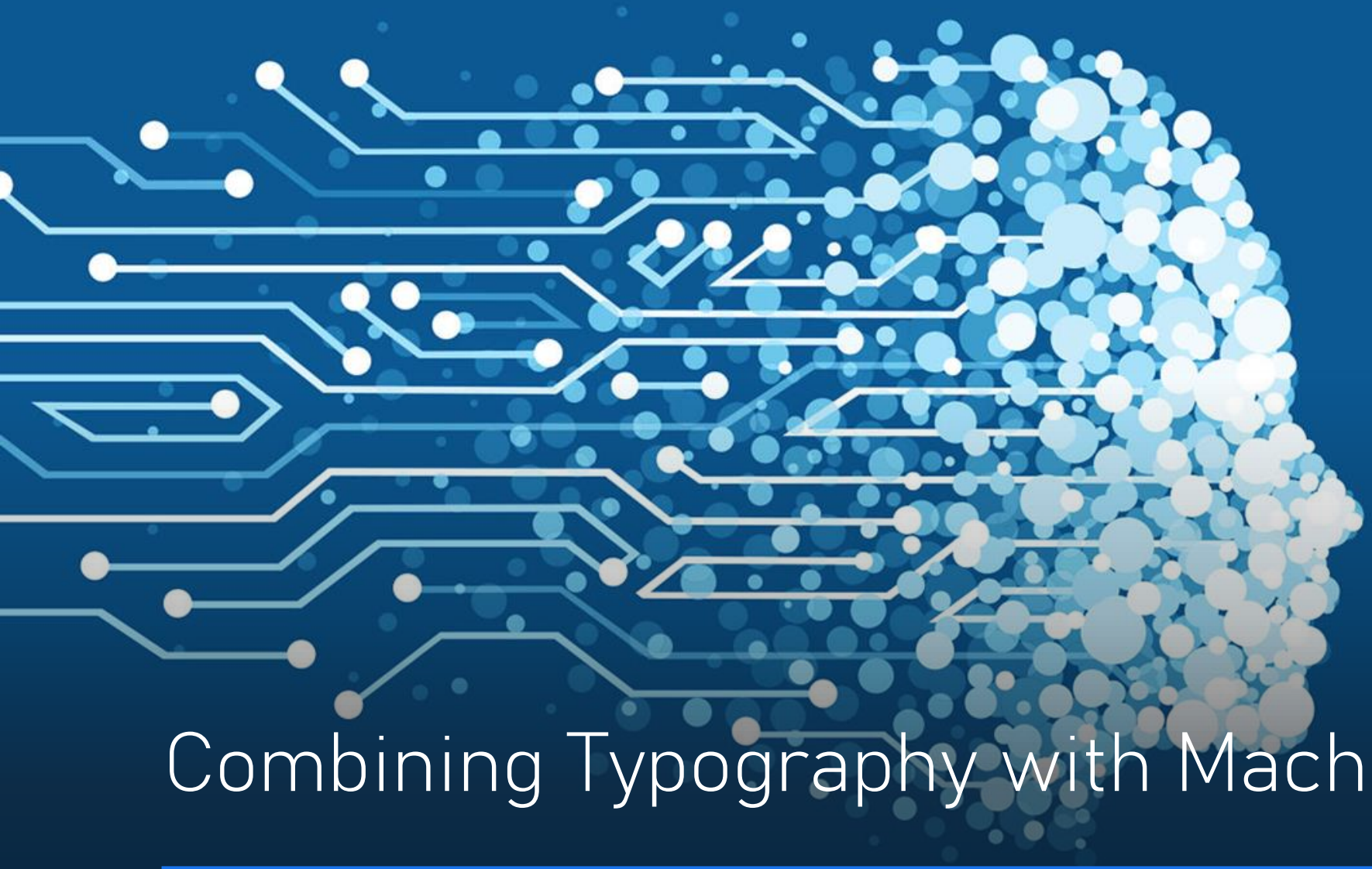


*Will be referred to the 'ICAO' Font during this presentation for the sake of simplicity

Potentially Problematic Characteristics

- The number ‘1’ is very similar to other straight lines
- The numbers ‘6’ and ‘9’ are **exactly** the same but flipped over
- Tire marks could make a ‘3’ or ‘5’ look like ‘8’





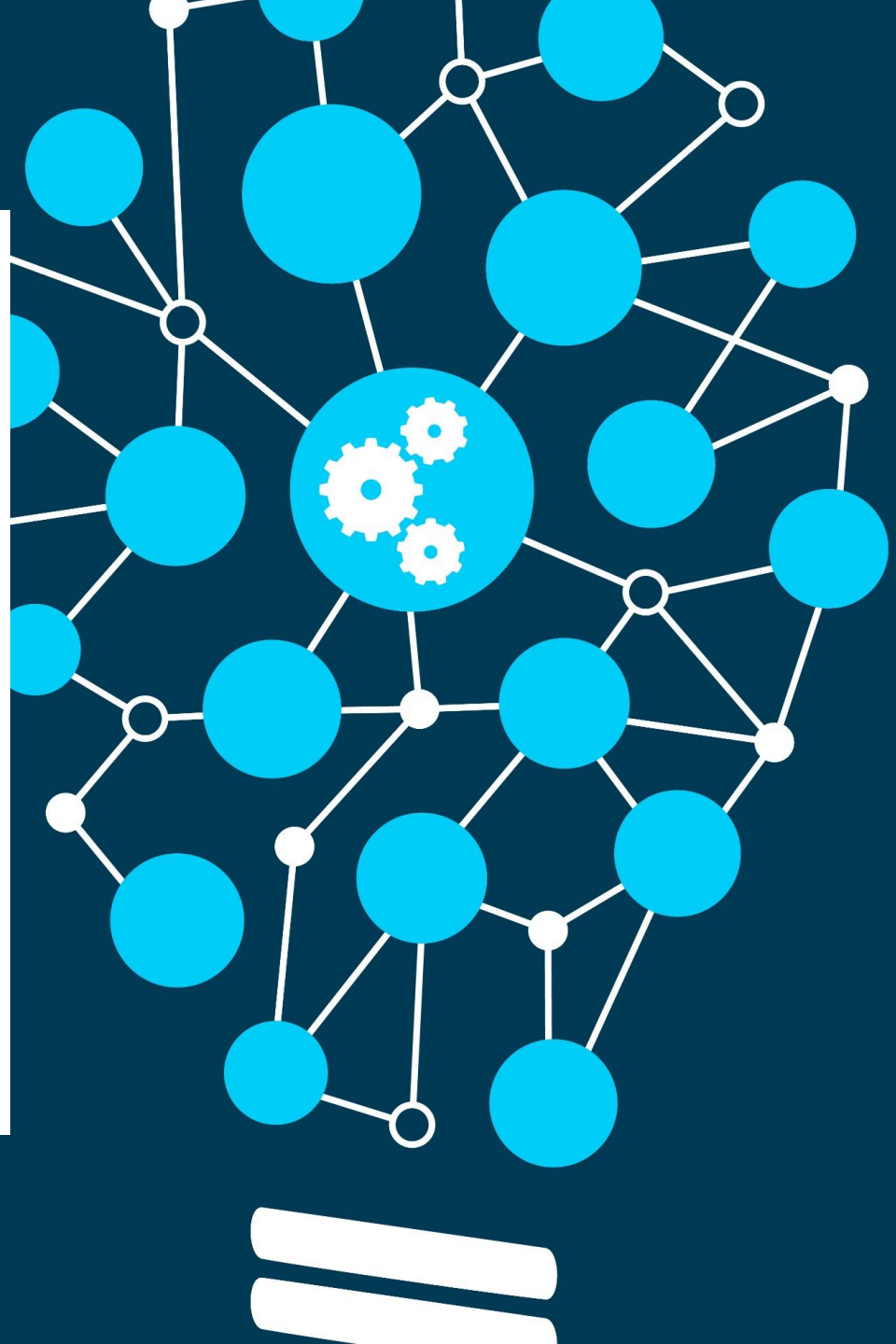
Combining Typography with Machine Learning

How Does Machine Learning Work?

- Step 1 – Collect Data Sets for Training
- Step 2 – Train ‘Model’
- Step 3 – Use Model to Interact with New Data

What is a Machine Learning Model?

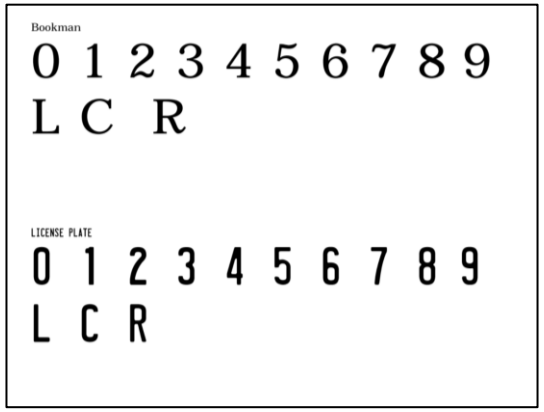
- A file that has been trained to recognize certain types of patterns
  - You train a model over a set of data, providing it an algorithm that it can use to interpret new data

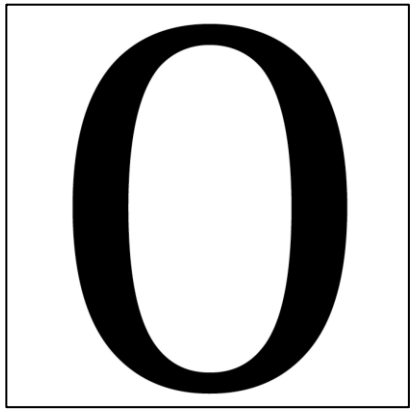


Step 1 – Collecting Data Sets

MULTI-FONT DATA SET

- 31 Different Fonts
- Classes are 0-9, L, C, R
- ICAO font IS included





REAL-WORLD DATA SET

- 137 Uncropped Images
- Classes are 0-9, L, C, R
- 143 Cropped Characters

Step 2 – Training the Model

Step 3 – Use Model To Interact With New Data

Project-Specific Details/Analysis

Options for Categorizing Characters in Images

CLASSIFICATION

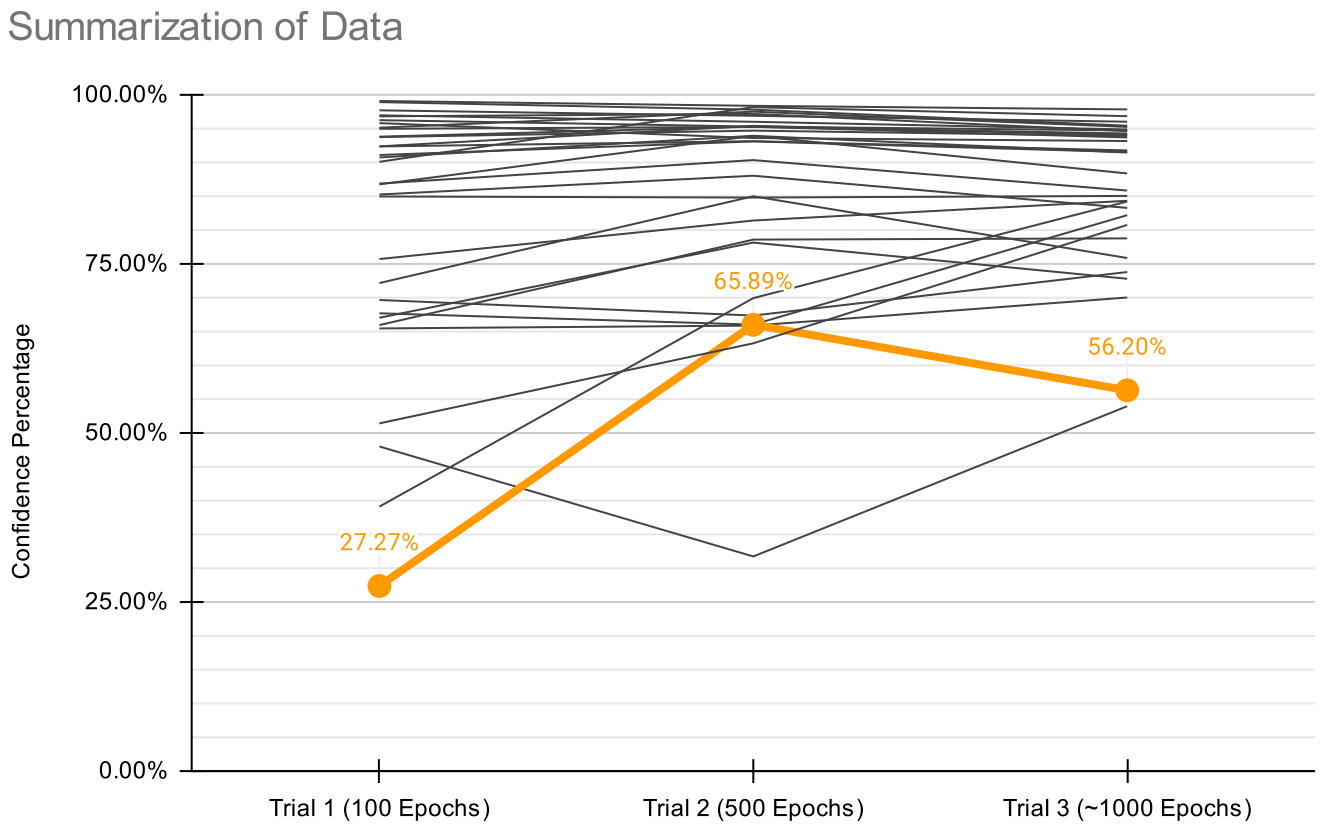
- Predicts the class of one item in an image
- Labels image with predicted class and confidence percentage

DETECTION/OBJECT LOCALIZATION

- Identifies the location of one or more items in an image
- Draws a bounding box around found item
- Labels bounding box with class and confidence percentage

Multi-Font Data Set Analysis

- Used Classification Method
- ICAO font **significantly** underperforms relative to majority
- Large selection of fonts are easily classifiable from early-on



ICAO Font Comparison

ICAO FONT PERCENTAGES

Font	Trial 1 (100 Epochs)	Correct Character Prediction	Trial 2 (500 Epochs)	Correct Character Prediction	Trial 3 (~1000 Epochs)	Correct Character Prediction
ICAO	27.27%	38.46%	65.89%	92.31%	56.20%	92.31%
0	47.67%	No	95.85%	Yes	24.05%	Yes
1	80.78%	Yes	82.03%	Yes	64.11%	Yes
2	53.80%	Yes	46.25%	Yes	43.32%	Yes
3	44.83%	Yes	43.84%	Yes	69.17%	Yes
4	75.83%	Yes	95.54%	Yes	98.48%	Yes
5	35.67%	No	65.25%	Yes	73.10%	Yes
6	37.21%	No	65.61%	Yes	26.36%	Yes
7	99.21%	Yes	98.43%	Yes	98.50%	Yes
8	37.71%	No	37.84%	No	54.88%	Yes
9	20.45%	No	73.85%	Yes	42.12%	Yes
L	71.00%	No	68.35%	Yes	66.76%	Yes
C	49.22%	No	44.43%	Yes	40.60%	No
R	55.39%	No	77.14%	Yes	69.72%	Yes

HIGHEST PERFORMING FONT

Font	Trial 1 (100 Epochs)	Correct Character Prediction	Trial 2 (500 Epochs)	Correct Character Prediction	Trial 3 (~1000 Epochs)	Correct Character Prediction
Allumi	98.99%	100.00%	98.27%	100.00%	97.74%	100.00%
0	99.04%	Yes	98.68%	Yes	93.74%	Yes
1	96.17%	Yes	94.71%	Yes	90.89%	Yes
2	99.98%	Yes	99.54%	Yes	99.63%	Yes
3	99.80%	Yes	99.85%	Yes	99.41%	Yes
4	99.56%	Yes	99.68%	Yes	99.85%	Yes
5	98.30%	Yes	99.90%	Yes	98.37%	Yes
6	99.34%	Yes	99.88%	Yes	99.39%	Yes
7	99.63%	Yes	99.60%	Yes	99.91%	Yes
8	96.86%	Yes	94.93%	Yes	99.37%	Yes
9	99.39%	Yes	99.53%	Yes	99.98%	Yes
L	99.43%	Yes	91.98%	Yes	92.55%	Yes
C	99.43%	Yes	99.32%	Yes	97.70%	Yes
R	99.95%	Yes	99.96%	Yes	99.89%	Yes

Real-World Data Set Analysis

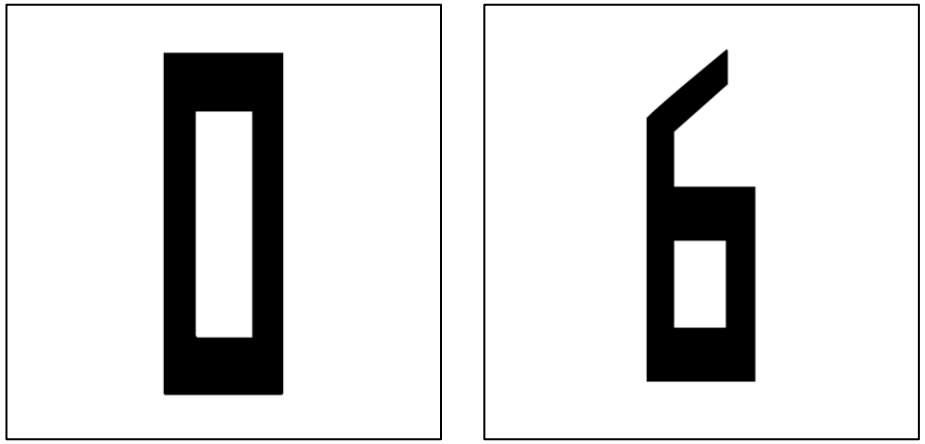
- Used Classification Method
- Does NOT Meet Minimum of ~80% Accuracy to be Considered Usable in a System
- Still Improves When Trained For Longer, Although Not Significantly

ICAO Character	Trial 1 (2000 Epochs)	Trial 2 (4000 Epochs)
0	1.52%	0.00%
1	0.00%	9.14%
2	0.00%	0.00%
3	0.00%	1.35%
4	0.00%	0.00%
5	0.00%	0.00%
6	7.68%	0.00%
7	0.00%	1.62%
8	0.00%	3.69%
9	1.25%	0.00%
L	0.00%	2.52%
C	0.00%	7.26%
R	0.00%	0.00%
Average Confidence %	0.80%	11.90%

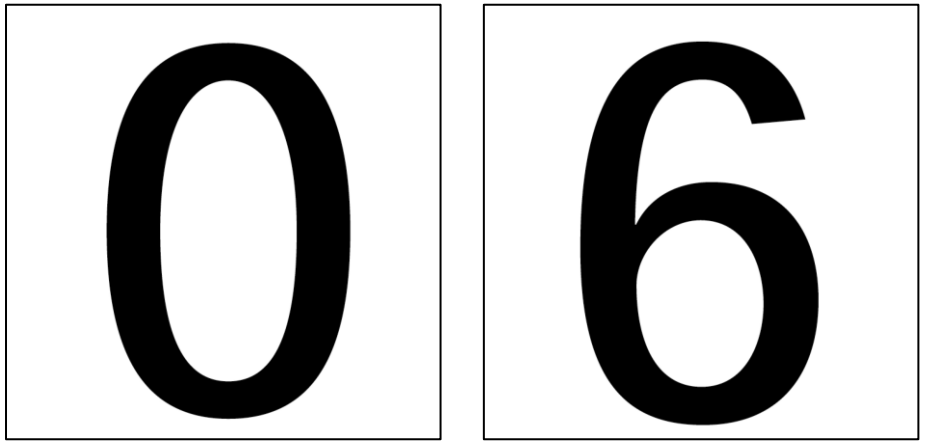
Improving Results

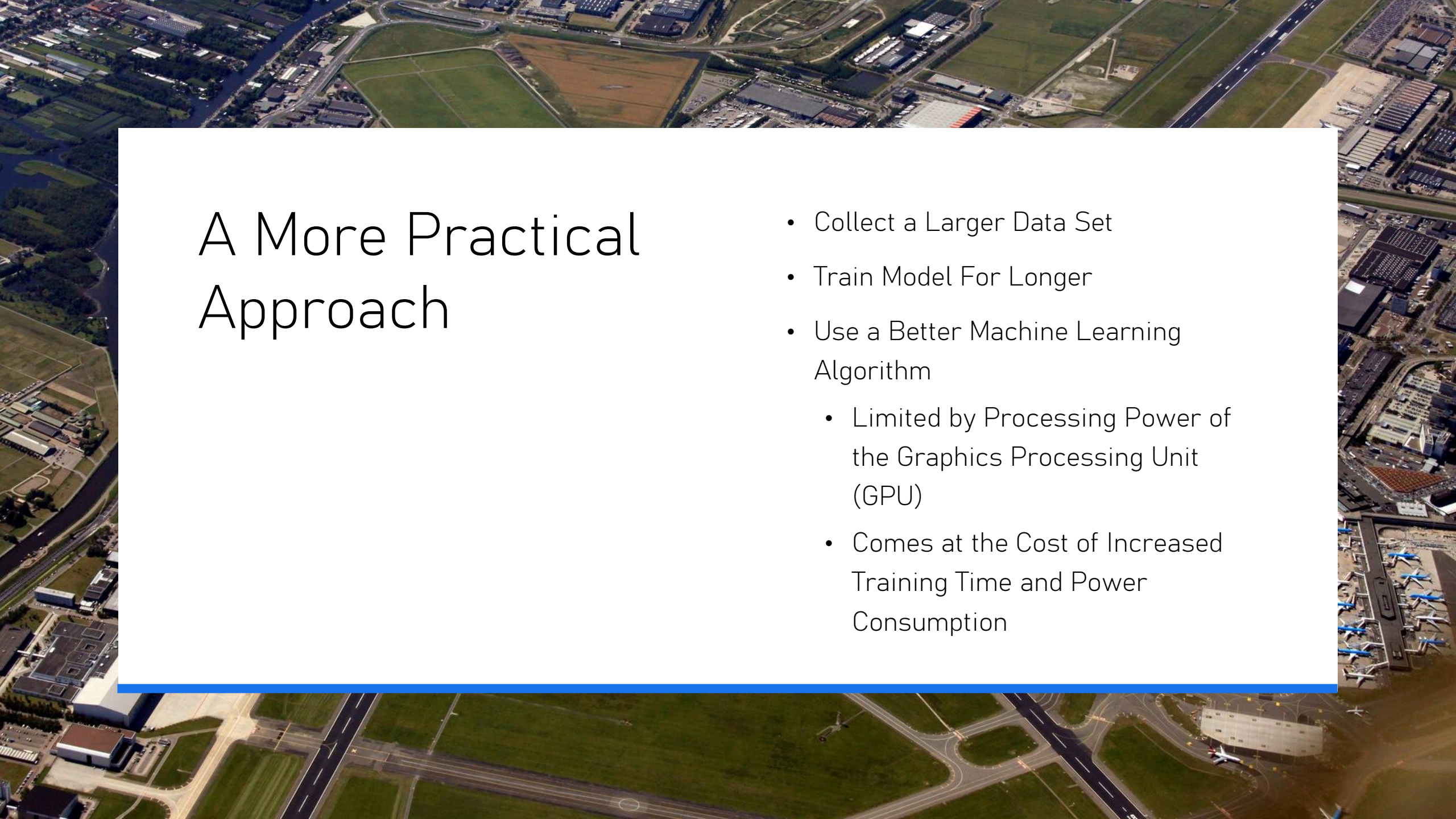
Potential Changes to the Font

ICAO FONT



HIGHEST PERFORMING FONT (ALLUMI)





A More Practical Approach

- Collect a Larger Data Set
- Train Model For Longer
- Use a Better Machine Learning Algorithm
  - Limited by Processing Power of the Graphics Processing Unit (GPU)
  - Comes at the Cost of Increased Training Time and Power Consumption

Acknowledgements

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Thank You For Listening!