



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

OLIVER AUSTIN, TUG 2021

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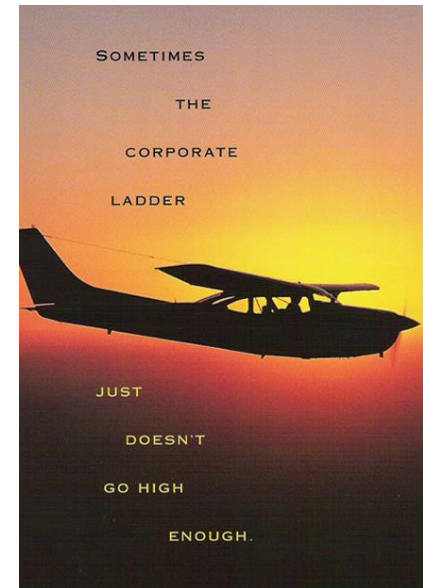
# Education/Experience



Oak Grove High School  
2018-Present



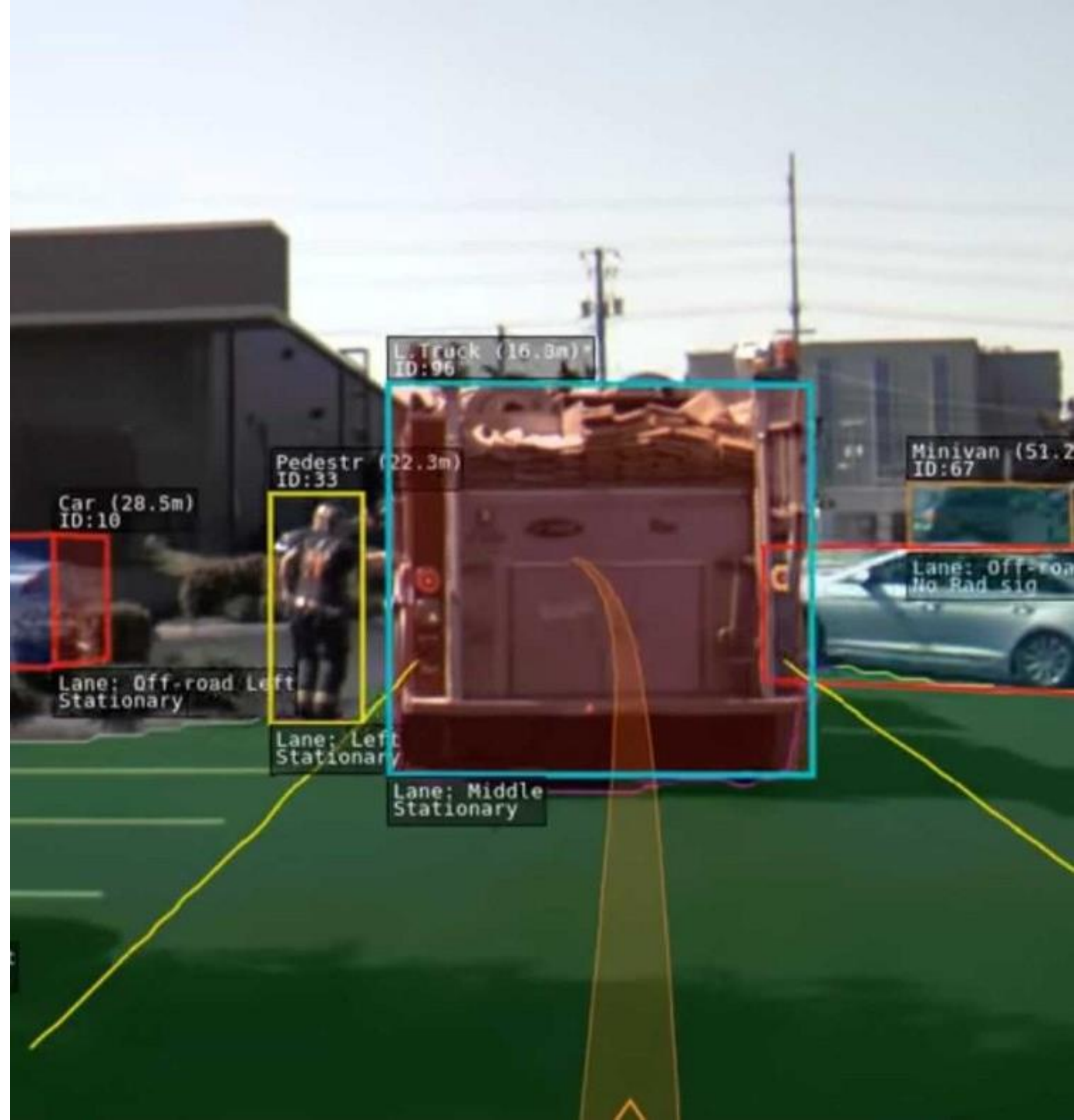
OGHS Maker Club/Makerspace Co-Founder  
2019-Present



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)







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## 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

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- 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

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An aerial photograph of an airport runway. The runway is a long, straight, light-colored strip of pavement. On either side of the runway are dark, grassy areas. At the top of the image, there are some small, rectangular structures, possibly taxiway lights or signs. The runway itself has several sets of white markings, including a series of parallel lines near the top and bottom. Two specific areas of the runway are highlighted with blue rectangular boxes. The box on the left contains the designator '30L' and the box on the right contains the designator '30R'.

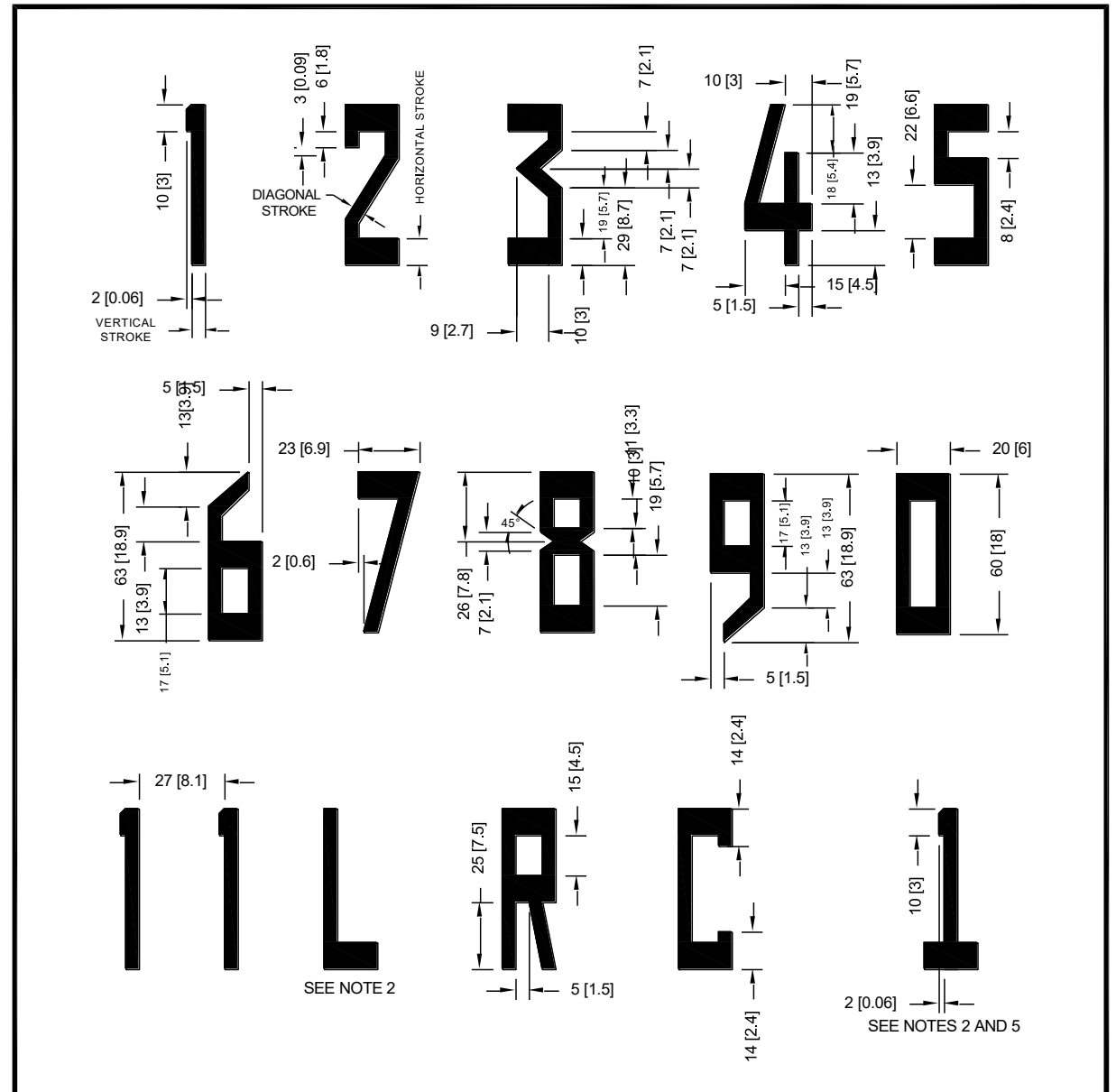
# What Are Runway Designators?

- Give Runways a Unique Code
- Numbers Indicate First Two Digits of Rounded Magnetic Heading (e.g.  $194^{\circ} \rightarrow 190^{\circ} \rightarrow \text{RWY19}$ )
- Letters Distinguish Parallel Runways (Left, Center, and Right)



# Characteristics of the Font

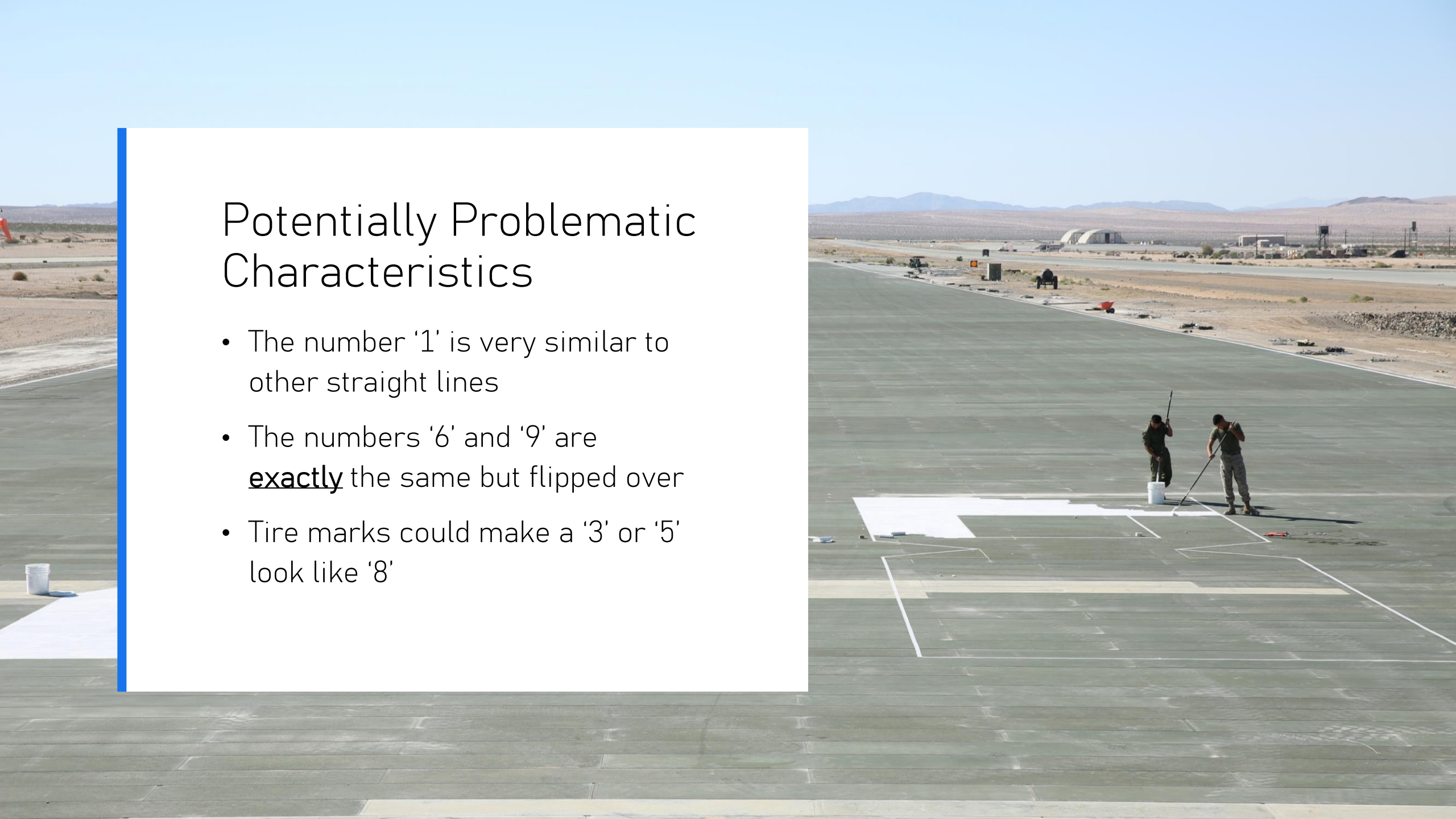
- Has No Official Name\*
- Highly Geometric
- Easily Recreatable by Groundskeepers without Typographic Training
- Set as a Global Standard by the International Civil Aviation Organization (ICAO)



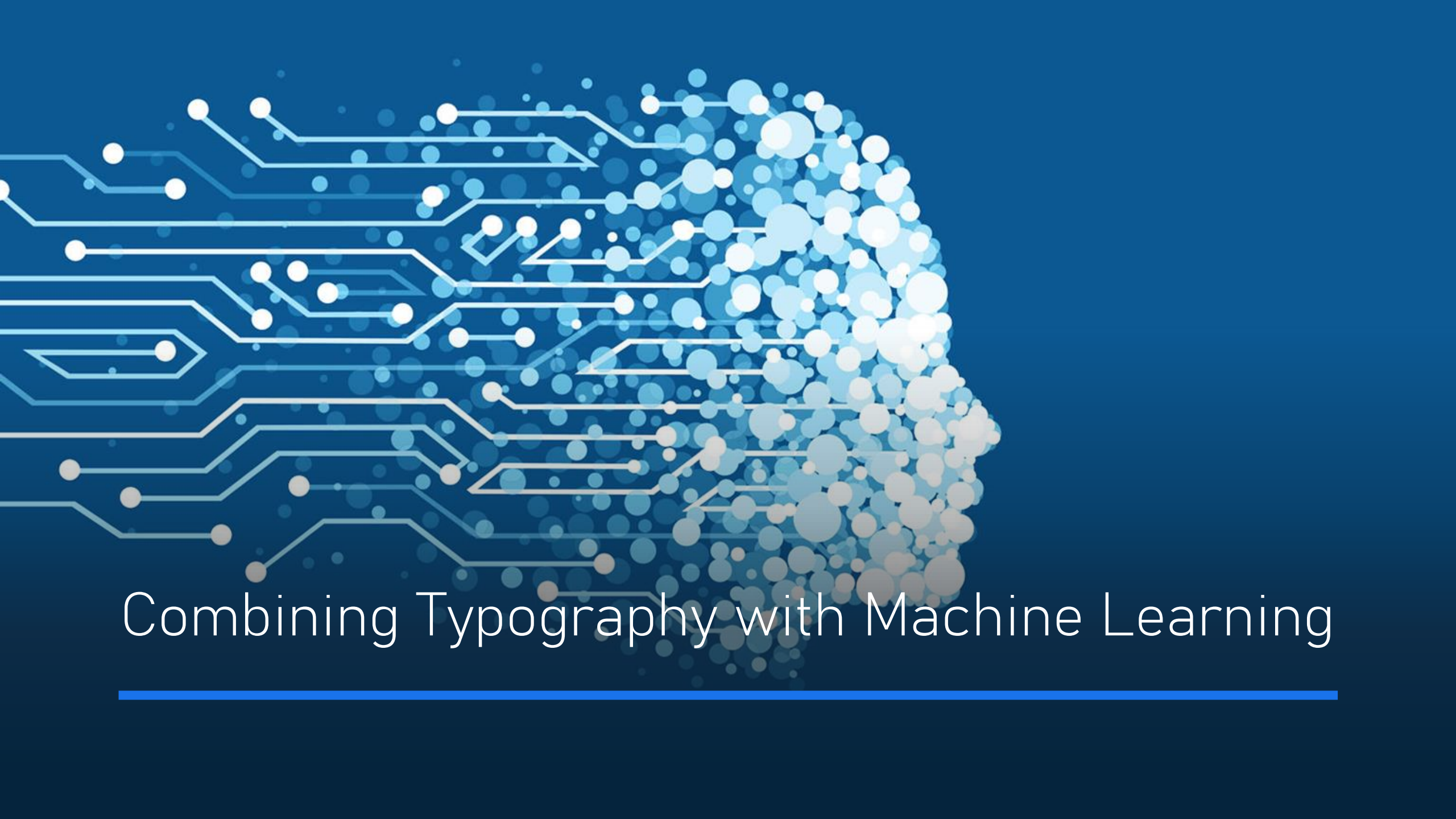
\*Will be referred to the 'ICAO' Font during this presentation for the sake of simplicity

# 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

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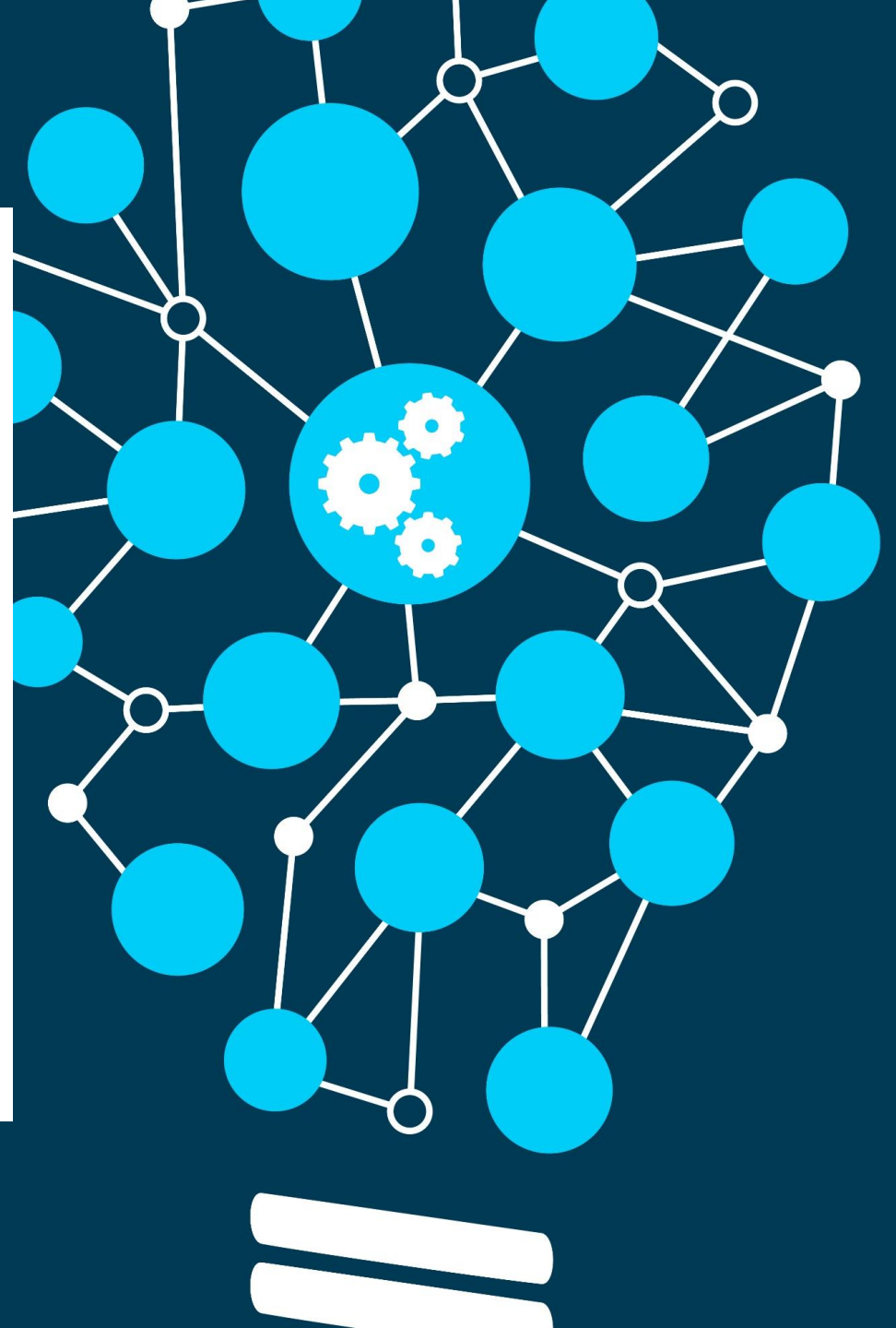
# How Does Machine Learning Work?

- 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

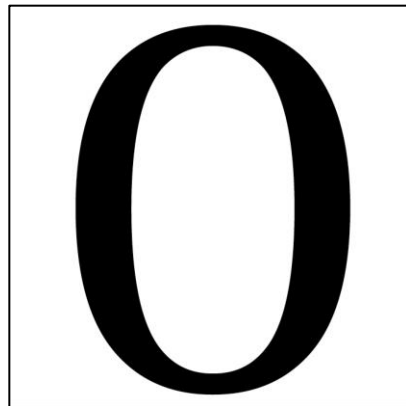
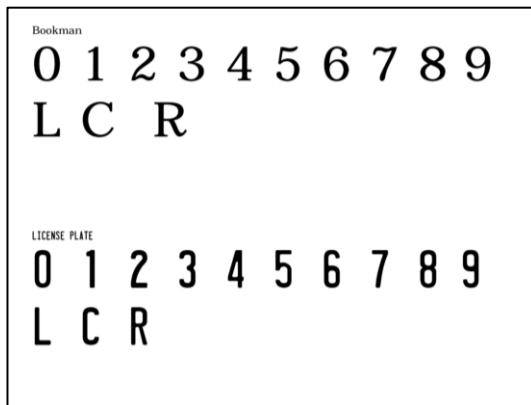


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# Step 1 – Collecting Data Sets

## MULTI-FONT DATA SET

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



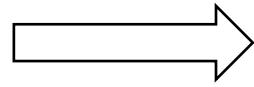
## REAL-WORLD DATA SET

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

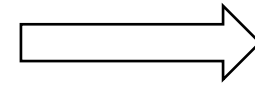




## Step 2 – Training the Model



  
PyTorch



  
ONNX

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## Step 3 – Use Model To Interact With New Data







Project-Specific Details/Analysis

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# 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

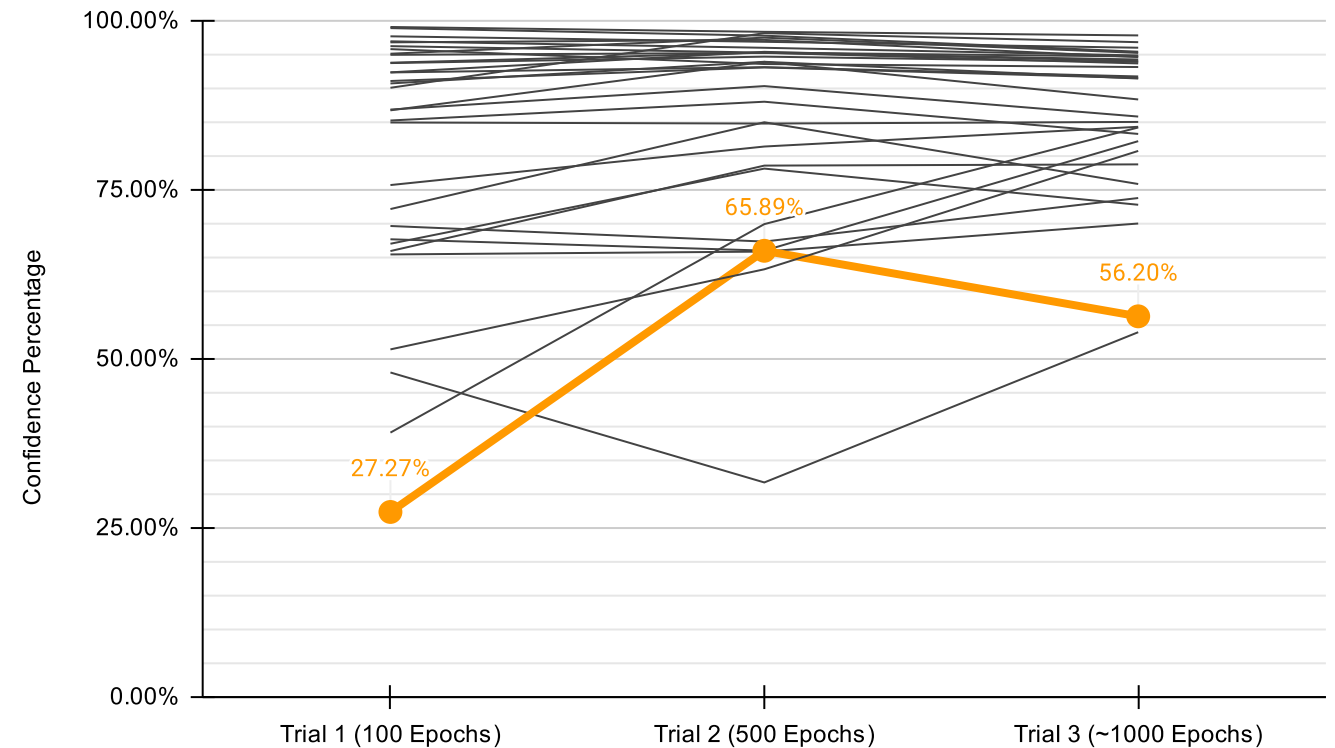
- Identifies the location of one or more items in an image
- Draws a bounding box around found item
- Labels bounding box with class and confidence percentage



# 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

Summarization of Data





# 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%



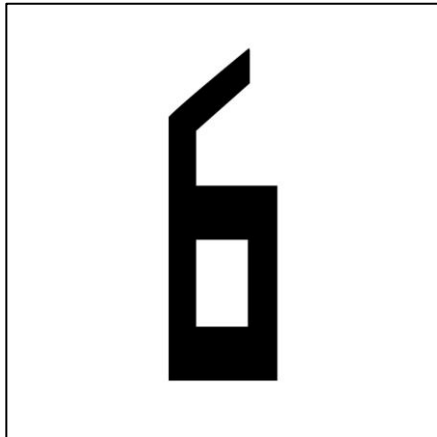
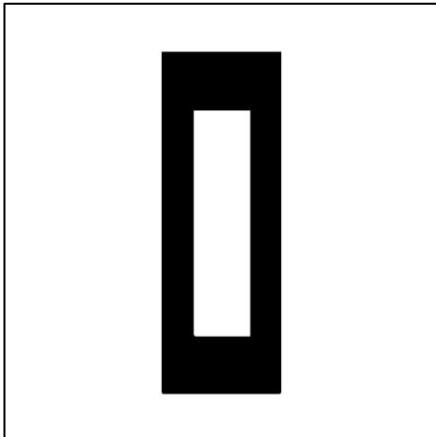


Improving Results

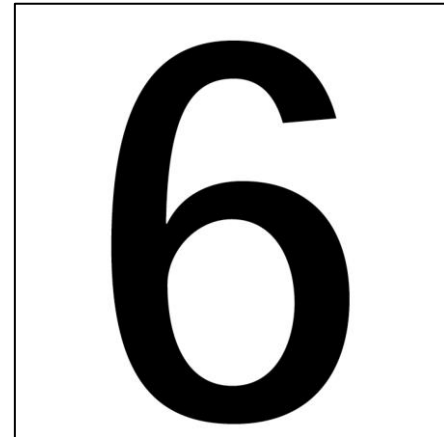
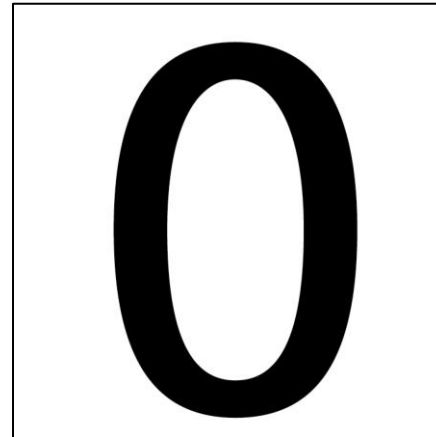
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# Potential Changes to the Font

ICAO FONT



HIGHEST PERFORMING FONT  
(ALLUMI)





An aerial photograph of an airport and surrounding urban area. The image shows a large runway, taxiway, and parking lot with many cars. There are several large buildings, including what appears to be a terminal or hangar. The surrounding area includes green fields, roads, and other buildings. The overall scene is a mix of natural and built environments.

# 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



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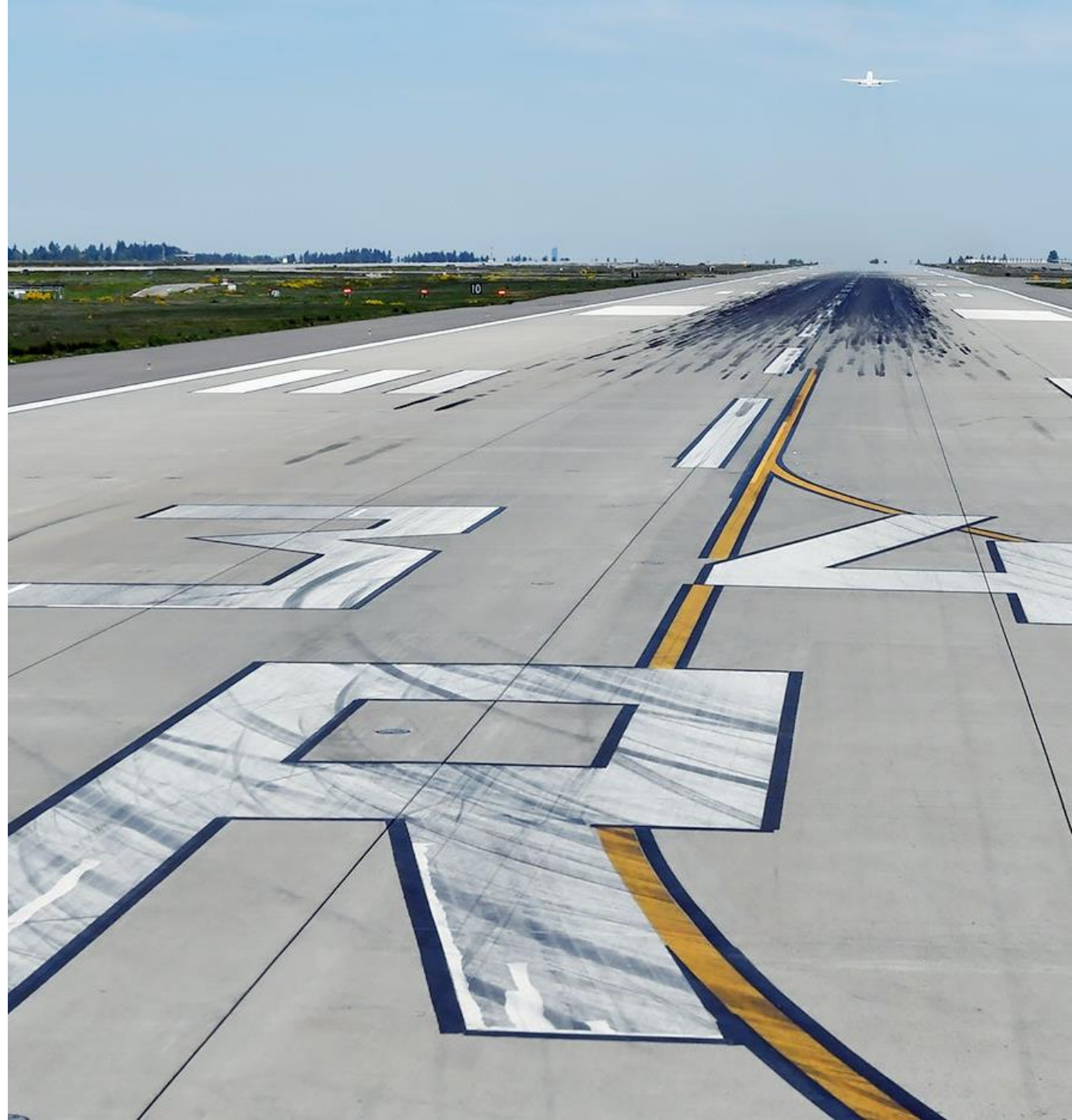
# Acknowledgements

## Mentor

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## Research Assistants

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- Thu Thao Nguyen





Thank You For Listening!

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