DATA+AI SUMMIT 2022

Machine Learning Models to Aid Autism Diagnoses

Using AI for interpretable diagnoses on sparse data

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ORGANIZED BY databricks

Who am I?

Thanks for asking!

- Rising Junior at Lynbrook High School, San Jose, CA
- Professional ~~copy and paster~~ coder
- r/ProgrammerHumor Junkie
- Researcher at Wall Lab, Stanford University

Agenda

Where we are headed

- ML Workflow
  - Introduction
  - Mission
  - Data Processing
  - Model Training
  - Results
- Demo
- Q&A Session

Introduction

Let's get started

- Worked at the Wall Lab ('21–'22)
- Developed a novel ML model(s) for classifying a key indicator of autism in videos for a faster diagnosis
- Demonstrates that ML is feasible for *explainable* diagnoses in healthcare
- Paper is published in JMIR Biomedical Engineering
- Preprint here: https://arxiv.org/abs/2108.07917

Create an ML model to detect hand flapping from crowdsourced videos to aid in an autism diagnosis.

Building a model

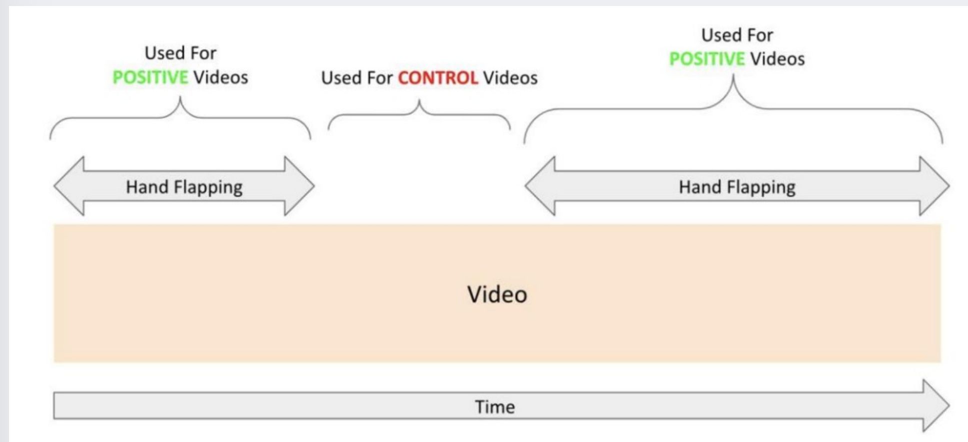
The bare necessities of creating an ML model

- Needed to collect relevant data
- Design a model to train
- Train that model
- Design a fair evaluation technique
- Evaluate that model
- Reiterate

Data Collection

Finally, we're talking data at a data conference!

- Needed videos of hand flapping (and without hand flapping)
- Self Stimulatory Behavior Dataset (SSBD) is the only publicly available dataset with this information
- ≈25 YouTube videos depicting hand flapping stored in XML Files



Data Cleaning

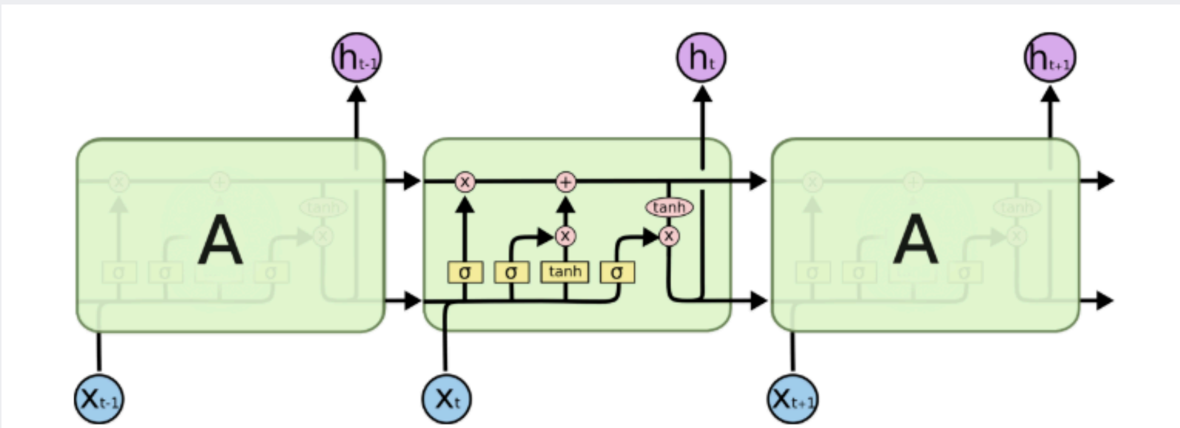
"Bad Data, Bad Data Everywhere"

- Shakiness + Excessive Motion in SSBD
- The application would be on a phone, so videos will be shaky
- Manually cleaned it up

Designing The Model

Long-Short Term Memory Primer

Sorry, it's not a transformer…



The repeating module in an LSTM contains four interacting layers.

$$z_t = \sigma\left(W_z \cdot [h_{t-1}, x_t]\right)$$

$$r_t = \sigma\left(W_r \cdot [h_{t-1}, x_t]\right)$$

$$\tilde{h}_t = \tanh\left(W \cdot [r_t * h_{t-1}, x_t]\right)$$

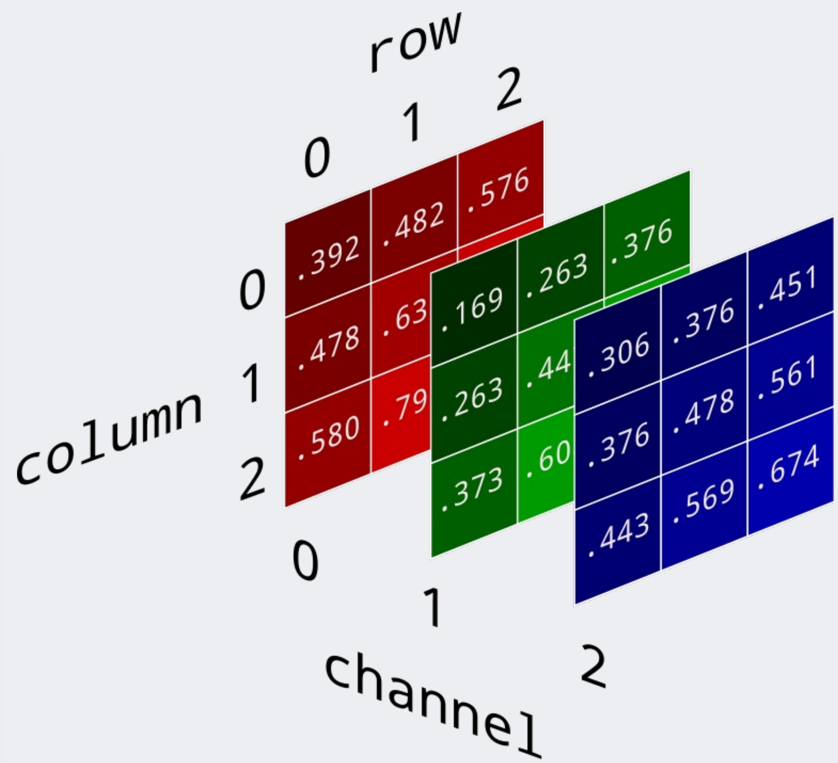
$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

Who even cares about this
when TensorFlow exists

Images are Huge

And machines don't "see" them

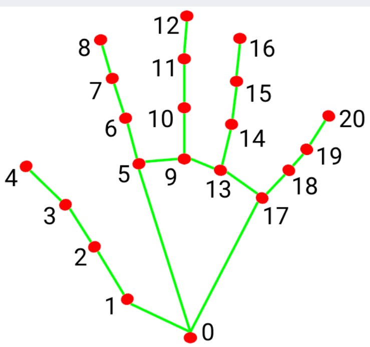
- Usually are around 10^6 floats
- Cannot squish images into vectors and feed them in
- Need to reduce dimensionality



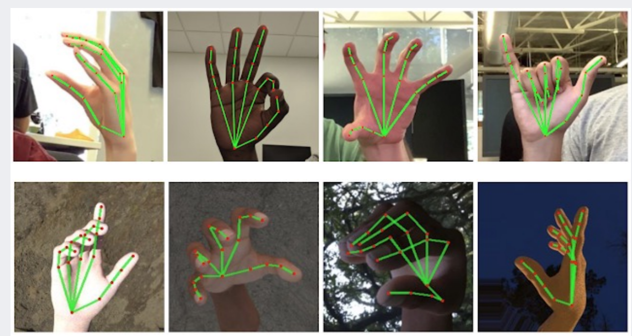
Approach 1: MediaPipe

Gotta start somewhere

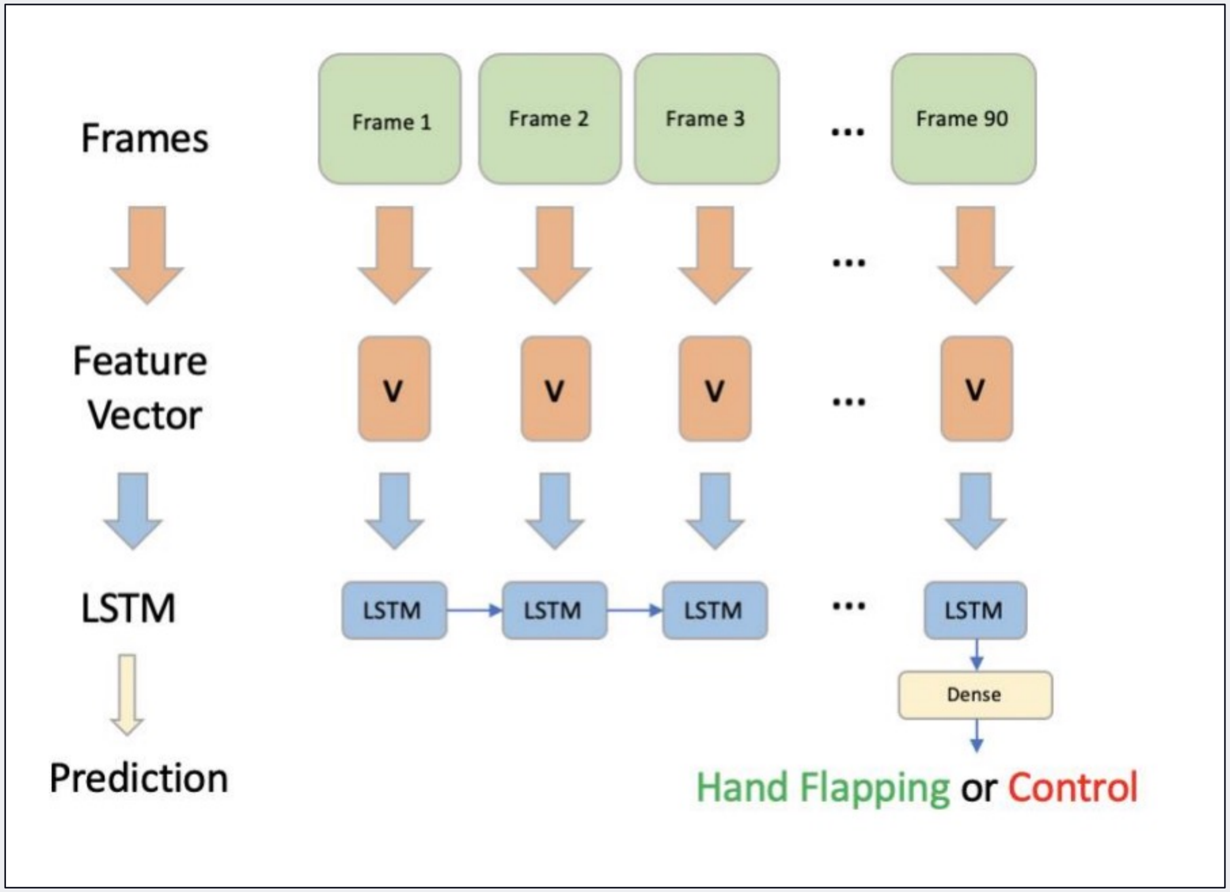
- Made by Google for Pose Estimation and Landmark Detection
- Landmarks = Key Points
- Used Hand Detection => returns the (x, y, z) coordinates for 21 landmarks



0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP
17. PINKY_MCP
18. PINKY_PIP
19. PINKY_DIP
20. PINKY_TIP



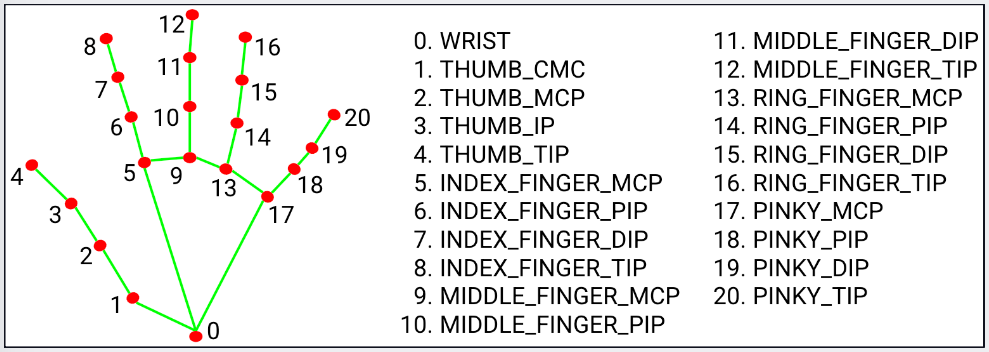
Quick Sketch



Variants of Approach One

Just different takes on the same idea

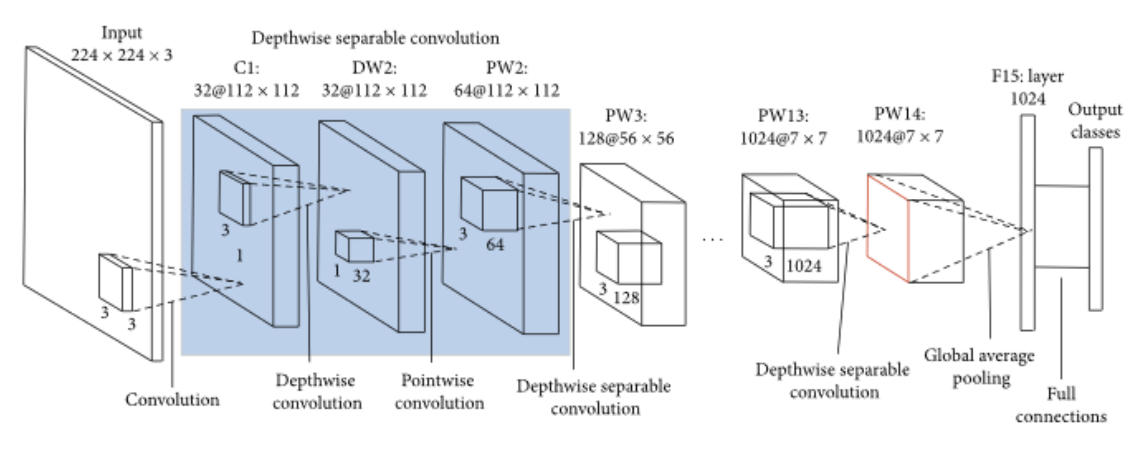
- All Landmarks: Use all 21 Landmarks on Each Hand
- Six Landmarks: Only use finger tips
- Mean Landmark: Take the mean location
- Single Landmark: Only use 1 landmark



Approach 2: MobileNet V2 Pretraining

Just use

- Used MobileNet V2's Convolutional Layers Pretrained on ImageNet
- Fed the extracted vector from these conv layers into the LSTM

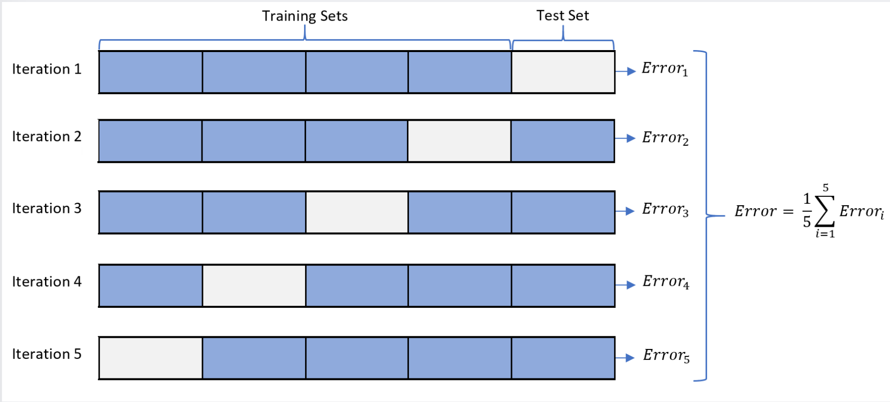


Evaluation Technique

Fair Evaluation: 5-fold Cross Validation 100x

`No cherry-picking!`

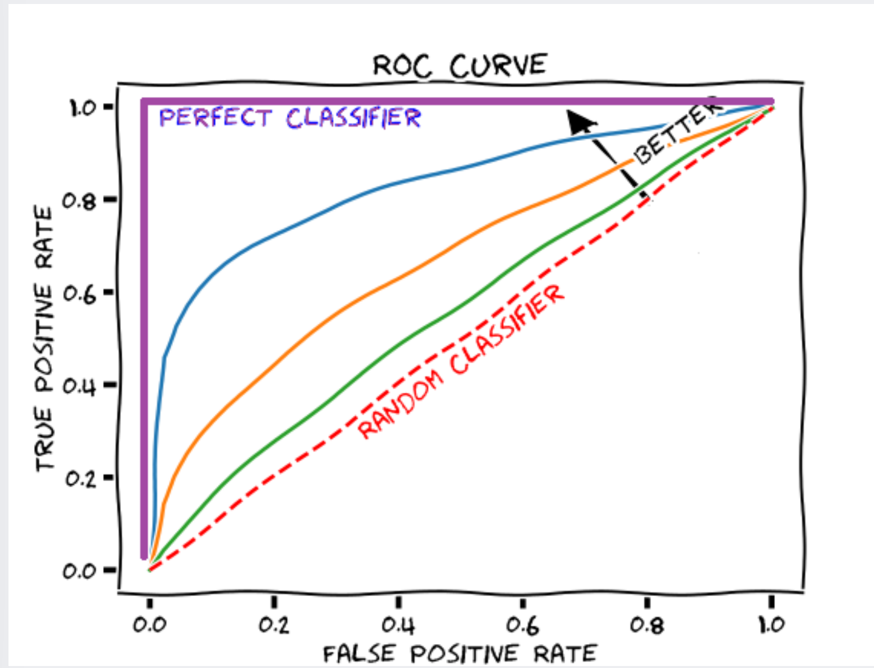
- Created 100 different datasets of 5 folds, and ran 5-fold cross validation on each of them
  - For all approaches (all, six, one, mean landmarks + mobile net)
- Needed for an objective measurement



Metrics

Can't manage what you can't measure

- ROC Curve (*receiver operating characteristics*)
- Accuracy, precision, recall, and F1
- Tracked both training + testing



Results

What I've been stalling all along

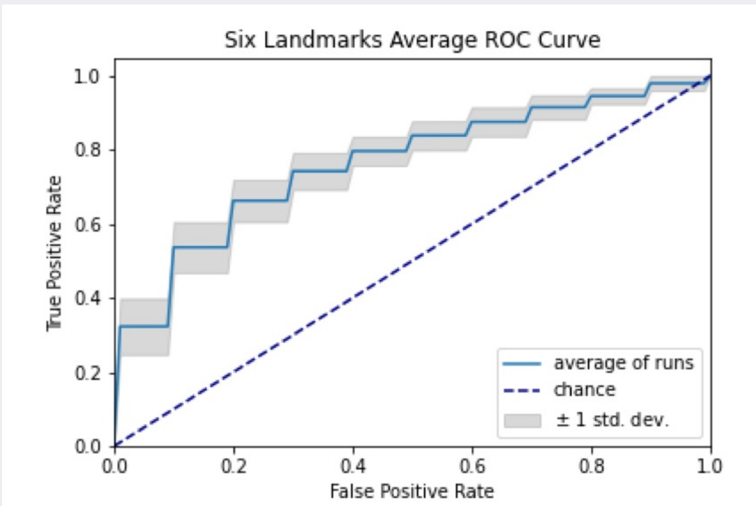
Approach 1: MediaPipe

- Got in the high 69-70%
- Could not overfit to 100% accuracy
- More Fluctuations between variant approaches
- Overall:
  - 1) Six Landmarks
  - 2) All Landmarks
  - 3) Mean Landmark
  - 4) One Landmark

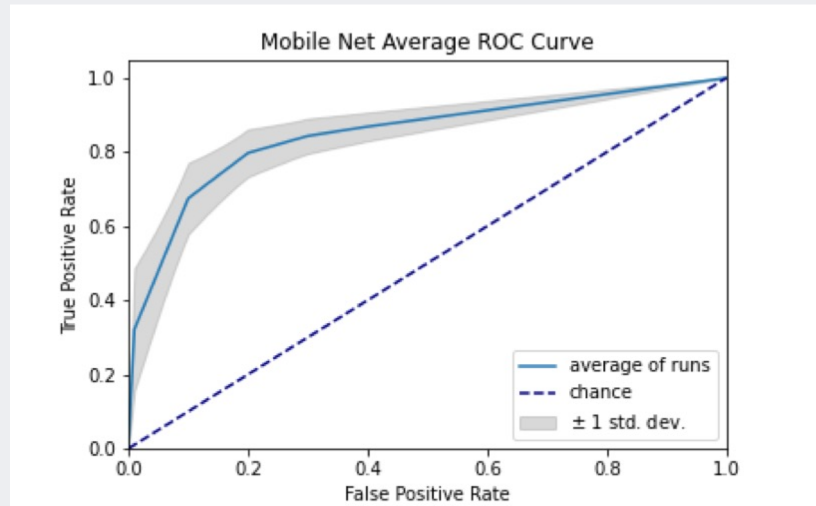
Approach 2: MobileNet V2 Pretrained

- Hovered in the 85% accuracy range
- Had capacity to overfit to 100% accuracy
- Overall a much more accurate model

More Comparisons



Run Type	Accuracy (%)	Precision (%)	Recall (%)	F1 (%)
Training	76.8 ± 1.95	78.7 ± 2.9	74.7 ± 3.5	76.2 ± 2.1
Testing	69.55 ± 2.7	71.7 ± 3.5	67.5 ± 5.5	68.3 ± 3.6



Run Type	Accuracy (%)	Precision (%)	Recall (%)	F1 (%)
Training	97.7 ± 1.0	99.5 ± 0.0	95.9 ± 1.7	97.6 ± 1.0
Testing	85.0 ± 3.14	89.6 ± 4.3	80.4 ± 6.0	84.0 ± 3.7

Code Demo

https://github.com/anish-lakkapragada/Hand-Classification-For-Autism-Diagnosis

Q&A Session!

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Thank you!

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