Detecting Deception through Facial Reading

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Background: Why Lie Detection?

Motivation

- For politicians, detecting dishonestly can foster accountability and trust in governance
- Earnings call and other financial disclosures

Goal

- Develop a face-reading ML model to detect lies from videos
- Less intrusive than traditional lie detection technologies like polygraph

How to Detect Lies: Signs of Deception

Lip Biting

Individuals disclose emotional distress by biting their lips

Micro-Expressions

Uncontrolled emotions like anxiety/fear lasting around ⅛ second before disappearing

Dilated Pupils

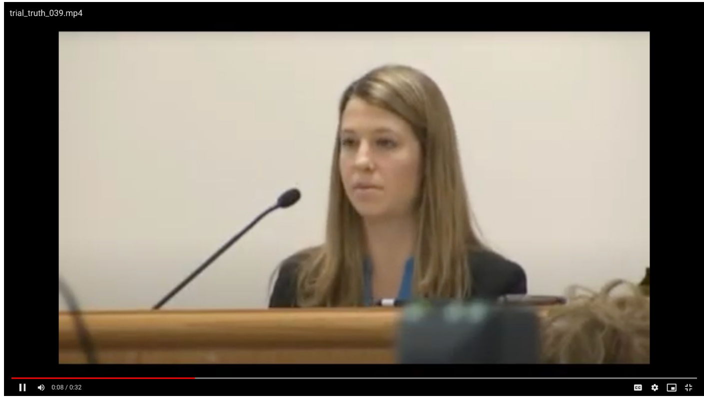
Pupils tend to enlarge when a person is under mental strain

Vocal Tones

Average pitch and fundamental frequency of their voice go up

Dataset

Dataset	No. of Videos	Stakes	Labels	Availability
UMiami	320	Low	160 Truths, 160 Lies	Special Access
Real Life Court Trial	121	High	60 Truths, 61 Lies	Public



Method1: Naive MLP Approach

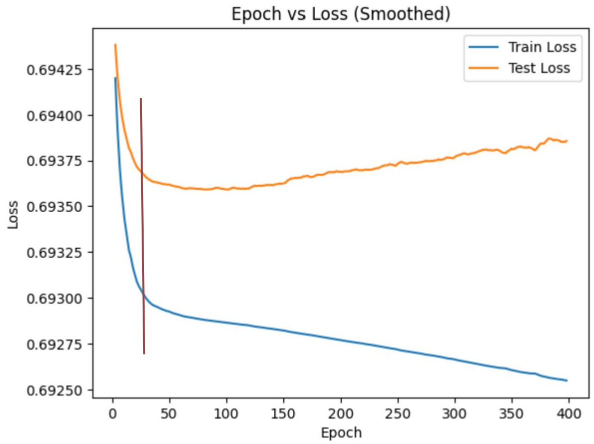
Each Video (U Miami) → Randomly take 40 frames (every 0.1 second) → Collect 478 Facial Landmarks from each frame → MLP

Result:

- Train Accuracy 50%
- Test Accuracy 50%
- Binary Cross Entropy Loss
- Loss decreases very slowly and reaches a limit

Debug:

- Microexpressions may appear anywhere in the video so need to use LSTM

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Epoch 0: train loss 0.6946, test loss 0.6946, train accuracy 0.5000, test accuracy 0.5000
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Epoch 1: train loss 0.6944, test loss 0.6945, train accuracy 0.5000, test accuracy 0.5000
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Epoch 2: train loss 0.6941, test loss 0.6943, train accuracy 0.5000, test accuracy 0.5000
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Epoch 3: train loss 0.6941, test loss 0.6943, train accuracy 0.5000, test accuracy 0.5000
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Epoch 4: train loss 0.6939, test loss 0.6942, train accuracy 0.5000, test accuracy 0.5000
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Epoch 5: train loss 0.6938, test loss 0.6941, train accuracy 0.5000, test accuracy 0.5000
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Epoch 6: train loss 0.6937, test loss 0.6941, train accuracy 0.5000, test accuracy 0.5000
--------------------
Epoch 7: train loss 0.6936, test loss 0.6940, train accuracy 0.5000, test accuracy 0.5000
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Epoch 8: train loss 0.6935, test loss 0.6940, train accuracy 0.5000, test accuracy 0.5000
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Epoch 9: train loss 0.6935, test loss 0.6939, train accuracy 0.5000, test accuracy 0.5000
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Epoch 10: train loss 0.6935, test loss 0.6939, train accuracy 0.5000, test accuracy 0.5000
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Epoch 11: train loss 0.6934, test loss 0.6939, train accuracy 0.5000, test accuracy 0.5000
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Epoch 12: train loss 0.6933, test loss 0.6938, train accuracy 0.5000, test accuracy 0.5000
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Epoch 13: train loss 0.6933, test loss 0.6938, train accuracy 0.5000, test accuracy 0.5000
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Epoch 14: train loss 0.6933, test loss 0.6938, train accuracy 0.5000, test accuracy 0.5000
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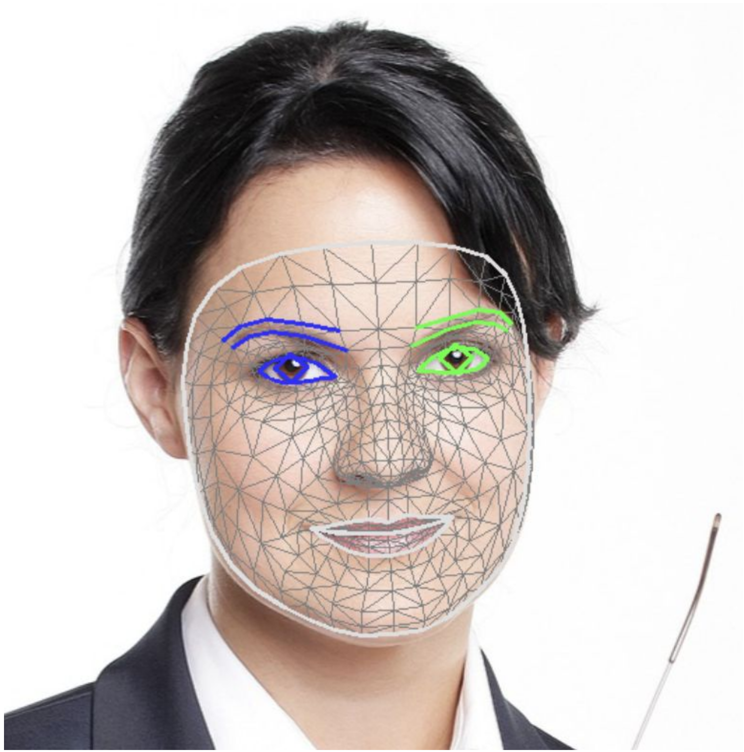
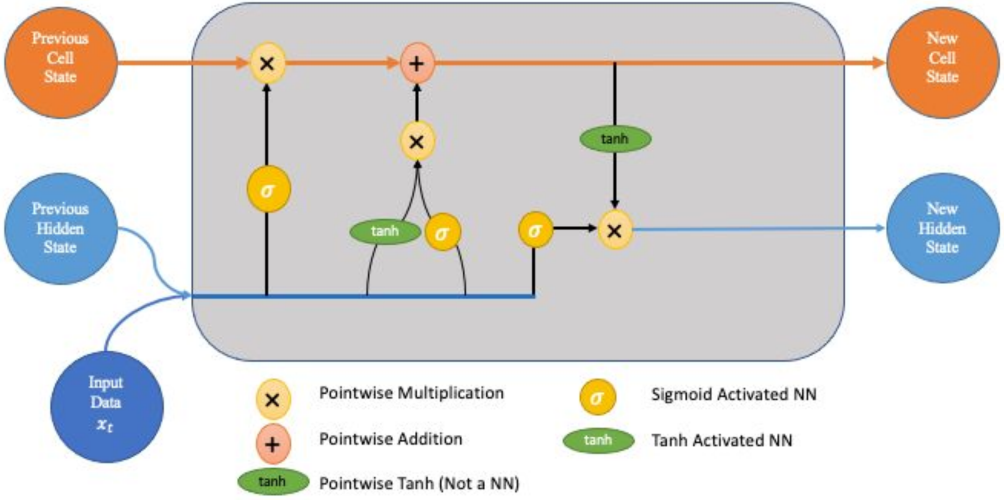
Google MediaPipe

- A python Package for feature extraction
- Facial Landmarks: 2D coordinate that represents important parts of a human face e.g. eyes, nose, mouth
- Each image has 478 facial features which is converted into an array
- XY coordinates are screen coordinates which are normalized to (0-1)

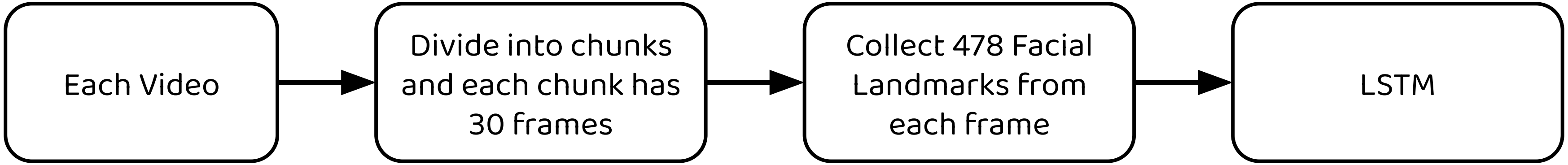


What is LSTM?

- Long short-term memory (LSTM) networks
- It is a type of Recurrent Neural Network (RNN)
- It is particular useful to process data to do with time
- It allows information to selectively remember or forget information over time

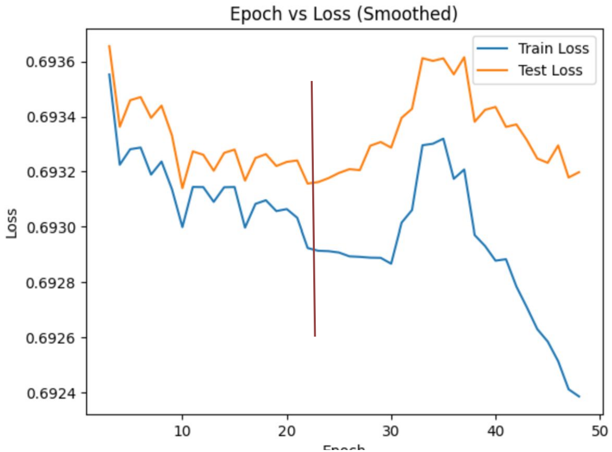


Method2: LSTM with Facial Landmarks



Result:
- Train Accuracy 51%
- Test Accuracy 51%

Debug:
- Too many features (noises)
- Need feature reduction

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Epoch 0: train loss 0.6950, test loss 0.6950, train accuracy 0.5000, test accuracy 0.5000
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Epoch 1: train loss 0.6933, test loss 0.6935, train accuracy 0.5000, test accuracy 0.5000
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Epoch 2: train loss 0.6930, test loss 0.6931, train accuracy 0.5078, test accuracy 0.5098
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Epoch 3: train loss 0.6934, test loss 0.6935, train accuracy 0.4995, test accuracy 0.5000
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Epoch 4: train loss 0.6929, test loss 0.6931, train accuracy 0.5068, test accuracy 0.5039
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Epoch 5: train loss 0.6934, test loss 0.6936, train accuracy 0.4990, test accuracy 0.5000
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Epoch 6: train loss 0.6936, test loss 0.6940, train accuracy 0.5000, test accuracy 0.5000
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Epoch 7: train loss 0.6930, test loss 0.6932, train accuracy 0.5054, test accuracy 0.5176
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Epoch 8: train loss 0.6930, test loss 0.6931, train accuracy 0.4985, test accuracy 0.4941
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Epoch 9: train loss 0.6932, test loss 0.6933, train accuracy 0.5049, test accuracy 0.5039
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Epoch 10: train loss 0.6929, test loss 0.6930, train accuracy 0.5098, test accuracy 0.4883
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Epoch 11: train loss 0.6929, test loss 0.6930, train accuracy 0.5132, test accuracy 0.5156
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Epoch 12: train loss 0.6938, test loss 0.6938, train accuracy 0.5000, test accuracy 0.5000
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Epoch 13: train loss 0.6930, test loss 0.6931, train accuracy 0.5059, test accuracy 0.4902
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Epoch 14: train loss 0.6929, test loss 0.6930, train accuracy 0.5161, test accuracy 0.5098
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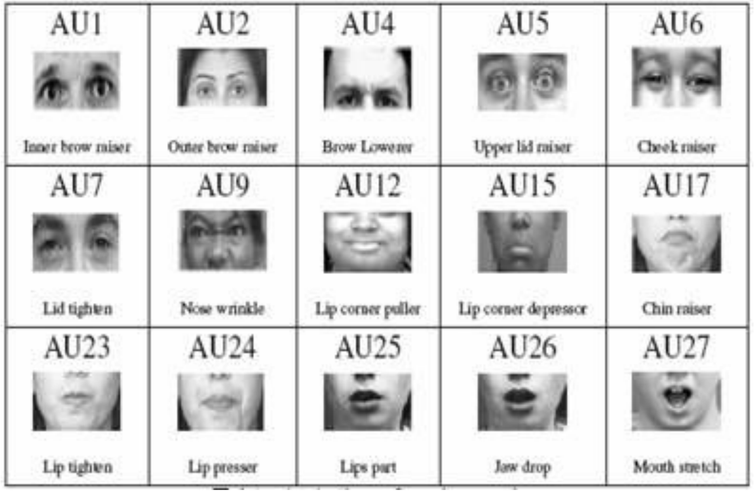
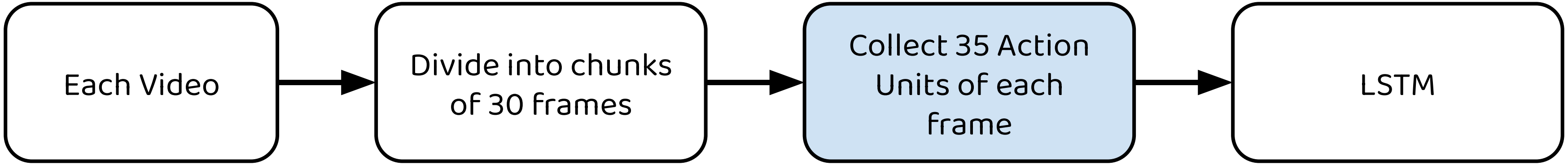
Action Units

- Facial Action Coding System (FACS) is a system developed by Paul Ekman in 1970s
- Action Units (AUs) track the movements of individual or group facial muscles.
- OpenFace is able to detect 35 Action Units
  - Judges existence of 18 AUs
  - Score intensity of 17 AUs
- Action Units are determined using facial landmarks

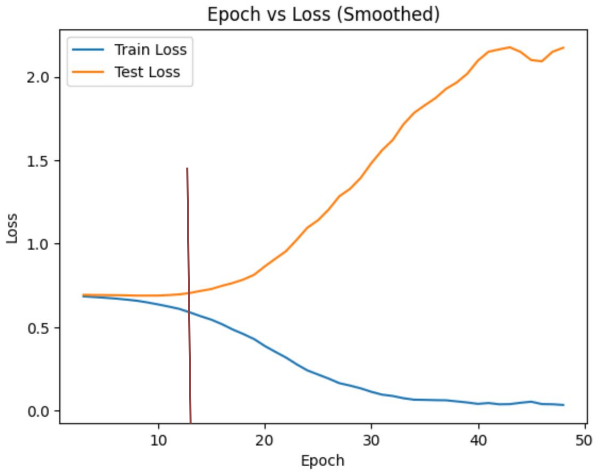


Method3: LSTM with Action Units



Result:
- Train Accuracy 99%
- Test Accuracy 57%

Debug:
- Dataset has low stakes

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Epoch 0: train loss 0.6894, test loss 0.6939, train accuracy 0.5318, test accuracy 0.4925
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Epoch 1: train loss 0.6890, test loss 0.6929, train accuracy 0.5470, test accuracy 0.5075
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Epoch 2: train loss 0.6827, test loss 0.6926, train accuracy 0.5581, test accuracy 0.5119
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Epoch 3: train loss 0.6782, test loss 0.6925, train accuracy 0.5555, test accuracy 0.5040
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Epoch 4: train loss 0.6819, test loss 0.6943, train accuracy 0.5682, test accuracy 0.5190
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Epoch 5: train loss 0.6695, test loss 0.6899, train accuracy 0.5768, test accuracy 0.5248
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Epoch 6: train loss 0.6680, test loss 0.6904, train accuracy 0.5887, test accuracy 0.5155
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Epoch 7: train loss 0.6585, test loss 0.6889, train accuracy 0.6057, test accuracy 0.5336
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Epoch 8: train loss 0.6472, test loss 0.6882, train accuracy 0.6151, test accuracy 0.5358
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Epoch 9: train loss 0.6476, test loss 0.6860, train accuracy 0.6246, test accuracy 0.5504
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Epoch 10: train loss 0.6183, test loss 0.6909, train accuracy 0.6486, test accuracy 0.5584
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Epoch 11: train loss 0.6074, test loss 0.6910, train accuracy 0.6627, test accuracy 0.5544
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Epoch 12: train loss 0.5948, test loss 0.7032, train accuracy 0.6705, test accuracy 0.5566
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Epoch 13: train loss 0.5763, test loss 0.7100, train accuracy 0.6928, test accuracy 0.5681
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Epoch 14: train loss 0.5413, test loss 0.7282, train accuracy 0.7238, test accuracy 0.5561
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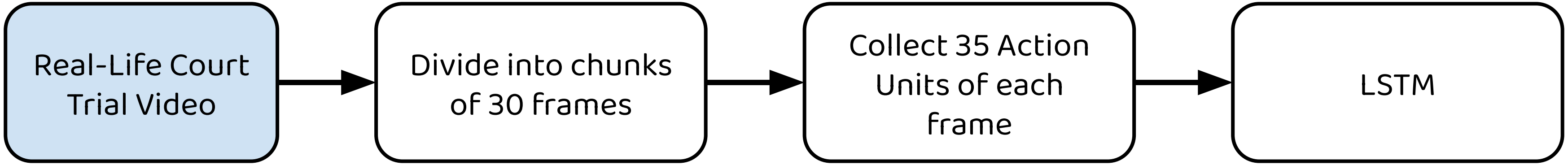
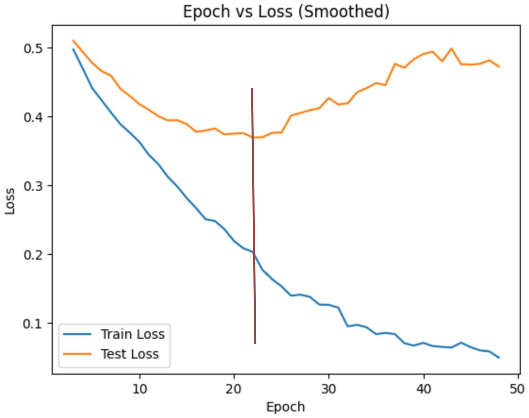
Method3: LSTM with Action Units



Result:

- Train Accuracy 99%
- Test Accuracy 86%

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Epoch 14: train loss 0.2857, test loss 0.3753, train accuracy 0.8632, test accuracy 0.8111
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Epoch 15: train loss 0.2777, test loss 0.4047, train accuracy 0.8632, test accuracy 0.8331
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Epoch 16: train loss 0.2446, test loss 0.3775, train accuracy 0.8859, test accuracy 0.8263
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Epoch 17: train loss 0.2273, test loss 0.3389, train accuracy 0.8939, test accuracy 0.8583
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Epoch 18: train loss 0.2176, test loss 0.4017, train accuracy 0.9027, test accuracy 0.8263
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Epoch 19: train loss 0.2721, test loss 0.3901, train accuracy 0.8813, test accuracy 0.8179
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Epoch 20: train loss 0.2187, test loss 0.3617, train accuracy 0.9011, test accuracy 0.8314
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Epoch 21: train loss 0.1596, test loss 0.3835, train accuracy 0.9267, test accuracy 0.8516
--------------------
Epoch 22: train loss 0.1732, test loss 0.3422, train accuracy 0.9385, test accuracy 0.8600
--------------------
Epoch 23: train loss 0.1913, test loss 0.3701, train accuracy 0.9162, test accuracy 0.8482
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Epoch 24: train loss 0.1439, test loss 0.3908, train accuracy 0.9427, test accuracy 0.8634
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Epoch 25: train loss 0.1480, test loss 0.3951, train accuracy 0.9385, test accuracy 0.8482
--------------------
Epoch 26: train loss 0.1077, test loss 0.3850, train accuracy 0.9566, test accuracy 0.8651
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Epoch 27: train loss 0.1052, test loss 0.4657, train accuracy 0.9562, test accuracy 0.8499
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Epoch 28: train loss 0.1985, test loss 0.3892, train accuracy 0.9162, test accuracy 0.8550
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Epoch 29: train loss 0.1283, test loss 0.4113, train accuracy 0.9427, test accuracy 0.8432
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Epoch 30: train loss 0.0917, test loss 0.4093, train accuracy 0.9655, test accuracy 0.8651
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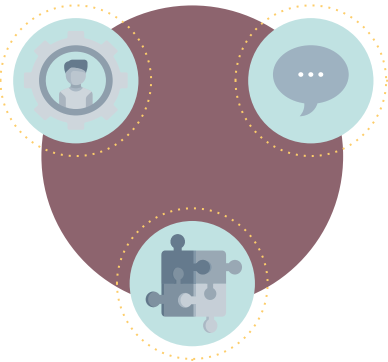
Challenges



Suitable Data

There are only a few datasets available (lab setting) because people are reluctant to have videos of themselves lying posted online.

Video processing

In class, our focus was primarily on image processing. However, since we were working with videos, we had to explore methods for data processing.

LSTM Model

LSTM wasn't covered in our class, and we're encountering issues using it with our dataset

Future Plan

Euclidean Distance

Use Euclidean distance to calculate the movement between different frames

Incorporating Text and Audio Data

Audio signals such as pitch, tone, and intonation, may convey emotional states or psychological stressors indicative of dishonesty.

Reduce # of Landmark

Focus on specific landmarks, such as eye movements, to reduce the number of landmarks and assess if there is any change in accuracy

Works Cited

Ahmed Khan, H.U.D., Bajwa, U.I., Ratyal, N.I. et al. Deception detection in videos using the facial action coding system. Multimed Tools Appl (2024). https://doi.org/10.1007/s11042-024-19153-4

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Thank You!