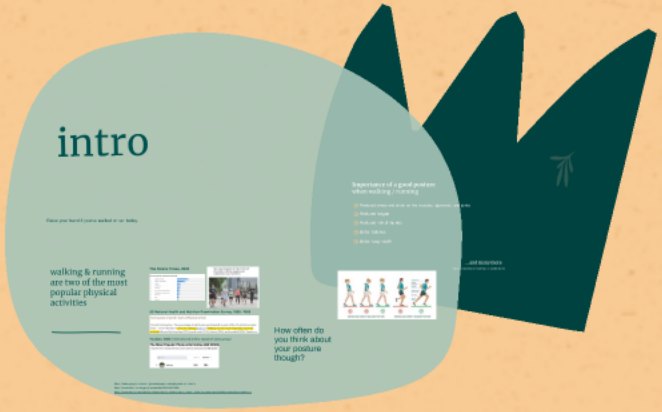
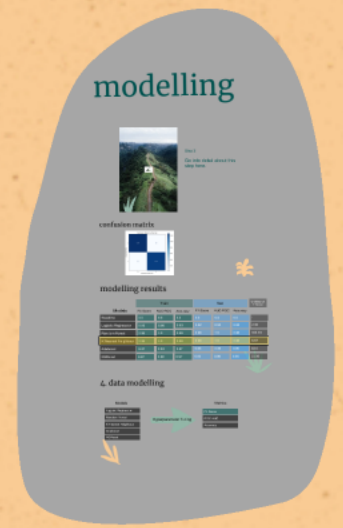
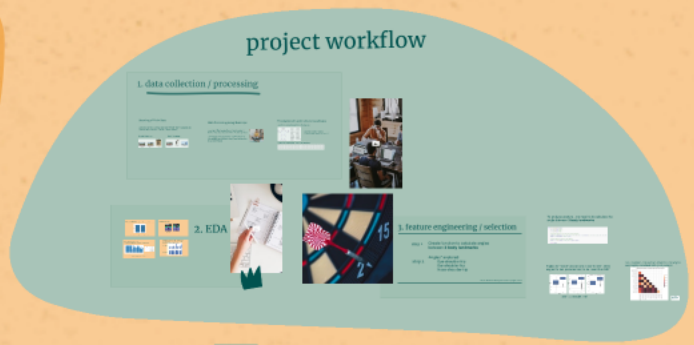
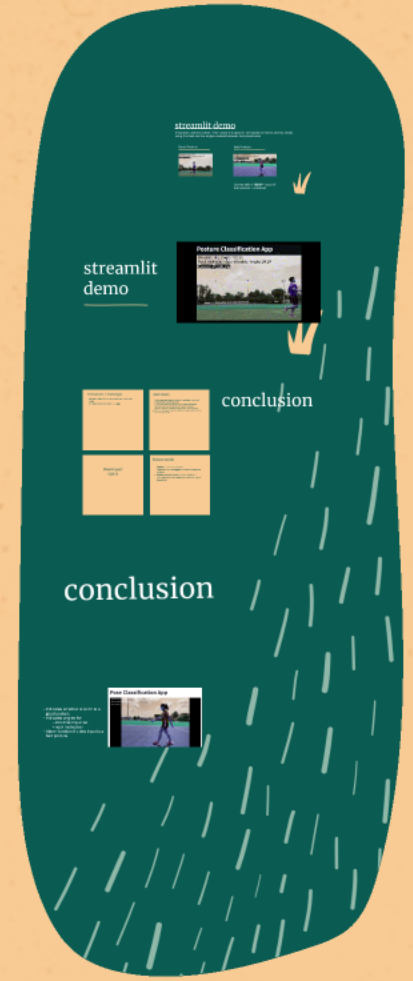
posture analysis.

capstone project









by Tiffany

Raise your hand if you've walked or run today.

walking & running are two of the most popular physical activities

The Straits Times, 2023

Top 10 activities for young adults (aged 20-39)

1	Jogging / running*	42%
2	Walking / brisk walking	30%
3	Cycling	12%
4	Calisthenics	12%
5	Swimming	11%
6	Other workout with equipment**	7%
7	Weightlifting / weight training	7%
8	Badminton	6%
9	Yoga	5%
10	Treadmill	3%

Sport participation in S'pore hits all-time high; walking, jogging and calisthenics top 3 activities

US National Health and Nutrition Examination Survey, 1999 - 2006

Participation in Specific Types of Physical Activity

Overall Participation The percentage of adults who participated in each of the 33 activities varied from < 1% for hockey to 34% for walking (Table 3). Walking was the most frequently reported activity followed by bicycling (12%), yard work (11%), dance (8%), and treadmill (8%). Similar to

YouGov, 2023 *(international online research data group)*

The Most Popular Physical Activities (Q3 2023)

Popularity is the % of people who have a positive opinion of a physical activity. **Find out more**

Search | Fame | **Popularity**

1	Walking	95%	**78%**

How often do you think about your posture though?

Importance of a good posture when walking / running

- Reduced stress and strain on the muscles, ligaments, and joints
- Reduced fatigue
- Reduced risk of injuries
- Better balance
- Better lung health

... and many more

https://www.healthline.com/health/how-to-walk#bottom-line

problem statement

In pursuit of a healthy lifestyle, many individuals turn to running or walking as a form of exercise.

However, poor running or walking posture can lead to unnecessary stress and strain on muscles and joints. **Poor posture can cause pain and injuries in up to 79% of adults, with low back pain affecting 25% of adults every year.**

Existing methods: Visiting a chiropractor for posture assessment - often *costly* and *inaccessible*.
Gap in market: no existing apps that track posture analysis.

objective

This project aims to **empower individuals to improve their running / walking postures** by leveraging computer vision to develop a classification model app *that identifies good or bad postures.*

target audience

casual runners / walkers

project workflow

1. Data Collection / Processing
   using Mediapipe
2. Exploratory Data Analysis
3. Feature Engineering
4. Data Modelling
   Evaluating Classification Models + Hyperparameter Tuning
5. Conclusion

project workflow

1. data collection / processing

Sourcing of Train Data

Collected photos and videos (self-filmed / from Google) and defined their classes - Good or Bad posture

Good Posture:

Bad Posture:

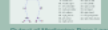
Data Processing using *Mediapipe*

Leveraged **Mediapipe Pose Landmarker** to identify key body locations from videos / photos.

It leverages existing trained machine learning (ML) models and outputs body pose landmarks in 3D coordinates

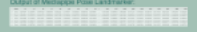
Translation of Landmarks to Coordinates

Landmark coordinates from Mediapipe



33 pose detection points,
4 coordinates per point (x,y,z,vis)

Output of Mediapipe Pose Landmarker:



2. EDA

3. feature engineering / selection

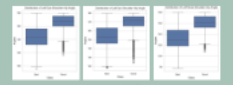
step 1 Create function to calculate angles between **3 body landmarks**

step 2 Angles* explored:
- Eye-shoulder-hip
- Ear-shoulder-hip
- Nose-shoulder-hip

*As per literature showing the "correct" upright posture

To analyse posture - we need to to calculate the angle between **3 body landmarks**

Angles for "Good" posture are closer to 180°, while angles for bad postures tend to be lower than 180°



180° == straight line!

Eye-Shoulder-Hip and Ear-Shoulder-Hip angles were highly correlated with good postures

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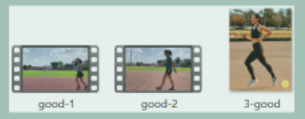

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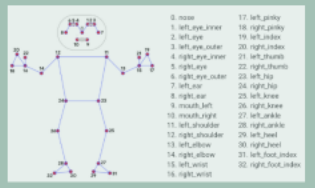
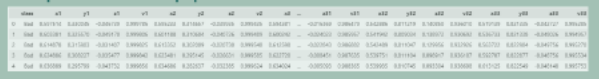
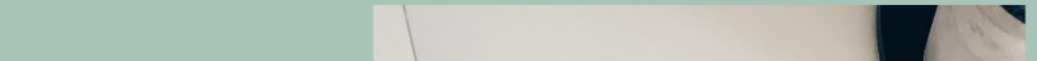


33 joints detection points,
4 coordinates per point (x,y,z,v*)

Output of Mediapipe Pose Landmarker:





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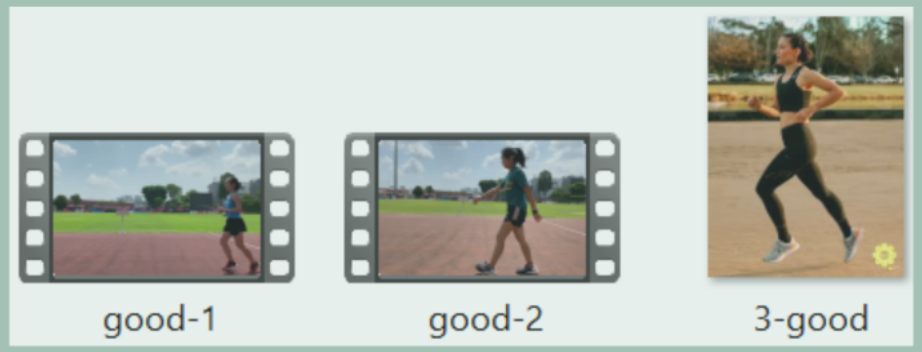
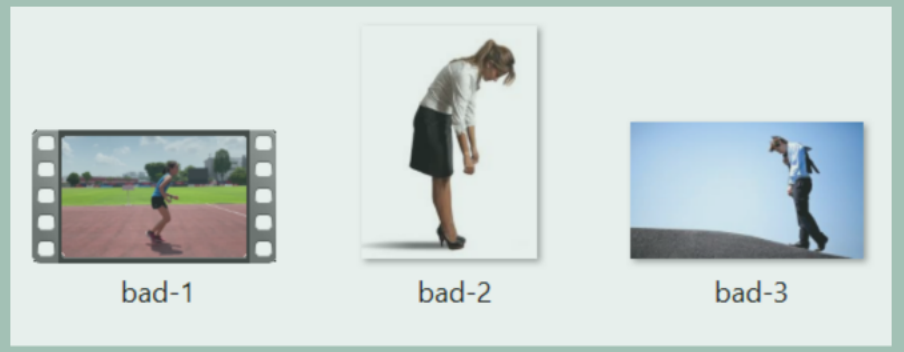


Bad Posture:



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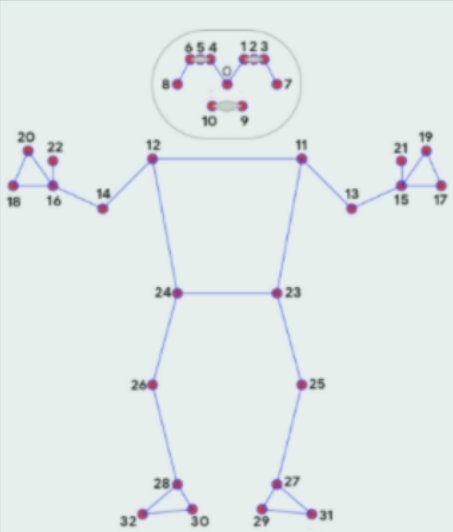


0. nose
1. left_eye_inner
2. left_eye
3. left_eye_outer
4. right_eye_inner
5. right_eye
6. right_eye_outer
7. left_ear
8. right_ear
9. mouth_left
10. mouth_right
11. left_shoulder
12. right_shoulder
13. left_elbow
14. right_elbow
15. left_wrist
16. right_wrist
17. left_pinky
18. right_pinky
19. left_index
20. right_index
21. left_thumb
22. right_thumb
23. left_hip
24. right_hip
25. left_knee
26. right_knee
27. left_ankle
28. right_ankle
29. left_heel
30. right_heel
31. left_foot_index
32. right_foot_index

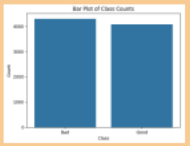
33 joints detection points,
4 coordinates per point (x,y,z,v*)

Output of Mediapipe Pose Landmarker:

	class	x1	y1	z1	v1	x2	y2	z2	v2	x3	...	z31	v31	x32	y32	z32	v32	x33	y33	z33	v33
0	Bad	0.597514	0.330045	-0.046739	0.999786	0.595233	0.314657	-0.039935	0.999435	0.594381	...	-0.016369	0.986479	0.542886	0.811219	0.140850	0.936010	0.519139	0.821335	-0.042727	0.995285
1	Bad	0.603381	0.325570	-0.049170	0.999806	0.601188	0.310604	-0.040726	0.999489	0.600242	...	-0.024023	0.985957	0.541942	0.809034	0.138972	0.930692	0.536733	0.821338	-0.048026	0.994957
2	Bad	0.614878	0.315903	-0.031407	0.999825	0.613352	0.302009	-0.020730	0.999540	0.612598	...	-0.022843	0.986882	0.542489	0.811047	0.129956	0.932926	0.563722	0.822904	-0.049756	0.995270
3	Bad	0.624886	0.308227	-0.035477	0.999842	0.623481	0.295145	-0.026631	0.999585	0.622720	...	-0.008451	0.987635	0.539751	0.811104	0.098917	0.936107	0.592707	0.822877	-0.048756	0.995534
4	Bad	0.636889	0.295799	-0.043732	0.999856	0.634686	0.282637	-0.032385	0.999624	0.634024	...	-0.005093	0.988365	0.539935	0.810745	0.093304	0.938698	0.613125	0.822549	-0.048148	0.995753

2. EDA

Check 1: Balanced class
Even class distribution of training data for unbiased classification model



Count refers to number of frames from photos / videos

Mediapipe overlays

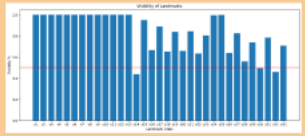
Good

Angle between head, shoulder and hip ~= 180°

Bad

Angle between head, shoulder and hip ≠ 180°

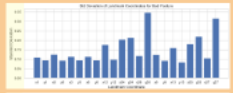
Check 2: Completeness of Data
Checking for null values using Mediapipe's visibility coordinates



Some extremities were not very visible (below 50% visibility)...
but that's ok because they do not affect *posture*

Standard deviation of coordinates for **good posture** was lower, suggesting that good posture is characterised by more *consistent alignment of body's landmarks*

Bad Posture



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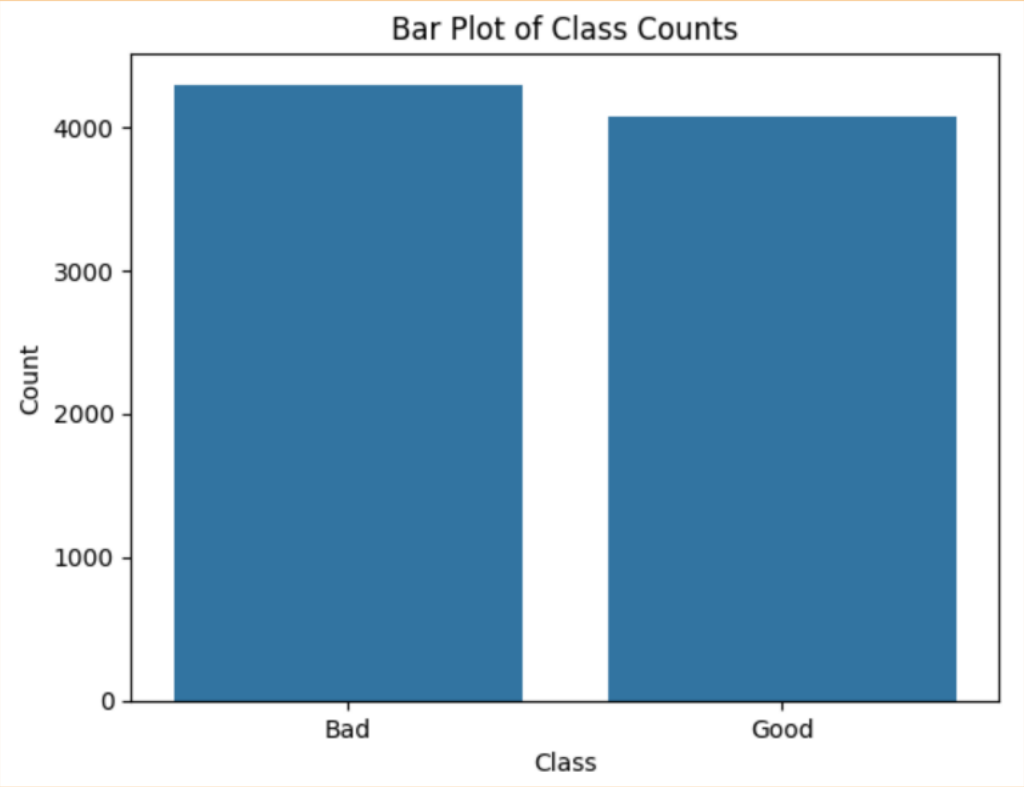

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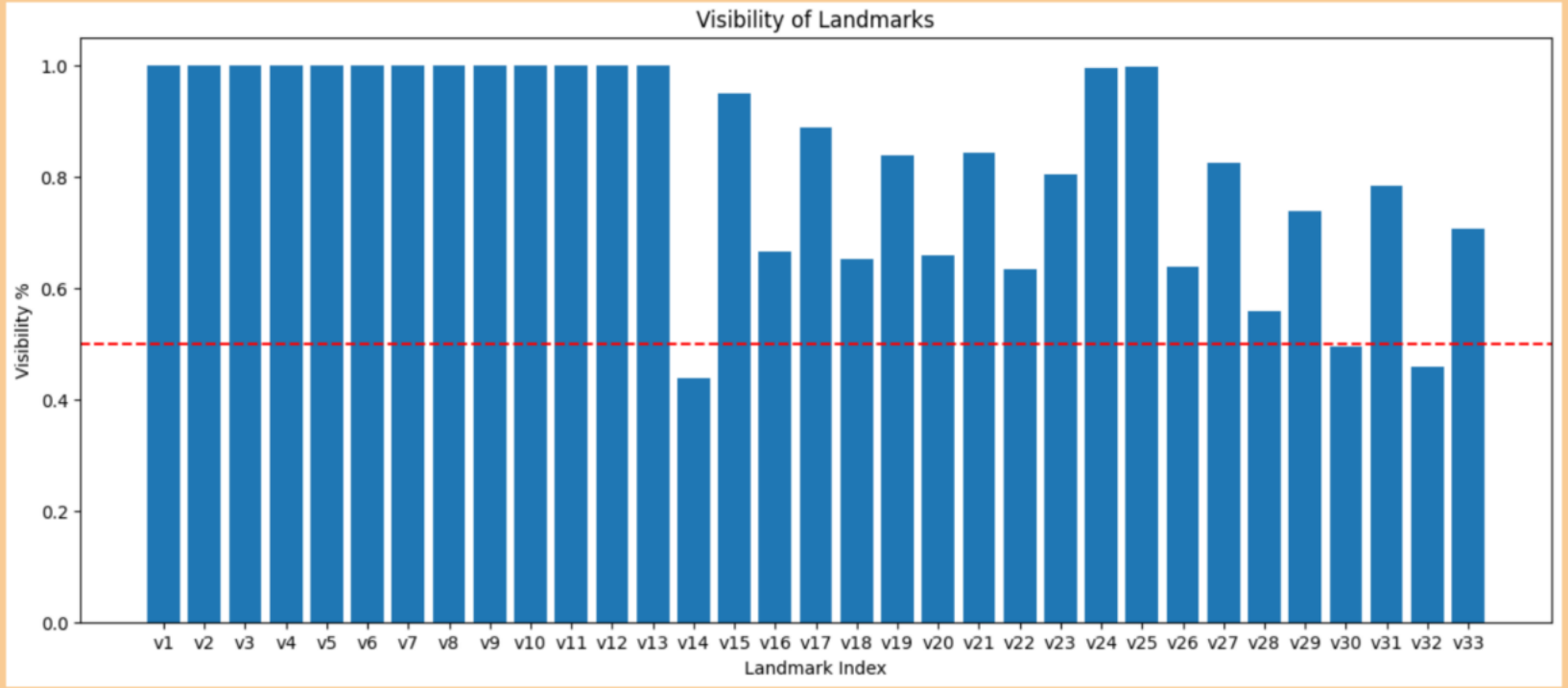

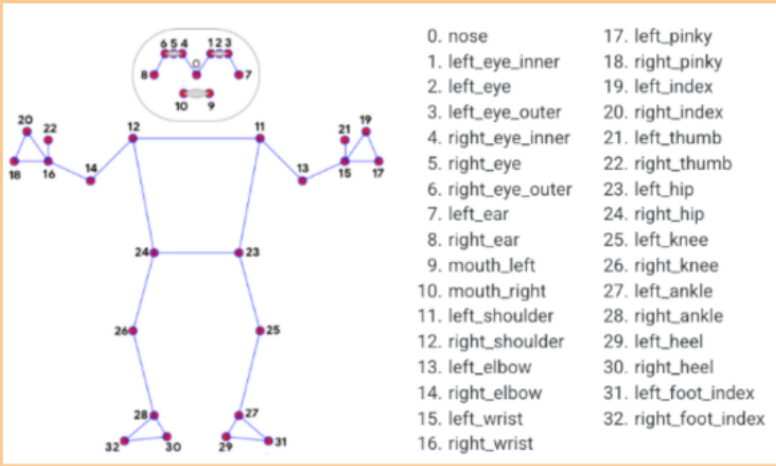

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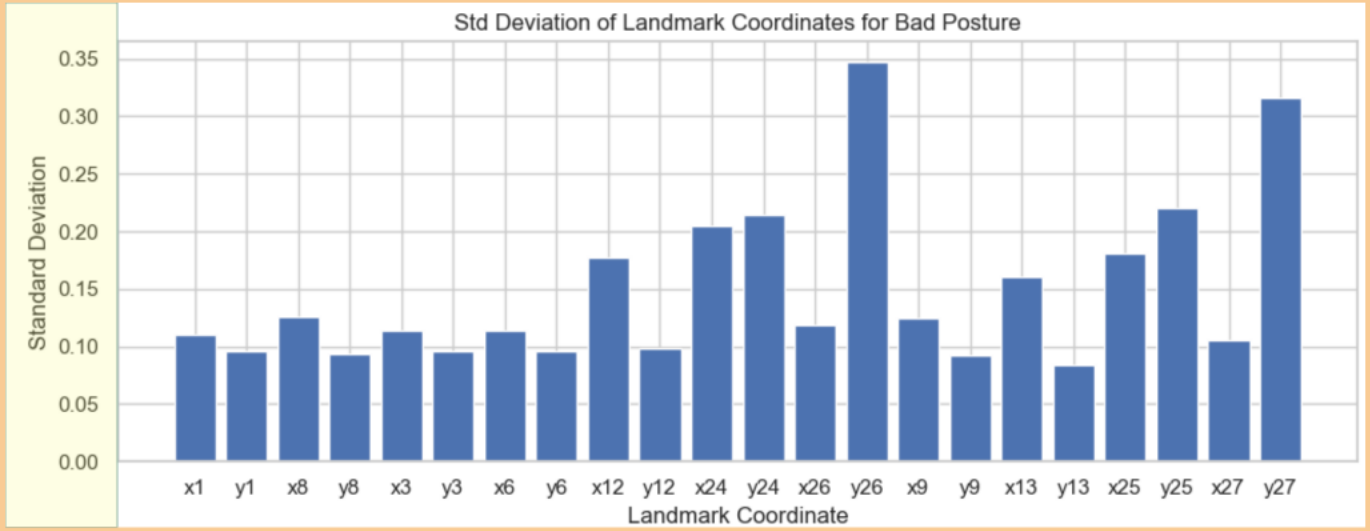

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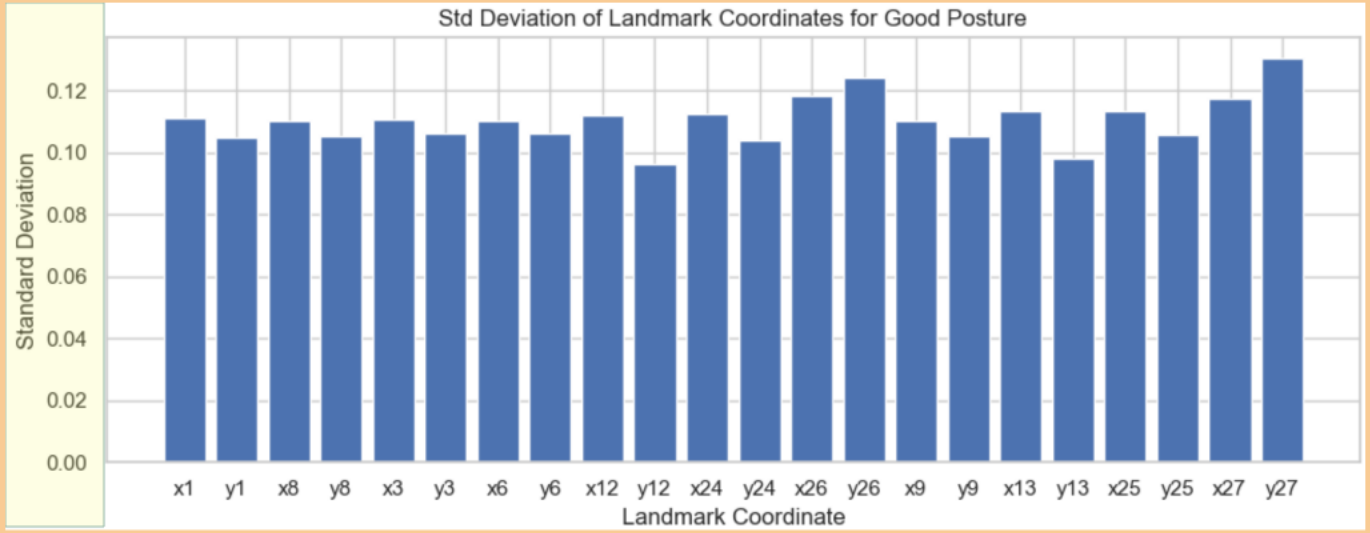

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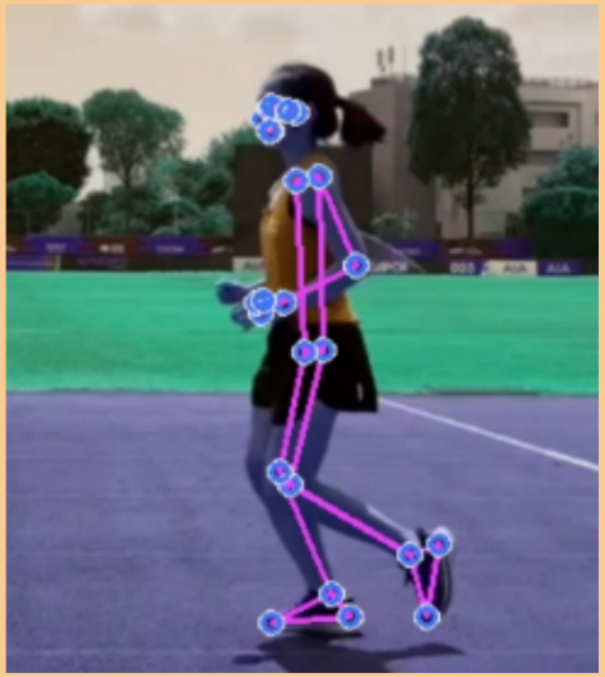

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3. feature engineering / selection

step 1 — Create function to calculate angles between **3 body landmarks**

step 2 — Angles* explored:

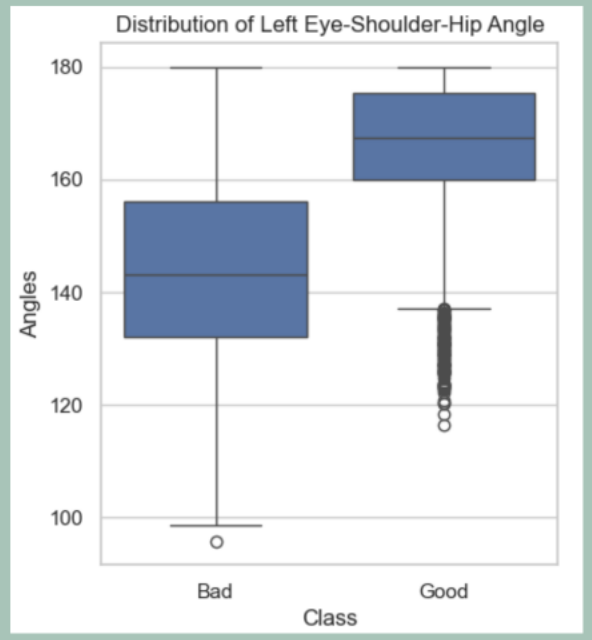
- Eye-shoulder-hip
- Ear-shoulder-hip
- Nose-shoulder-hip

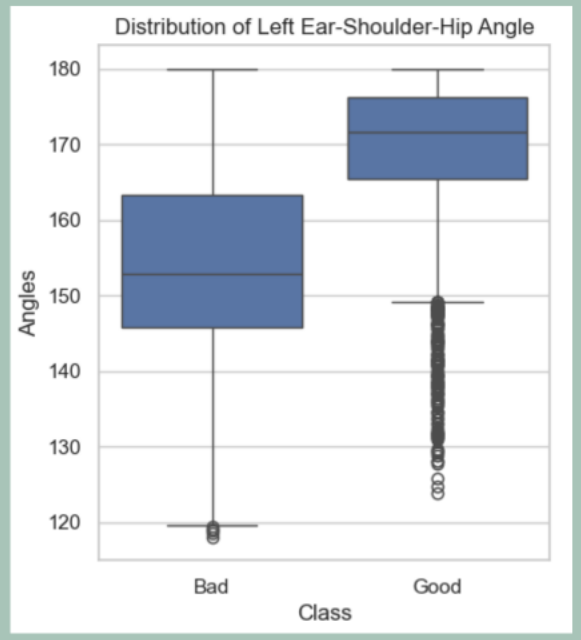
**As per literature showing the "correct" upright posture*

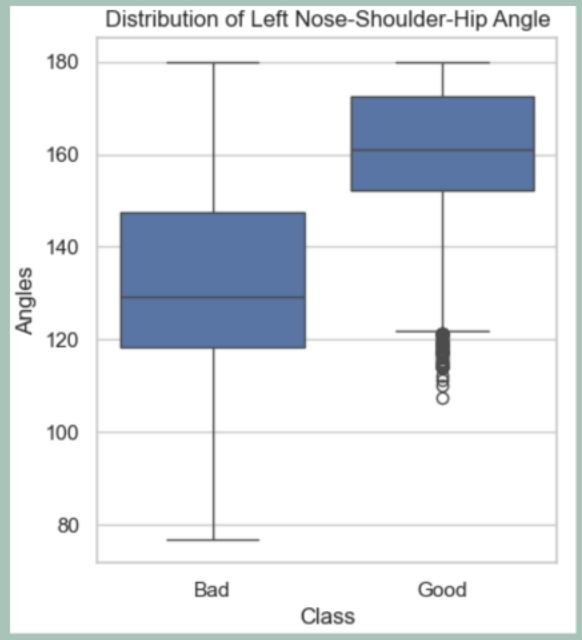
To analyse posture - we need to to calculate the angle between **3 body landmarks**

```python
def calculate_angle(a,b,c):
    a = np.array(a) # First
    b = np.array(b) # Mid
    c = np.array(c) # End

    # Calculate angles for all rows using vector operations
    radians = np.arctan2(c[:, 1] - b[:, 1], c[:, 0] - b[:, 0]) - np.arctan2(a[:, 1] - b[:, 1], a[:, 0] - b[:, 0])
    angles = np.abs(radians * 180.0 / np.pi)

    # Ensure angles are within [0, 360) degrees
    angles = np.where(angles > 180.0, 360 - angles, angles)

    return angles
```

Angles for "Good" posture are closer to 180°, while angles for bad postures tend to be lower than 180°

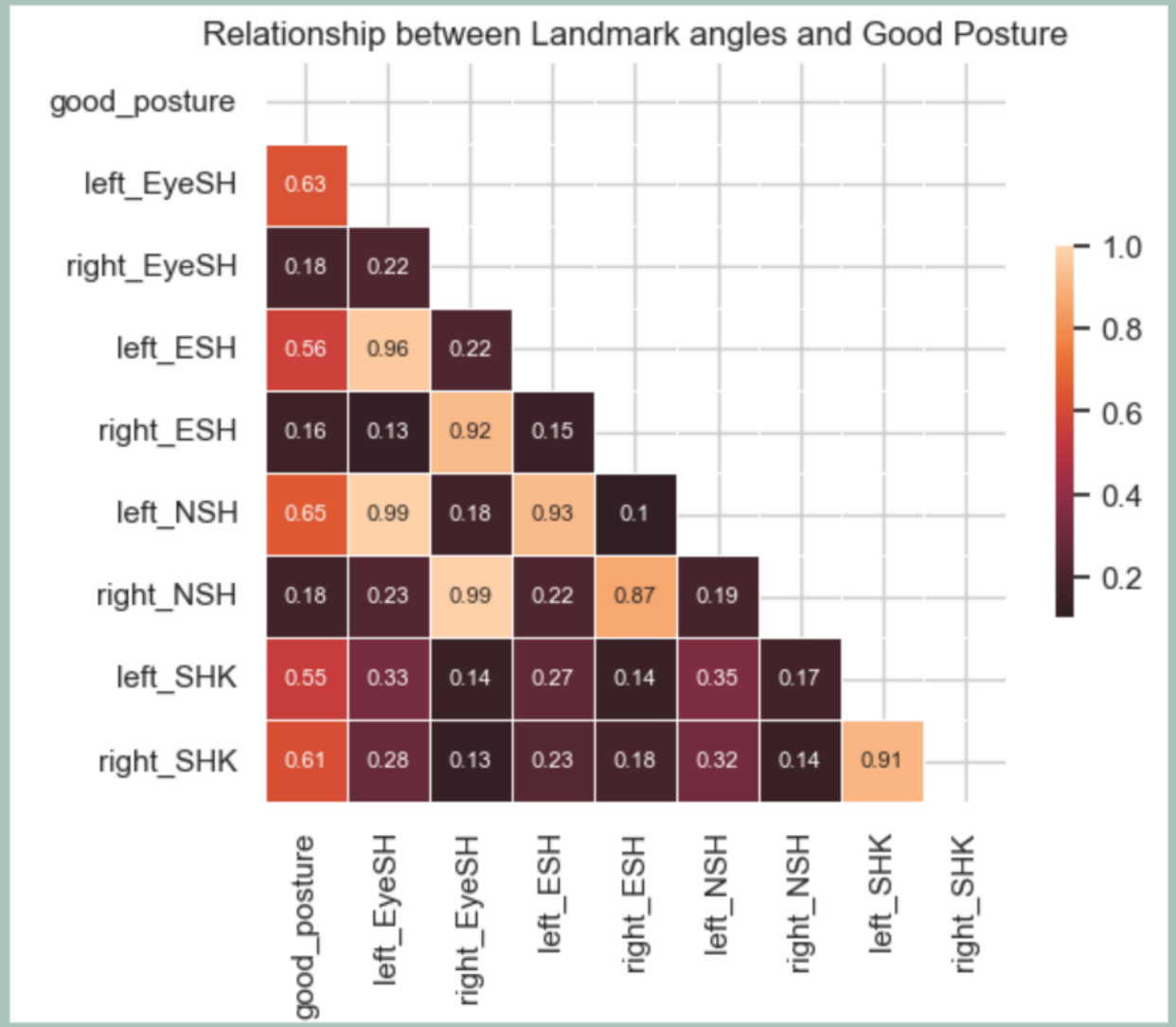






180° == straight line!

Eye-Shoulder-Hip and Ear-Shoulder-Hip angles were highly correlated with good postures



Left side angles tend to have higher correlation as most of my train data was taken from the left side

4. data modelling

Models

- Logistic Regression
- Random Forest
- K Nearest Neighbour
- Adaboost
- XGBoost

Hyperparameter Tuning

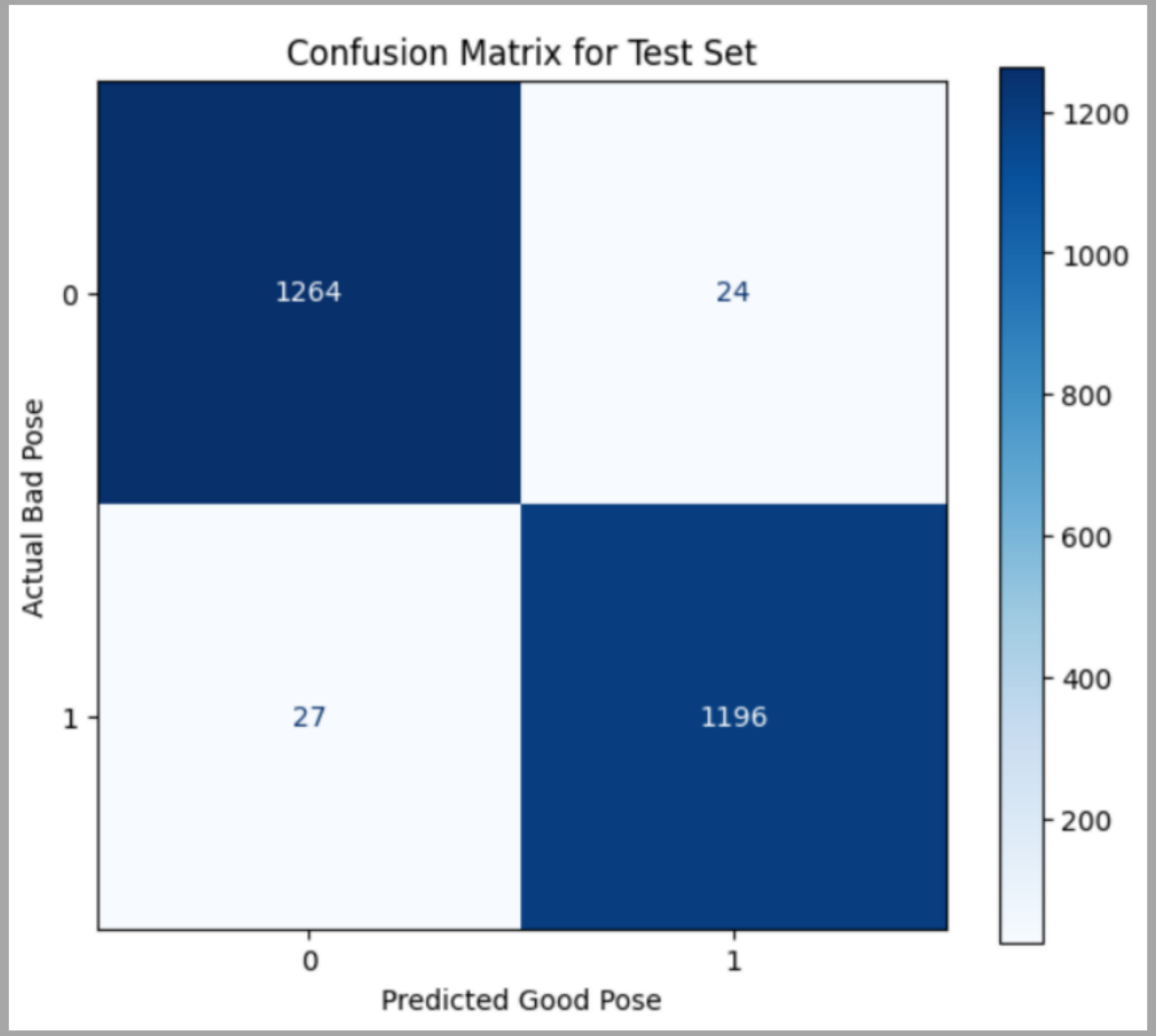
Metrics

- F1 Score
- ROC-AUC
- Accuracy

modelling results

Models	Train			Test			GridSearch Time (s)
	F1-Score	AUC-ROC	Accuracy	F1-Score	AUC-ROC	Accuracy	
Baseline	0.5	0.5	0.5	0.5	0.5	0.5	-
Logistic Regression	0.93	0.96	0.93	0.92	0.95	0.92	2.65
Random Forest	0.99	1.0	0.99	0.98	1.0	0.98	105.28
K Nearest Neighbour	0.99	1.0	0.99	0.98	1.0	0.98	5.57
Adaboost	0.97	0.99	0.97	0.95	0.98	0.95	53.0
XGBoost	0.97	0.99	0.97	0.95	0.98	0.95	15.56

confusion matrix



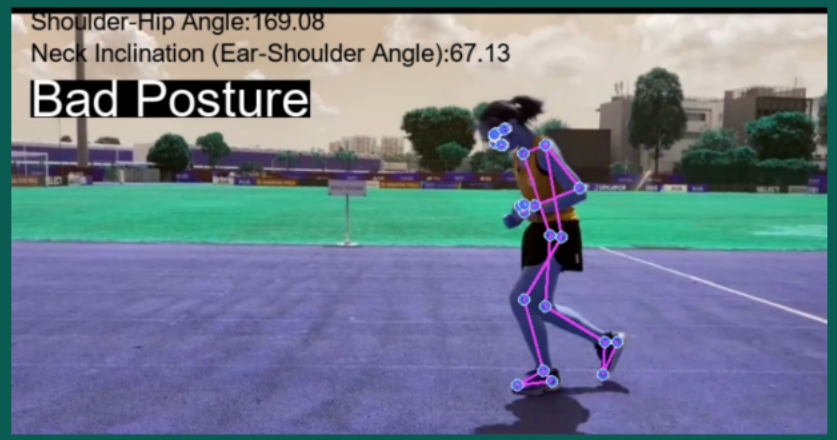
streamlit demo

streamlit demo

Empowers users to check if their posture is good or not based on the trained ML model, using the features like angles created between body landmarks

Good Posture

Bad Posture



Comes with a ***BEEP*** sound if bad posture is detected

conclusion

limitations / challenges

- Multiple bodies in frame causes confusion for model
- App deployment to cloud is laggy

use cases

- Public exercise areas like parks / stadiums to remind people to have good posture
- In schools, can be used during Physical Education classes to ensure students have good postures
- Assist in teleconsultation with doctors / chiropractors
- Can be deployed to phone app for individuals to monitor their own postures

thank you!
Q & A

future work

- Deploy it to a phone app
- Prescriptive messages on how to improve posture
- Detect specific types of bad posture / medical conditions such as overarching or slouching

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