



# Dance Move Classifier

(Originality Never Dies)

LUA YEOW WEN  
DSIF-11 Capstone Project

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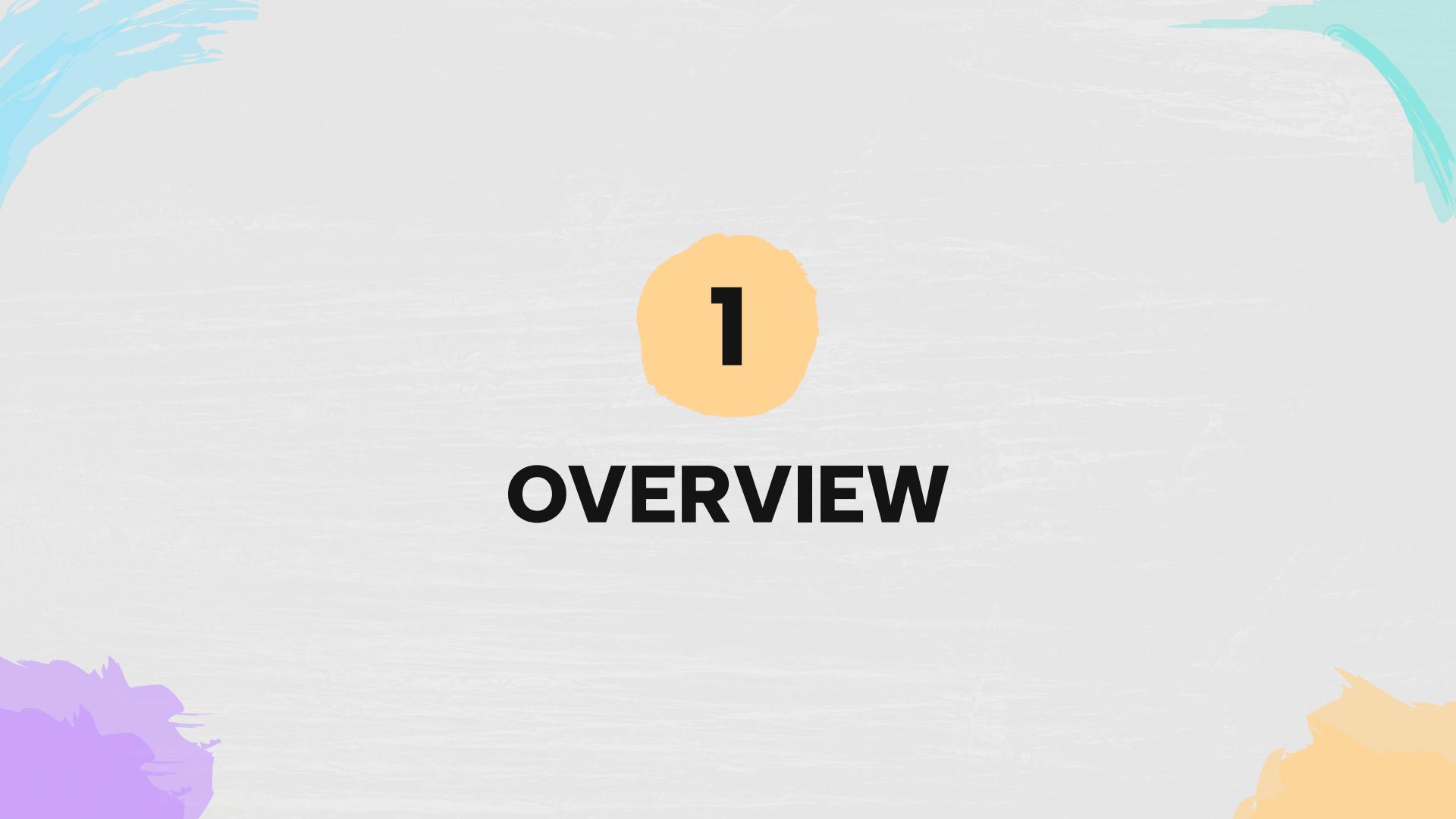
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# OVERVIEW

# BACKGROUND

Breaking or bboying is a form of dance that has evolved from the battling at the streets of the Bronx into global stage.

Nowadays, winners in dance competitions or events can receive rewards and incentives such as cash prizes, invitations to events, inclusion in an all-star team, or even representation of a country in the 2024 Paris Olympics.



# PRIZES FOR OVERSEAS COMPETITIONS



## World Breaking Classic 2 vs 2 2024

Top 16: €200

Top 8: €400

Top 4: €1000

2nd Place: €1500

1st Place: €5000



## Silverback Open Championships 3 vs 3

Top 32: USD \$50

Top 16: USD \$250

Top 8: USD \$500

Top 4: USD \$1,000

2nd Place: USD \$5000 + silver Silverback medal

1st Place: USD \$15,000 + gold Silverback medal

# PRIZES FOR LOCAL COMPETITIONS



## Lion City Dance Convention 4 vs 4

3rd Place: SGD \$800

2nd Place: SGD \$1,200

1st Place: SGD \$3,200

## Lion City Dance Convention 1 vs 1

1st Place: SGD \$800

# OTHER INCENTIVES



Red Bull BC All Star Team

Multiple Bboy sponsorships such as Samsung, Toyota, Alibaba and etc for Paris 2024 Games



TOYOTA

SAMSUNG

Sponsorships like Rimowa, Sony Xperia, G-Shock, and Red Bull

Featured in movie documentary

The WDSF Breaking For Gold series, which is a crucial event where breakers earn points that are essential for qualifying for the 2024 Paris Games

# PROBLEM STATEMENT

Over the years, instances have arisen where a bboy's performance closely resembles that of others , leading to an appearance of imitation, a phenomenon known as "Biting" in the breaking community. Given the extensive array of moves within the bboy scene, judges may occasionally overlook instances of "Biting," especially in the fast-paced environment of a bboy battle.

This oversight can consequently lead to potential misjudgment in scoring and decision-making.



# WHY SHOULD WE BE CONCERN



It is important to ensure that sponsors support the right Bboy or athlete to maintain the integrity of the sponsorship process.



Addressing potential backlash from the public is essential, as it could become more challenging to attract corporate funding for Bboy events in the future.



Misjudgment could potentially discourage new dancers from participating in dance events or competitions, leading to the deterioration of the Bboy dance scene.

# REVENUE MADE IN EVENTS

**\$825,000**

Breakin tournament that at the world  
finals

**\$207,000**

Breakin Festival held in a city

Deterioration of the Bboy dance scene can  
hurt revenues made for such events.

Rough estimations were made by a veteran bboy



# INTRODUCTION



**Who am I**  
An advocate bboy data scientist



**Stakeholders**  
Dance event organizers



**Secondary Stakeholders**  
Corporate Sponsors

# GOAL



Develop a multi-class classifier that accurately identifies moves, assisting bboy judges in detecting instances of biting.

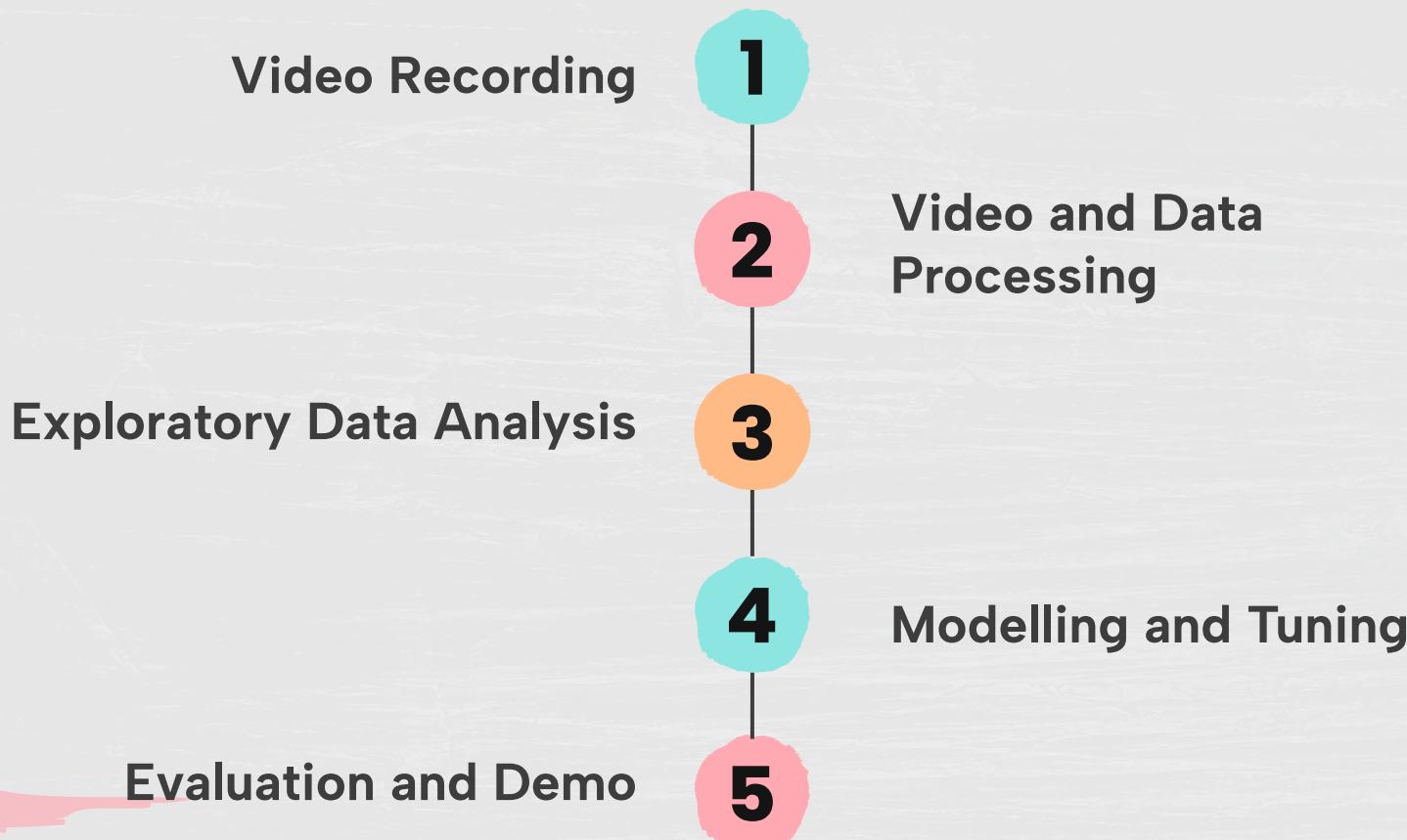


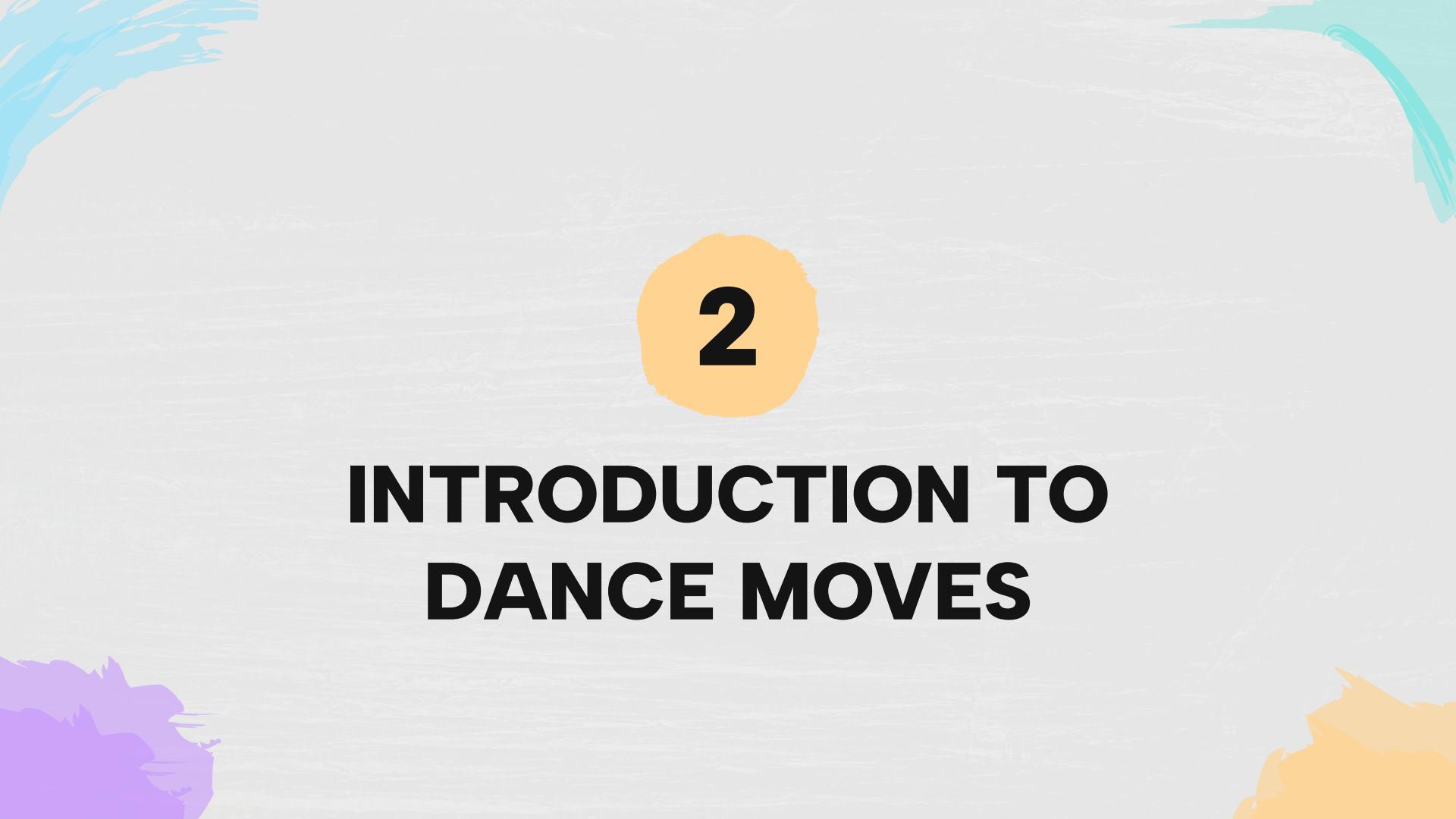
Encourage breakers to create more original moves.



Assisting corporations in selecting the appropriate bboy or bgirl for sponsorship.

# PROCESS





**2**

# **INTRODUCTION TO DANCE MOVES**

## **CC (Footwork)**



- The move is performed by kicking the left leg forward, diagonally whilst twisting the body so that the right upper limb can swing and palm can touch the ground for support.
- The motion is done only once.
- The start pose and mid pose of the move is different.
- End pose is the same as the start pose.

## Jackhammer (Powermove)



- The move requires the wrist to turn to the maximum range of movement before each hop.
- The hopping movement is done by bending and extending the knee.
- The body spins as each hop is executed.
- The hopping movement is repetitive and it is in a rotary motion.
- The left upper limb plays a role of balancing the body while spinning and hopping.
- The hopping pace is based on the dancer's level of fatigue.

## **Handhop (Tricks)**



- The hopping movement is done by bending and extending the knee.
- The hopping movement is repetitive.
- The left upper limb plays a role of balancing the body while hopping.
- The hopping pace is based on the dancer's level of fatigue.



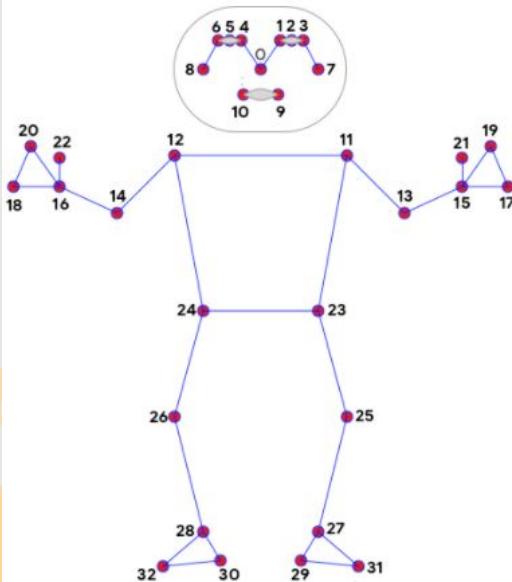
3

# DATASET

# VIDEO RECORDINGS

- All video attempts were self recorded with Samsung Galaxy S22 (settings: UHD, 30 fps)
- There are 8 videos attempts for each move (7 for training, 1 for validation)
- There are 3 moves in total
- There are 24 video attempts in total for modelling
- 2 seconds /60 frames of data were extracted from each video attempts
- There are also 1 videos attempts for each move for prediction

# BODY LANDMARKS SELECTION



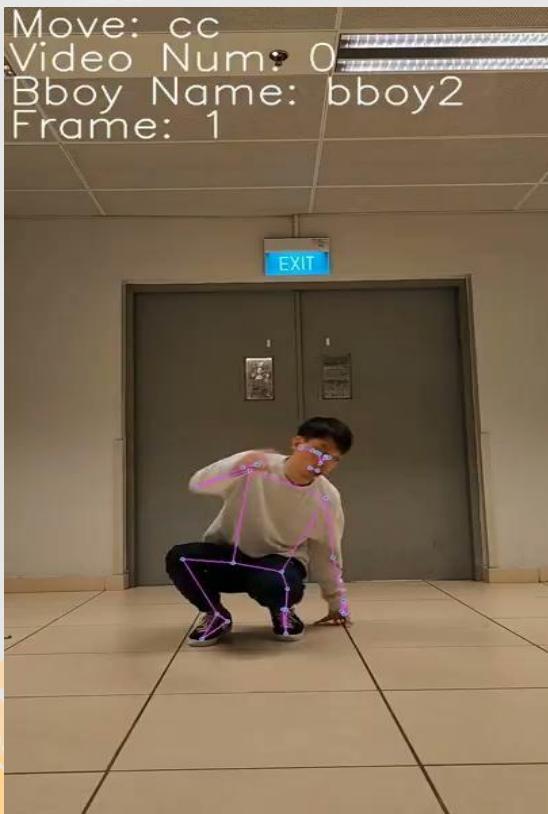
- |                    |                      |
|--------------------|----------------------|
| 0. nose            | 17. left_pinky       |
| 1. left_eye_inner  | 18. right_pinky      |
| 2. left_eye        | 19. left_index       |
| 3. left_eye_outer  | 20. right_index      |
| 4. right_eye_inner |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

15 body landmark numbers for x,y,z coordinates and visibility that are extracted with Mediapipe Library:

- p0 : nose  
p9 : mouth\_left  
p10 : mouth\_right  
p12 : right\_shoulder  
p14 : right\_elbow  
p16 : right\_wrists  
p11 : left\_shoulder  
p13 : left\_elbow  
p15 : left\_wrists  
p24 : right\_hip  
p26 : right\_knee  
p28 : right\_ankle  
p23 : left\_hip  
p25 : left\_knee  
p27 : left\_ankle

# PROCESSED VIDEOS

Move: cc  
Video Num: 0  
Bboy Name: bboy2  
Frame: 1



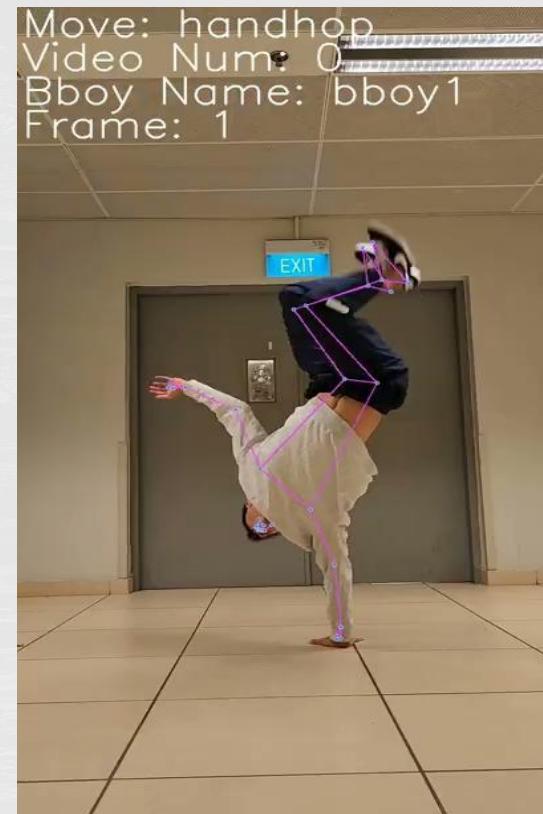
CC

Move: jackhammer  
Video Num: 0  
Bboy Name: bboy0  
Frame: 1



Jackhammer

Move: handhop  
Video Num: 0  
Bboy Name: bboy1  
Frame: 1



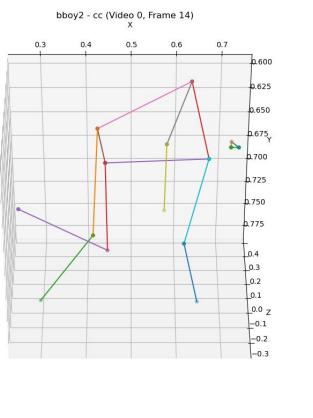
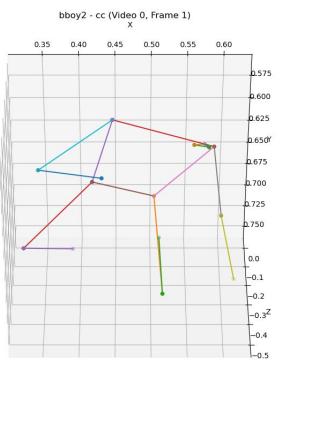
Handhop



**4**

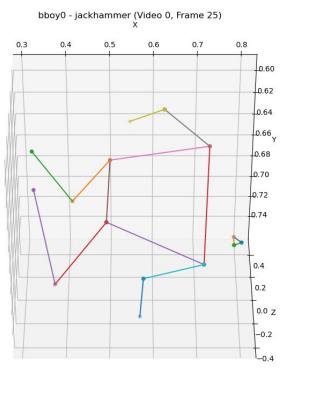
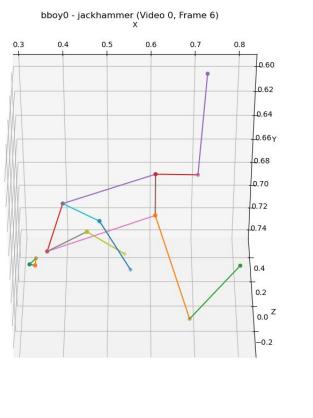
# **EXPLORATORY DATA ANALYSIS**

# CC IN 3D PLOT



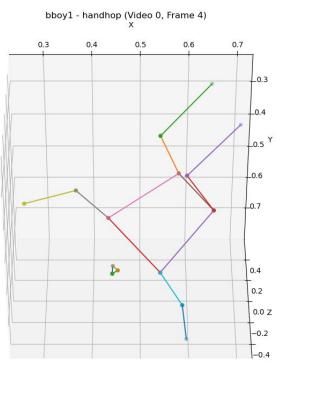
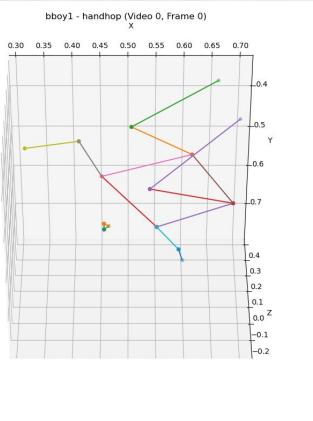
- The landmarks value changes significantly in the x and z axis as the right upper limb and head swung to the left whereas the left lower limb kicked forward and diagonally to the right.
- The change in y axis is observed as the left hand is in contact the ground and right lower limb is bent upwards into a pose.

# JACKHAMMER IN 3D PLOT



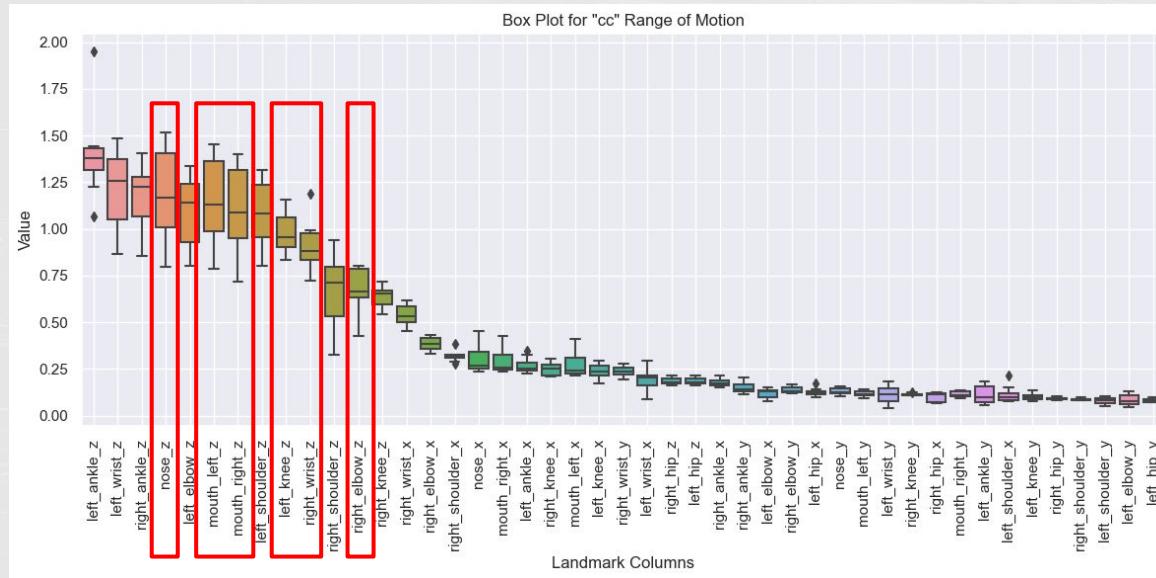
- All the landmarks in the x and z axis values varied across the different frames due to the spinning movement of this move along the axis.
- The values of landmarks in y axis varied as well due to the hopping motion.

# HANDHOP IN 3D PLOT



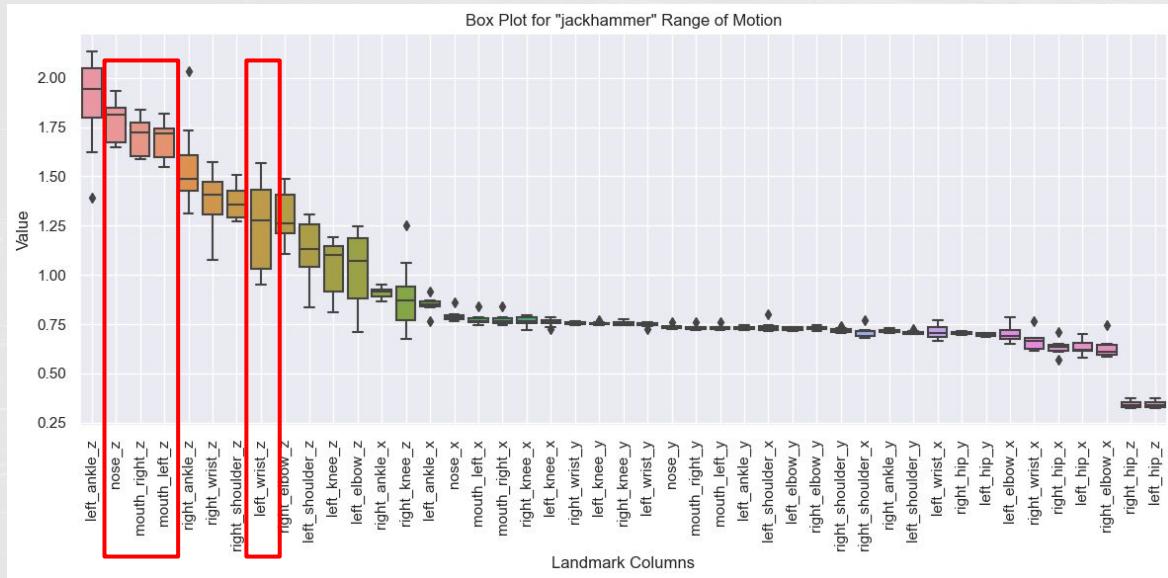
- When the dancer body moves away from the ground, the lower limbs landmark values in y axis are at their maximum before returning to its original pose.
- The landmark values in the x and z axis changes as the dancer lands on different spot after each hop is executed.
- The left upper limb landmark value may vary across the x , y and z axis as the dancer is balancing himself.
- The landmark values in the y axis for mouth is higher than the eyes at all time which signify that the dancer's body is inverted.

# BOX PLOT FOR CC RANGE OF MOTION



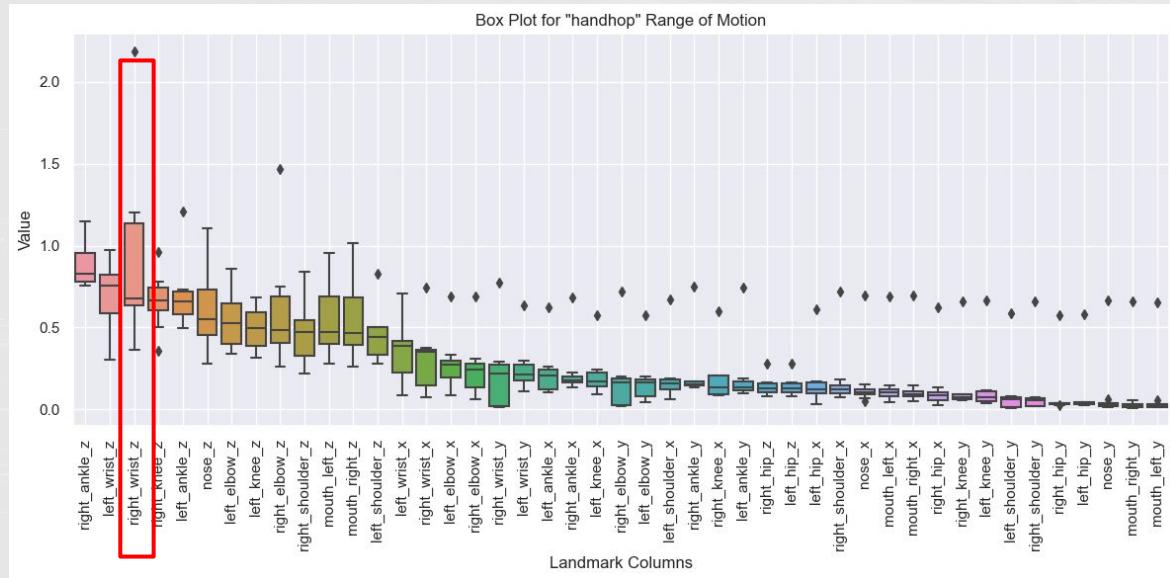
- Due to landing different points, boxplot for mouth\_right\_z, mouth\_left\_z, left\_knee\_z and right\_elbow\_z are skewed to the right.
- More variabilities on how the dancer moves his head when executing the move indicated by the wide spread from nose\_z, mouth\_right\_z, mouth\_left\_z boxplots.
- The outliers might be caused by the increased level of fatigue in the dancer as the forms in executing the move deteriorate.

# BOX PLOT FOR JACKHAMMER RANGE OF MOTION



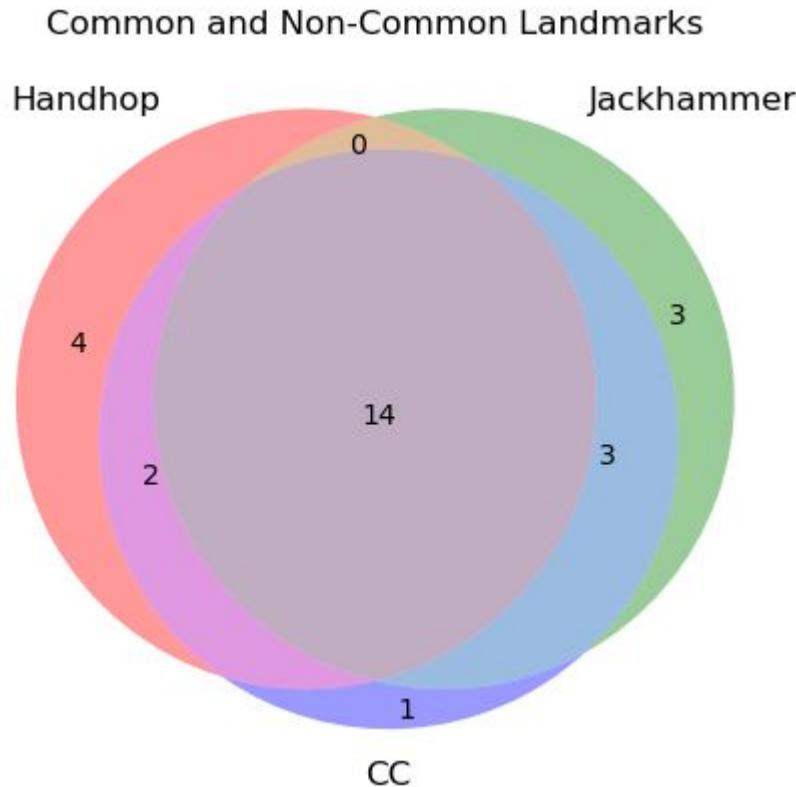
- Due to landing different points, boxplot for nose\_z, mouth\_right\_z, mouth left\_z, left\_knee\_z and left\_elbow\_z are skewed to the left.
- The spread for for left\_wrist\_z is wide which indicates that there are more variability which might be due to the counter balancing done with the left upper limb.
- The outliers might be caused by the increased level of fatigue in the dancer as the forms in executing the move deteriorate.

# BOX PLOT FOR HANDHOP RANGE OF MOTION



- The boxplot for right\_wrist\_z suggest that the distribution might be skewed to the right due to landing different points.
- There are quite a few outliers present in the plot, especially in the z axis. This indicates that there is a significant variation in how the handhop is performed, or it could suggest moments where the dancer's body parts are at the peak of their movement.

# COMMON LANDMARKS AMONG MOVES



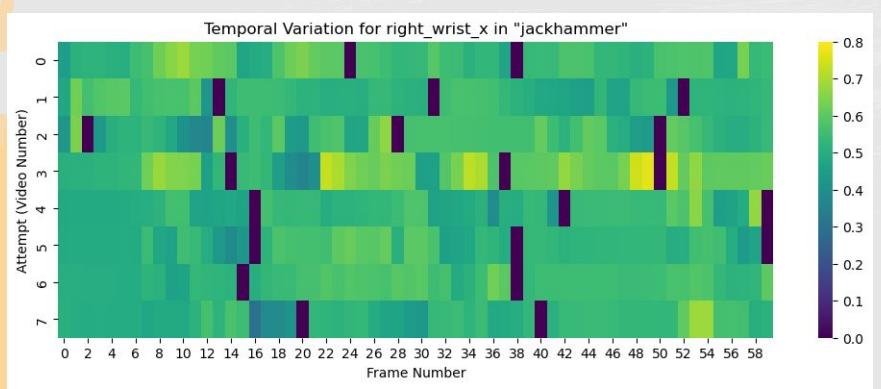
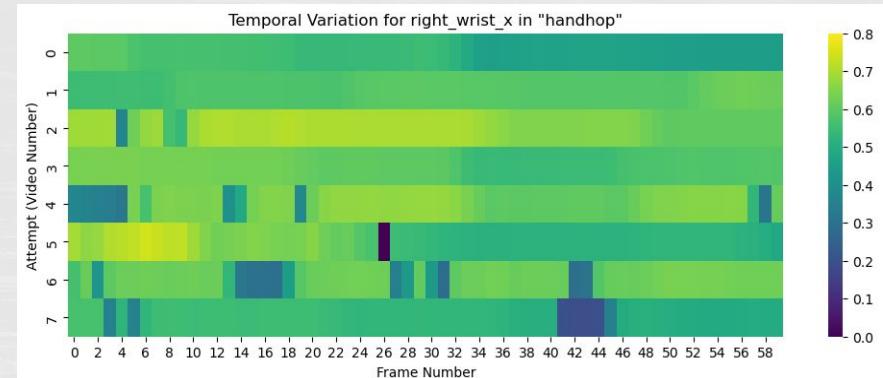
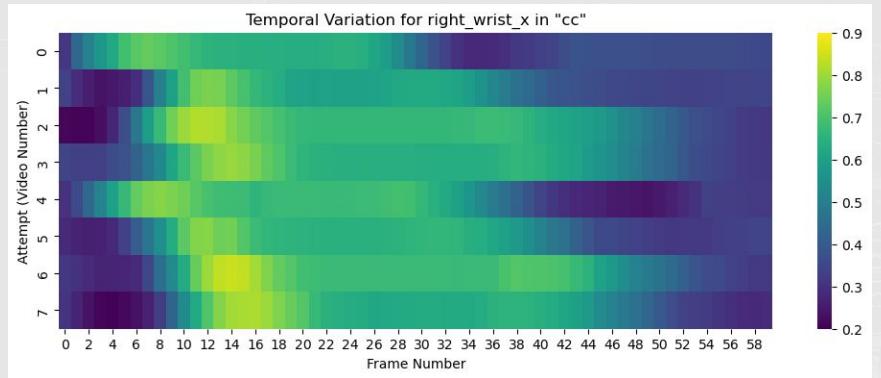
- right\_ankle\_z
- left\_knee\_z
- left\_wrist\_z
- right\_elbow\_z
- right\_wrists\_z
- right\_shoulder\_z
- right\_knee\_z
- mouth\_left\_z
- left\_ankle\_z
- mouth\_right\_z
- nose\_z
- left\_shoulder\_z
- left\_elbow\_z
- left\_ankle\_x

# COMMON LANDMARKS AMONG MOVES

Landmark	handhop	jackhammer	cc
<b>right_ankle_z</b>	kick	rotation	kick out but different pose from left ankle
<b>right_wrist_z</b>	landing	rotation	swing
<b>left_ankle_z</b>	kick	rotation	kick out but different pose from right ankle
<b>right_wrist_x</b>	landing	rotation	swing
<b>right_wrist_y</b>	hop	hop	swing

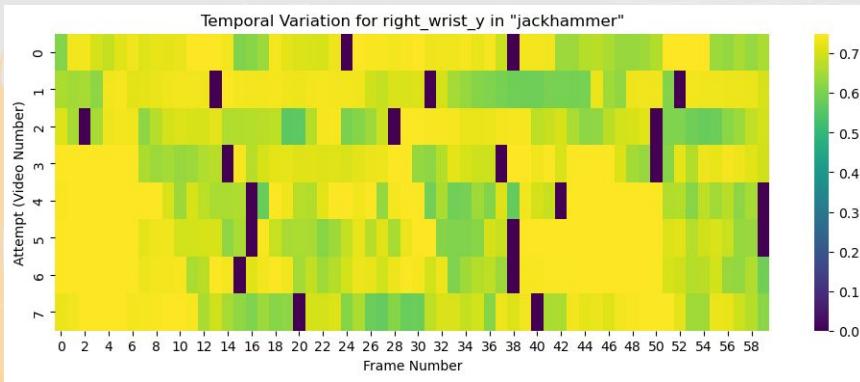
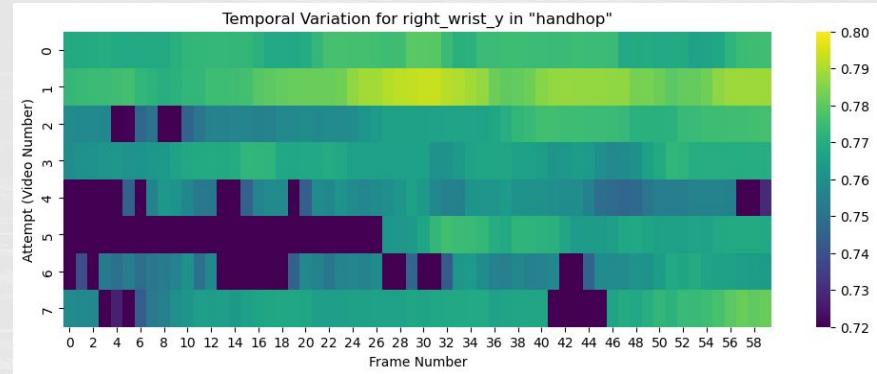
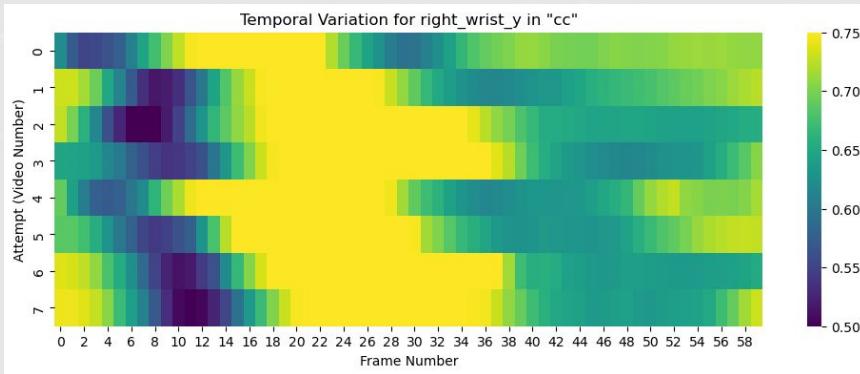
These moves requires substantial movements and effort from these body parts for execution.

# Temporal Variation of right\_wrist\_x

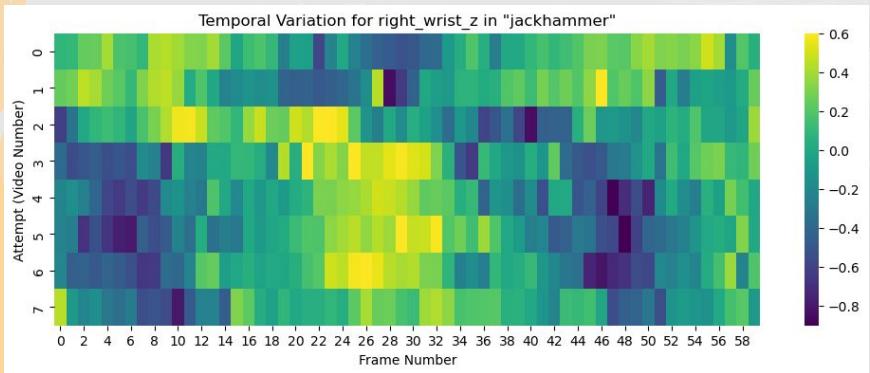
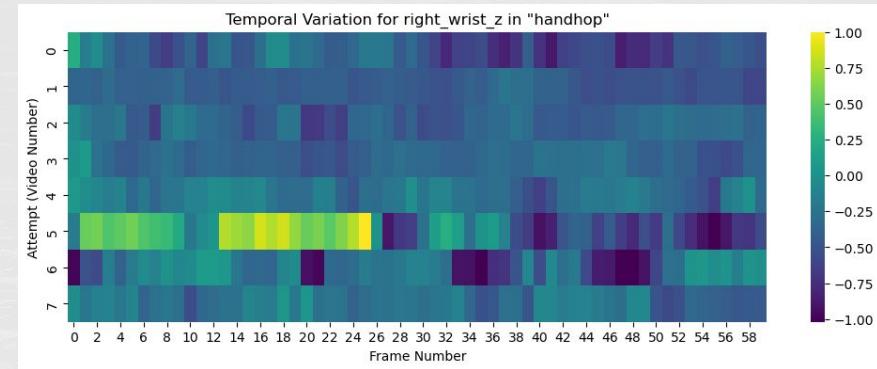
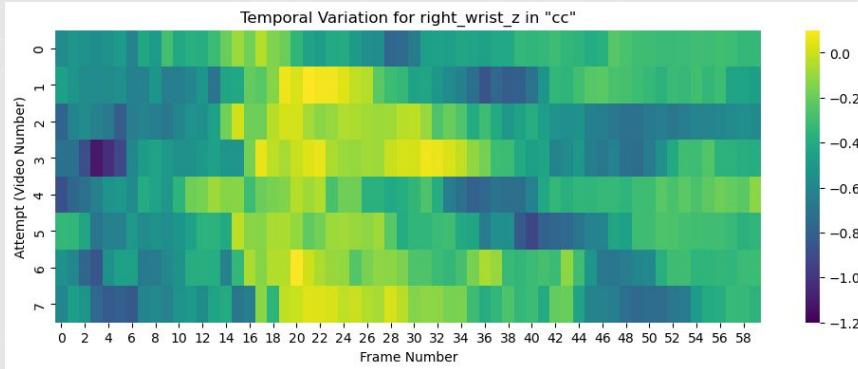


- Clear pattern seen in cc as right upper limb swung to the left.
- Some fluctuations seen in handhop from 5th attempt onwards.
- Zero values seen in jackhammer. Might be due to completion of each rotation.

# Temporal Variation of right\_wrist\_y

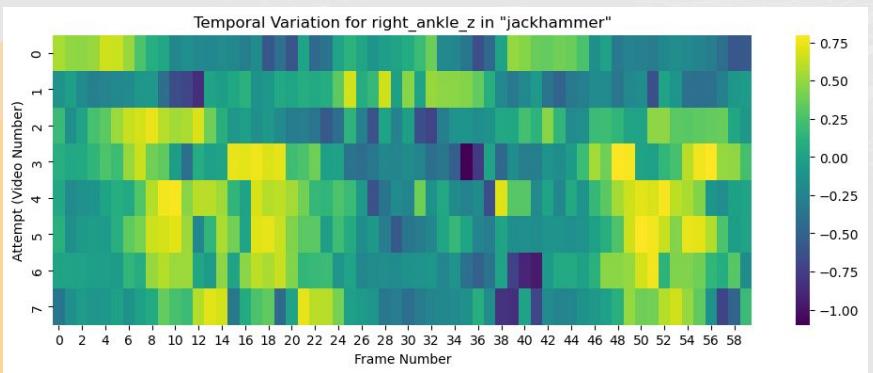
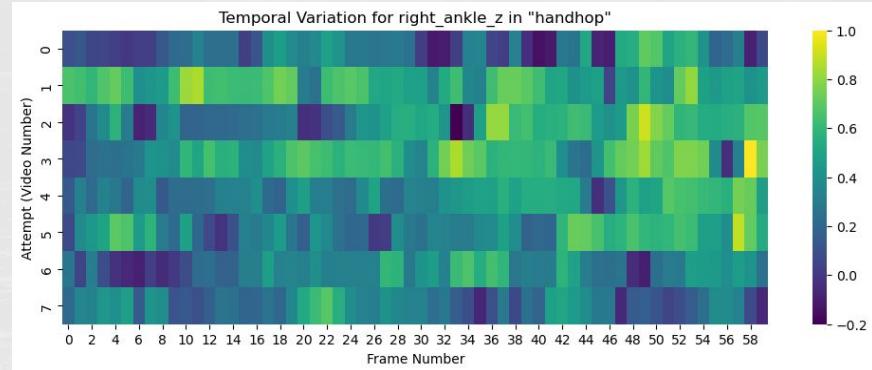
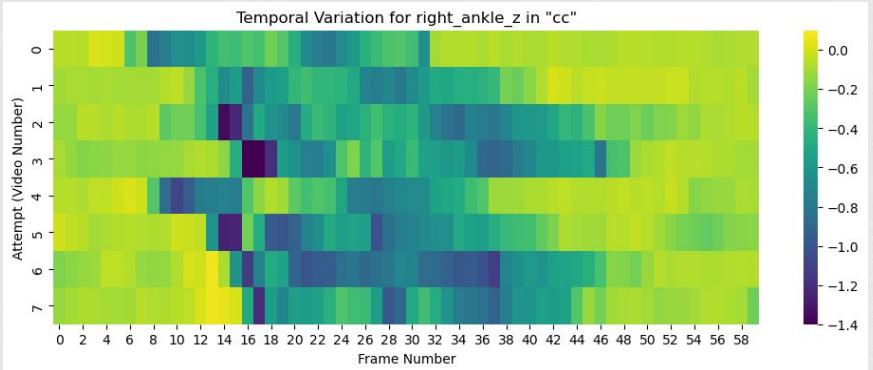


# Temporal Variation of right\_wrist\_z



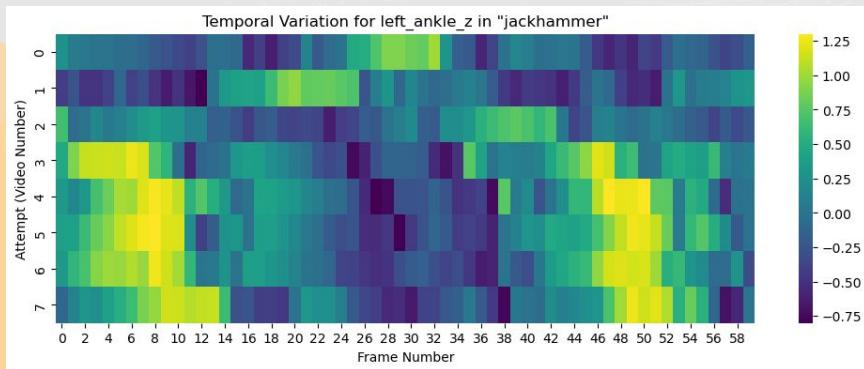
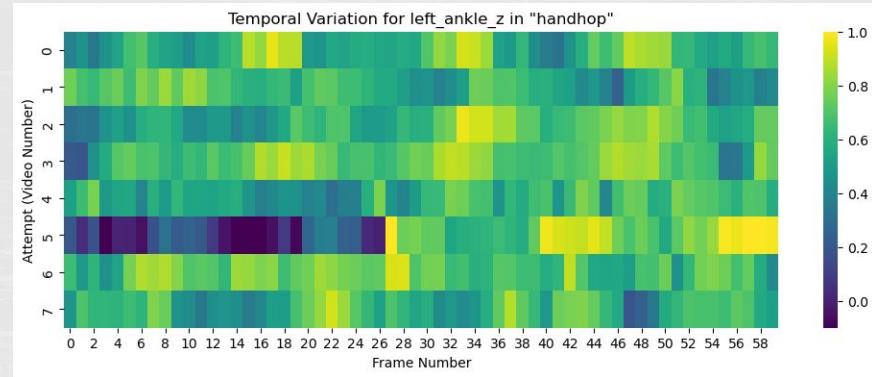
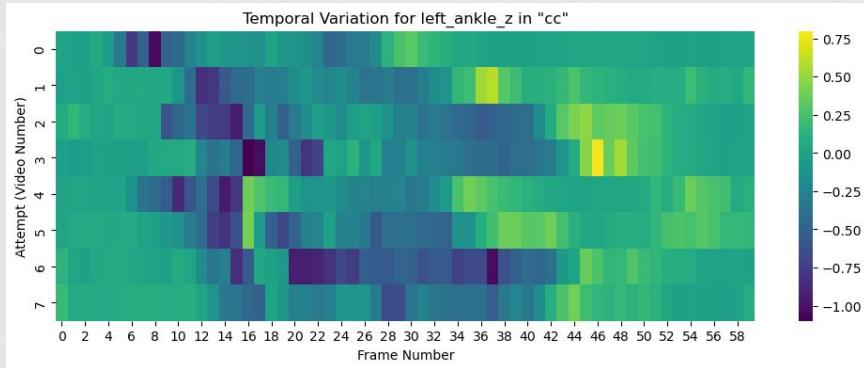
The unique temporal fluctuations of right\_wrist\_x, right\_wrist\_y and right\_wrist\_z in the 3 moves may improve models that identify sequential patterns.

# Temporal Variation of right\_ankle\_z



- Clear pattern seen in cc as right lower limb is kicked forward.
- Fluctuations seen in handhop as position of right ankle is dependent on how each hop is executed.
- Fluctuations seen in jackhammer as values are mixed with spin and hop.

# Temporal Variation of left\_ankle\_z

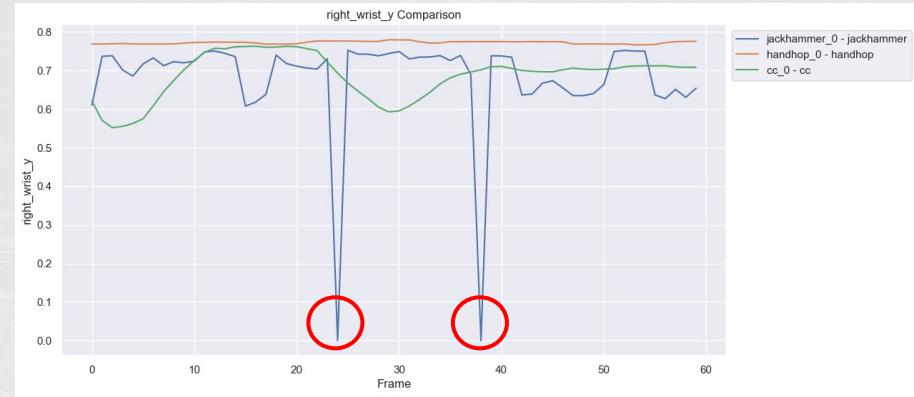
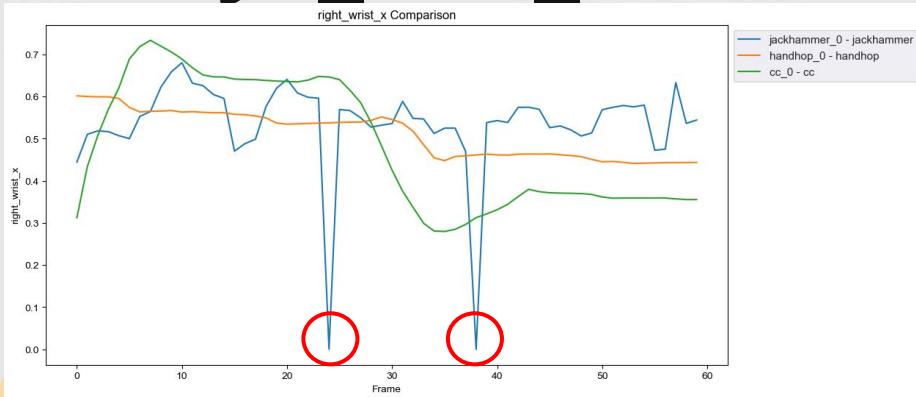


The unique temporal fluctuations of right\_ankle\_z and left\_ankle\_z in the three dances may improve models that identify sequential patterns.

# Temporal Variation Insights

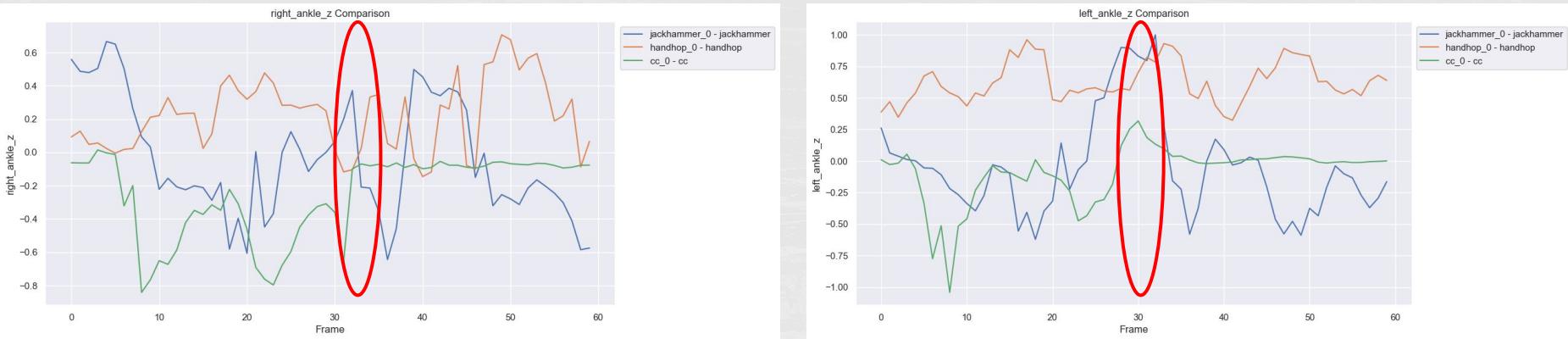
- The unique temporal patterns among the different landmarks and moves can be used as an advantage for models that can utilize these patterns to differentiate between dance moves.
- This is because they are considering the full context of the movement, not just isolated positions.

# Line Plot for 'right\_wrist\_x', 'right\_wrist\_y', 'right\_wrist\_z'



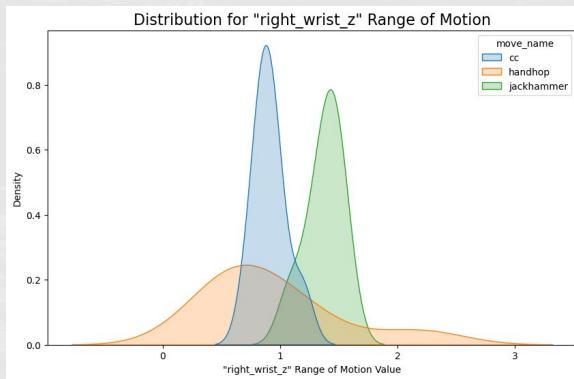
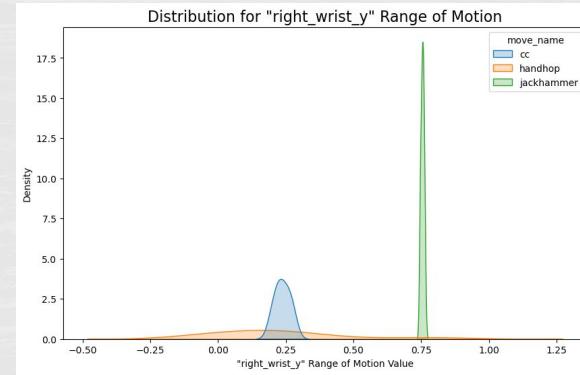
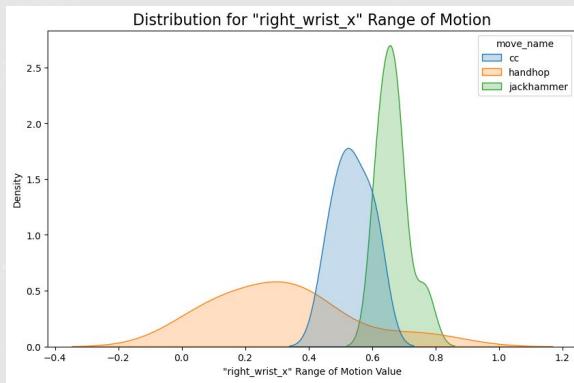
- Rapid movement and angles of filming the moves which made difficult for the Mediapipe algorithm to track the landmarks accurately.

# Line Plot for 'right\_ankle\_z', 'left\_ankle\_z'



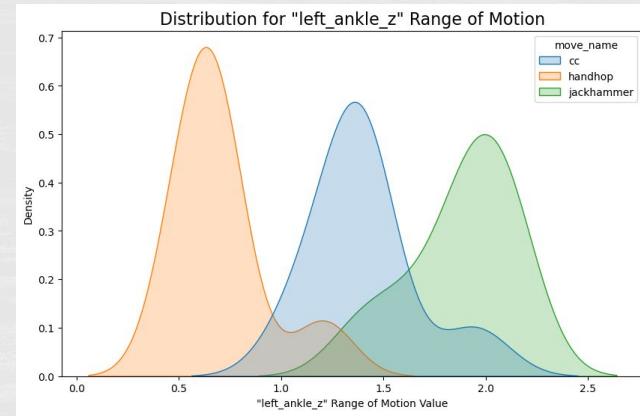
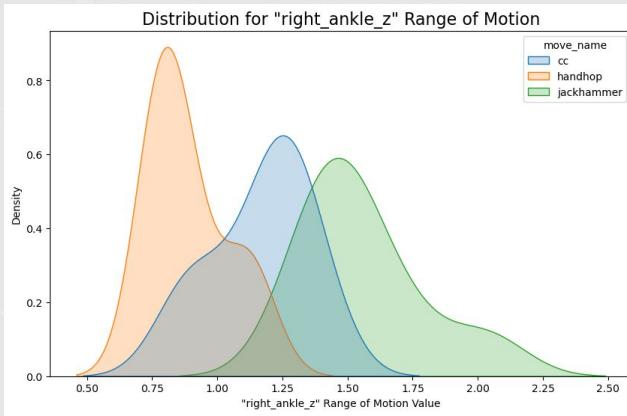
- Jackhammer demonstrates the greatest variation, indicative of active and varied ankle movements.
- Handhop shows less fluctuation than Jackhammer but is more varied than CC.
- CC is relatively stable, suggesting less movement of the right ankle in the z axis.
- The increased in the value at frame 30 onwards indicates that the right lower limb that kicked towards the camera stabilizes after hitting the pose.

# KDE Plot for 'right\_wrist\_x', 'right\_wrist\_y', 'right\_wrist\_z'



- More variability seen in handhop.
- Jackhammer is the most consistent.

# KDE Plot for 'right\_ankle\_z', 'left\_ankle\_z'



- Each move has a distinct peak, indicating different typical range of motion for these moves.
- The distributions suggest that some moves have specific, characteristic movements that could be key in identifying them.
- The overlap in distributions for some moves means that a single coordinate movement might not be sufficient for classification, and combining multiple coordinates or landmarks might be necessary.

# INSIGHTS FROM THE FEATURES



## **Complex Movements:**

Each landmark captures a crucial aspect of the movement, and removing any could omit important information necessary for accurate classification.



## **Unique Information:**

Even if some landmarks are highly correlated, they may still provide unique information about different aspects of the dance moves. For example, while the right and left wrists may move together, they might have different roles in different moves that are important to capture.



## **Temporal Dynamics:**

The correlation between landmarks might change over time as the dancer moves. Keeping all landmarks allows the model to capture these temporal dynamics, which are essential for recognizing the sequences of movements in bboying.



## **Model Robustness:**

Advanced machine learning models, especially neural networks, can handle high dimensionality and multicollinearity. These models can learn the underlying patterns in the data even when features are correlated.



**5**

# **MODELLING AND TUNING**

# RECURRENT NEURAL NETWORK (RNN) ARCHITECTURE



## Gated Recurrent Unit (GRU)

Outperforms with smaller datasets, and offers quicker training times on larger datasets



## Long Short-Term Memory (LSTM)

Capable to handle complex architecture compared to GRU

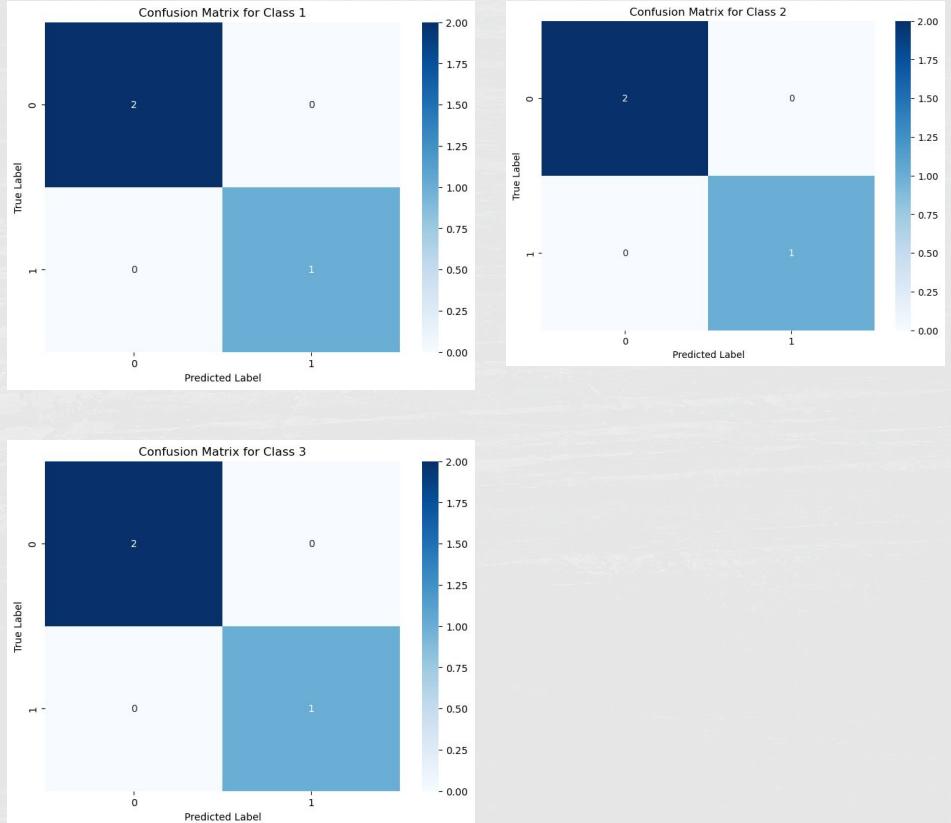
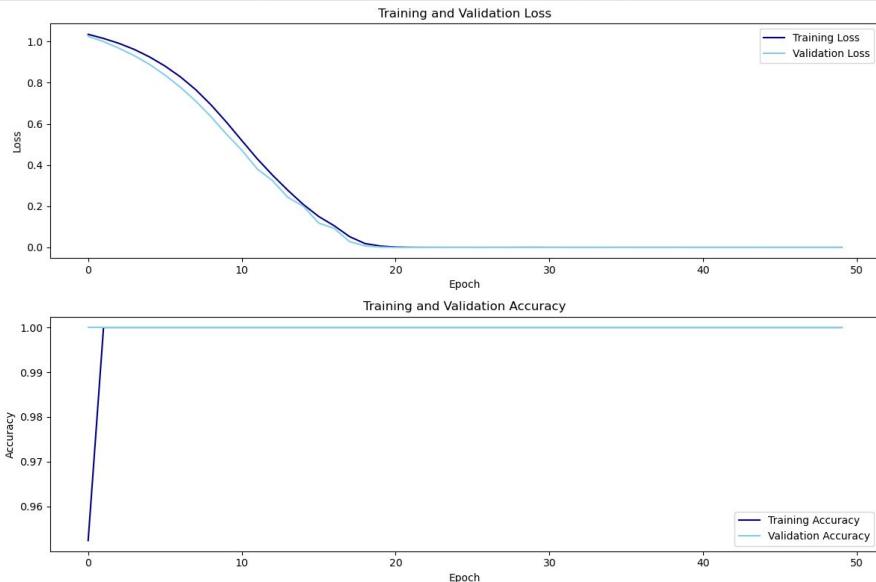
# MODELLING STAGES

- 
- ```
graph TD; 1((1)) --- 2((2)); 2 --- 3((3)); 3 --- 4((4)); 4 --- 1;
```
- Set parameters for `random_search_tuner` for training
  - Retrain Model with Best Hyperparameters
  - Model Evaluation
  - Repeat Step 1 to 4 with Regularization Techniques

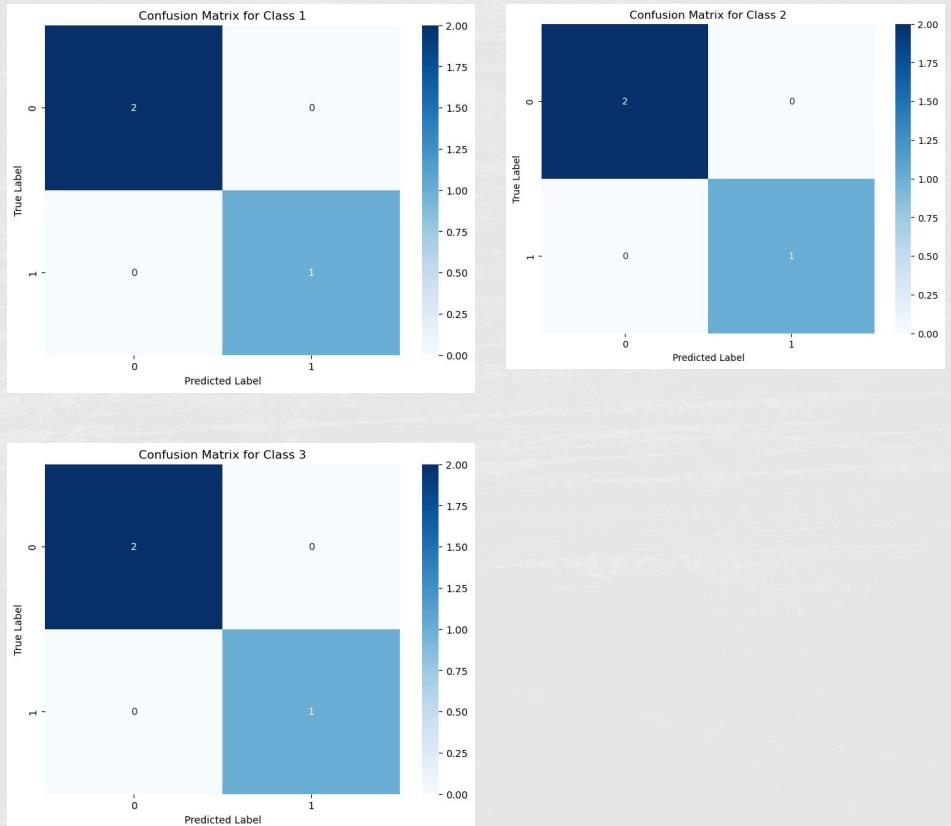
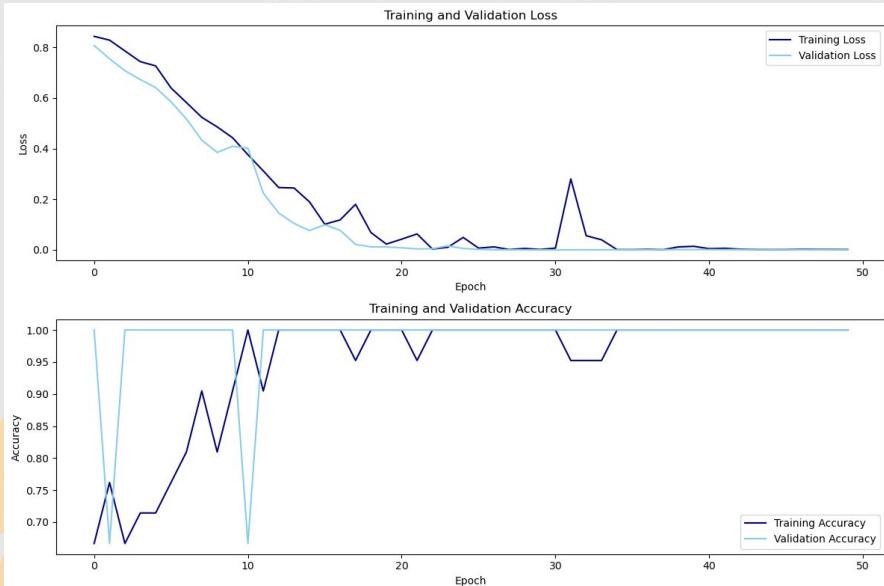
# MODEL COMPARISON

| Model                  | Accuracy Score | Run Time<br>HH:MM:SS |
|------------------------|----------------|----------------------|
| GRU Model (base model) | 100%           | 0:03:40              |
| LSTM Model             | 33.33%         | 0:03:35              |
| GRU Model DO           | 100%           | 0:02:53              |
| LSTM Model DO          | 66.67%         | 0:03:03              |
| GRU Model ES           | 100%           | 0:04:00              |
| LSTM Model ES          | 66.67%         | 0:04:17              |
| GRU Model DO and ES    | 100%           | 0:03:19              |
| LSTM Model DO and ES   | 100%           | 0:03:17              |

# GRU Model (base model)



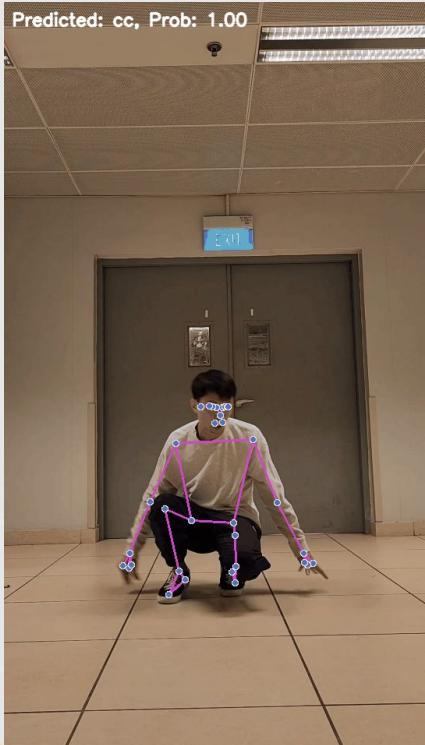
# GRU Model with Dropout Regularization



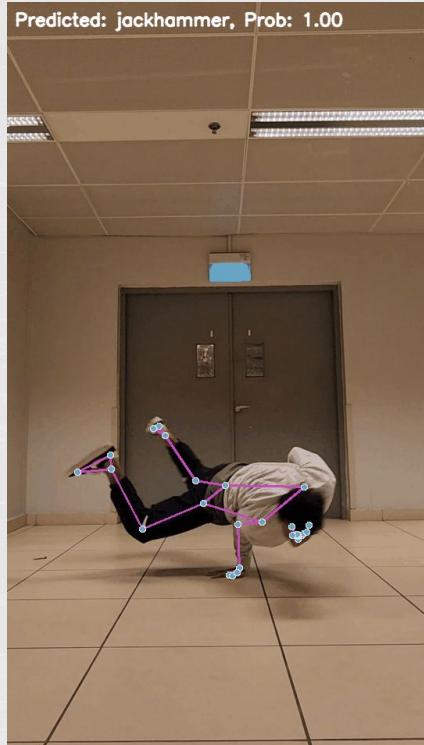
6

**DEMO**

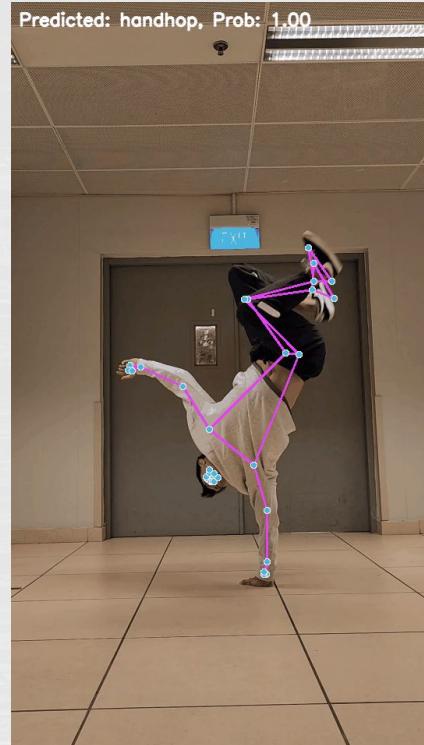
# DEMO



CC



Jackhammer



Handhop



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# CONCLUSION RECOMMENDATION FURTHER IMPROVEMENTS

# Conclusion



The model accurately identifying moves to help bboy judges detect instances of biting.



This will assist corporations in selecting the right bboy or bgirl for potential sponsorship.



The fairness and rewarding incentives will encourage bboys and bgirls to create more original moves.

# RECOMMENDATION

## Event Organizers

Dance competitions and events can utilize this model to provide judges with valuable insights, helping them assess the originality of performances. Just like VAR system in soccer matches to detect fouls.



## Corporate Sponsors

The marketing team of a company can utilize this model to identify dancers with exceptional originality for potential sponsorship opportunities.



List of people I actually can stand

# FURTHER IMPROVEMENTS



Incorporate videos captured from various angles



Diversify move durations during execution



Extend the dance moves database to encompass various hip-hop styles, including popping and locking



Develop a user-friendly app for bboys and bgirls, encouraging the creation of original dance moves

# THANK YOU!

Questions?



# REFERENCE LINK

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- <https://dancesport.app.box.com/s/fowfqyiedh1z3vryqa0a963acptv1vhv>
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