A dynamic photograph of two MMA fighters in a octagonal cage. One fighter, wearing black shorts, is in the foreground performing a high kick towards the other fighter's midsection. The second fighter, wearing grey shorts, is on the receiving end of the kick. A referee in a black shirt is visible in the background, monitoring the fight. The lighting is dramatic, highlighting the intensity of the moment.

MMA STRIKE ANALYSIS USING COMPUTER VISION

GA DSI 25 – HAZIQ

Overview

- Introduction
- Part 1 : Fight Predictor
 - EDA, Modelling
- Part 2: Computer Vision Analysis of Strikes
 - Assistive Tool for Fight Judges
- Conclusion and Recommendation
- Future Improvements

Background

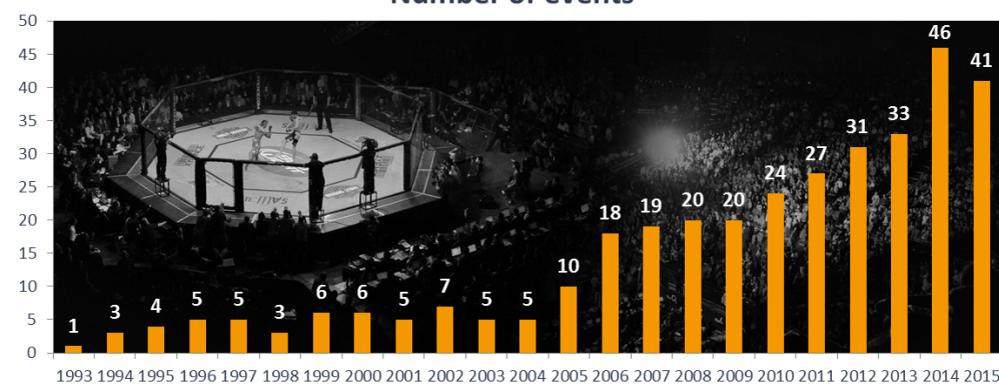
USD 7 billion



USD 1 billion



Number of events



Background

A quick introduction on MMA

- Multi-disciplinary fighting styles:

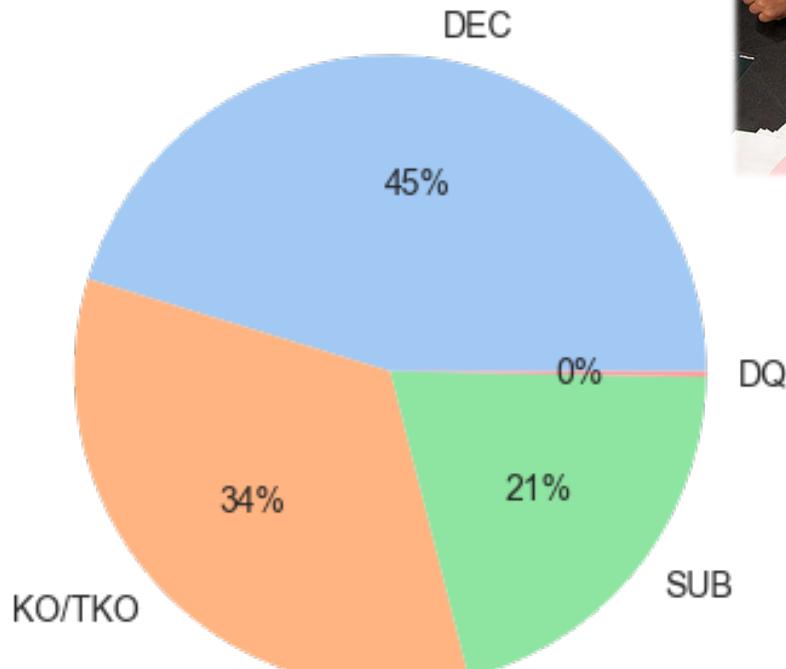
- Boxing
- Kickboxing
- Muay Thai
- Taekwondo
- Karate
- Brazilian Jiu-Jitsu (BJJ)
- Wrestling
- Sambo



Background

A quick introduction on MMA

- 3 methods for fights to end:
 - Decision
 - KO/TKO
 - Submission
- 45% of fights are decided by judges



How are fights scored?

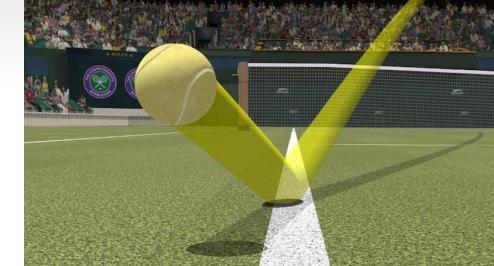
- Effective striking
 - Effective grappling
 - Effective aggressiveness
 - Control of fighting area
-
- Strikes attempted
 - Significant strikes landed
 - Striking accuracy

Background info

W/L	FIGHTER	KD	STR	TD	SUB	WEIGHT CLASS	METHOD	ROUND	TIME
WIN ➤	<u>Charles Oliveira</u>	0	73	0	3	Lightweight	SUB	3	1:02
	<u>Dustin Poirier</u>	1	58	0	0	 *PERF	Rear Naked Choke		
WIN ➤	<u>Julianne Pena</u>	0	79	1	1	Women's Bantamweight	SUB	2	3:26
	<u>Amanda Nunes</u>	0	46	1	0	 *PERF	Rear Naked Choke		
WIN ➤	<u>Geoff Neal</u>	0	85	0	0	Welterweight	S-DEC	3	5:00
	<u>Santiago Ponzinibbio</u>	0	91	1	0				
WIN ➤	<u>Kai Kara-France</u>	2	23	0	0	Flyweight	KO/TKO	1	3:21
	<u>Cody Garbrandt</u>	0	9	0	0	 *PERF	Punches		
WIN ➤	<u>Sean O'Malley</u>	1	39	0	0	Bantamweight	KO/TKO	1	4:42
	<u>Raulian Paiva</u>	0	11	0	0	 *PERF	Punches		

Problem Statement

- **Problem:** Judging the winner of a fight can be tricky and even subjective at times.
- **Objective:** Assist judges in measuring striking metrics to give a better overview of the round.
- **Solution:** Computer vision tool that can assist judges in scoring rounds and reduce subjectivity in decisions



Tennis – Hawk Eye



Football – Goal Line Technology



Football – VAR



Part 1: MMA Fight Predictor

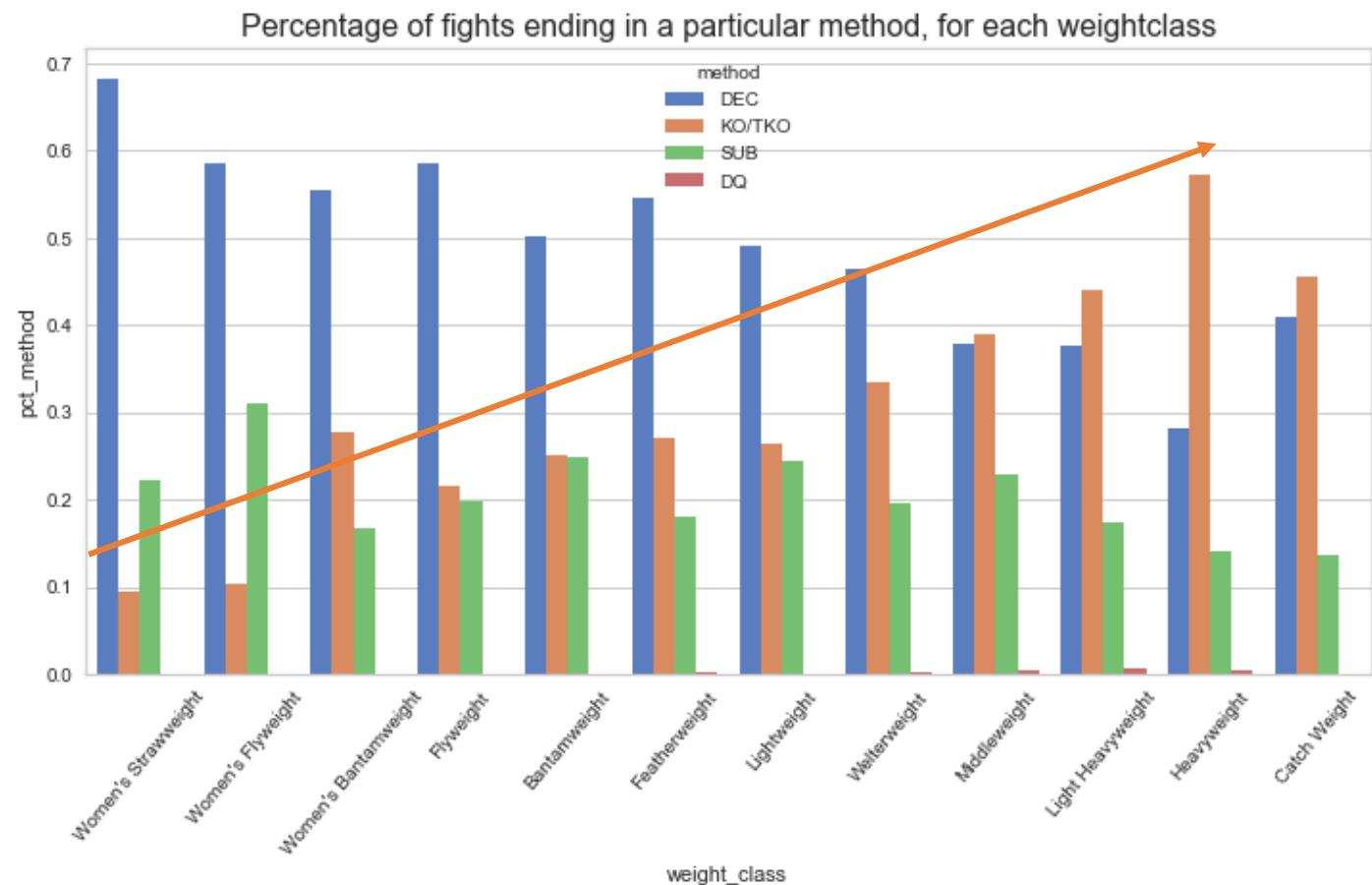


Data Cleaning

- Features in dataset:
 - Bio-related features
 - Age, Height, Reach, Stance
 - Fight-related features
 - Strikes: Landed, Absorbed, Defended, Accuracy
 - Takedown: Landed, Defended, Accuracy
 - Submission: Attempted
 - Other features
 - Weight Class (Flyweight, Lightweight, Heavyweight, etc)
 - Title Fight (True/False)
- Features removed
 - Round end, Method

EDA

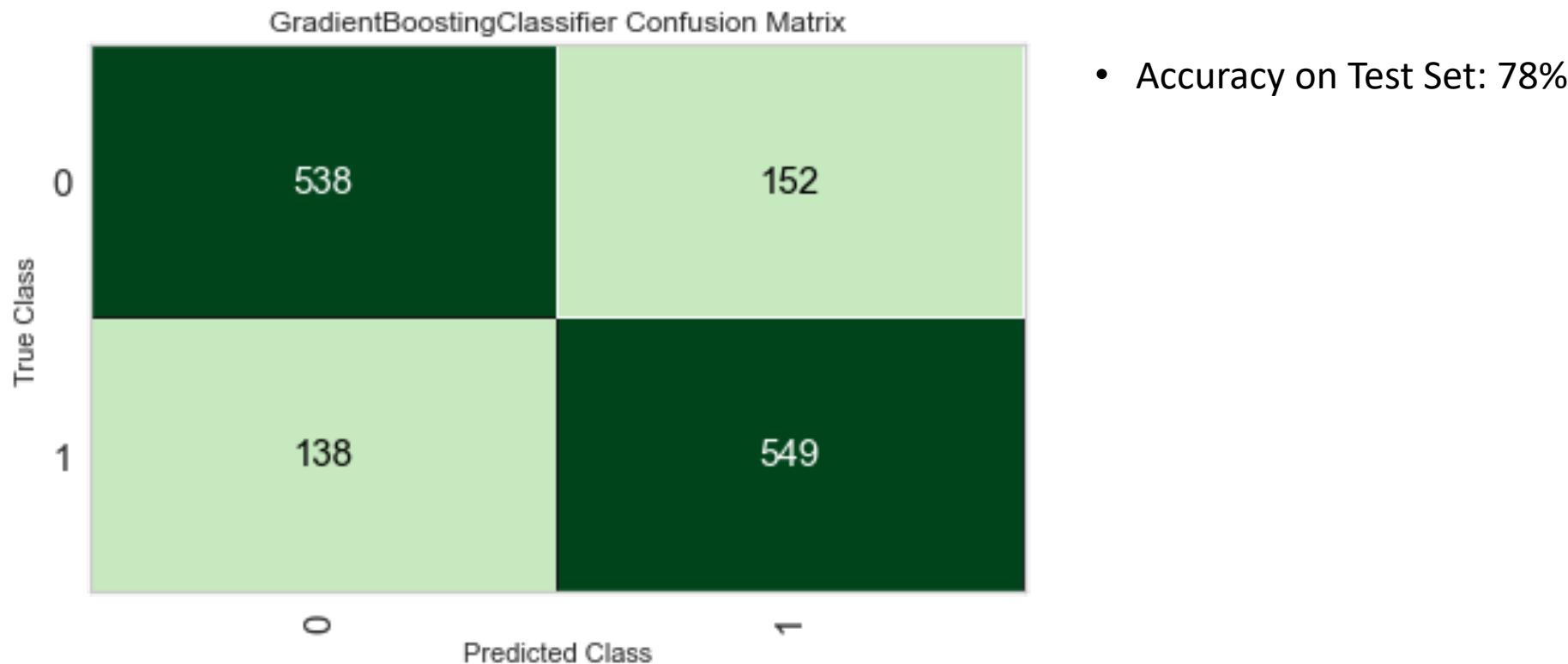
- As weight class increases, higher percentage of fights end in KO/TKO



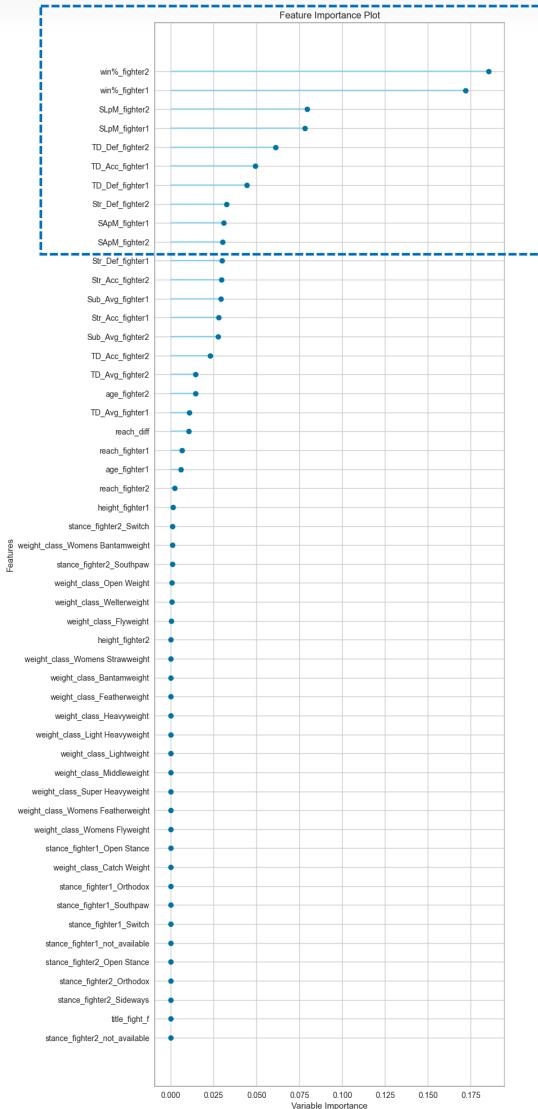
Modelling

Model		Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	TT (Sec)
gbc	Gradient Boosting Classifier	0.7104	0.7857	0.7075	0.7118	0.7095	0.4207	0.4209	0.2620
lightgbm	Light Gradient Boosting Machine	0.7051	0.7773	0.6995	0.7078	0.7033	0.4102	0.4106	0.7900
ada	Ada Boost Classifier	0.6979	0.7739	0.7013	0.6974	0.6991	0.3958	0.3961	0.0570
lda	Linear Discriminant Analysis	0.6960	0.7647	0.6975	0.6964	0.6962	0.3921	0.3929	0.0130
ridge	Ridge Classifier	0.6957	0.0000	0.6975	0.6961	0.6960	0.3915	0.3923	0.0040
lr	Logistic Regression	0.6951	0.7664	0.6982	0.6948	0.6958	0.3902	0.3910	0.2840
rf	Random Forest Classifier	0.6926	0.7587	0.6808	0.6977	0.6889	0.3853	0.3857	0.2340
xgboost	Extreme Gradient Boosting	0.6923	0.7683	0.6870	0.6953	0.6909	0.3846	0.3849	0.7040
et	Extra Trees Classifier	0.6789	0.7438	0.6690	0.6828	0.6756	0.3578	0.3581	0.2100
svm	SVM - Linear Kernel	0.6400	0.0000	0.6484	0.6427	0.6404	0.2799	0.2842	0.0100
knn	K Neighbors Classifier	0.6216	0.6654	0.6248	0.6217	0.6229	0.2433	0.2435	0.0550
dt	Decision Tree Classifier	0.6048	0.6052	0.5992	0.6056	0.6018	0.2096	0.2099	0.0130
nb	Naive Bayes	0.6035	0.7157	0.6257	0.6285	0.5654	0.2075	0.2239	0.0050
qda	Quadratic Discriminant Analysis	0.5036	0.5035	0.6803	0.5005	0.5474	0.0072	0.0060	0.0110
dummy	Dummy Classifier	0.5005	0.5000	1.0000	0.5005	0.6671	0.0000	0.0000	0.0040

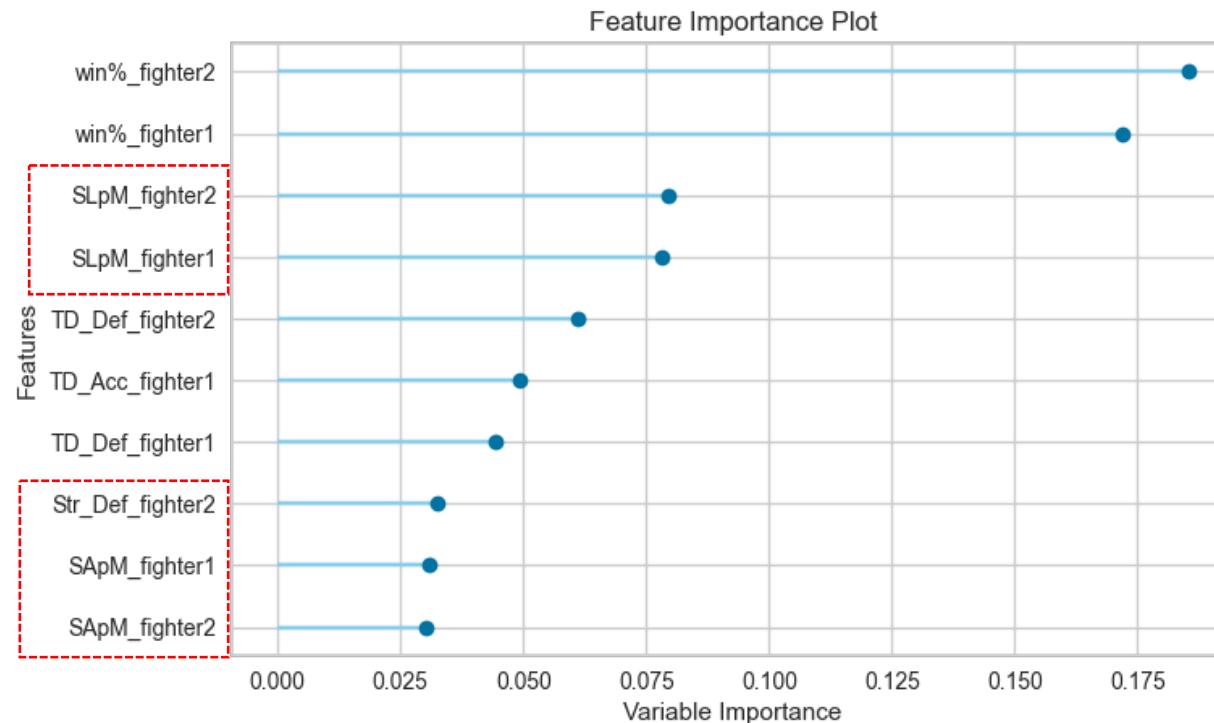
Modelling – Confusion Matrix



Modelling – Feature Importance



Modelling – Feature Importance



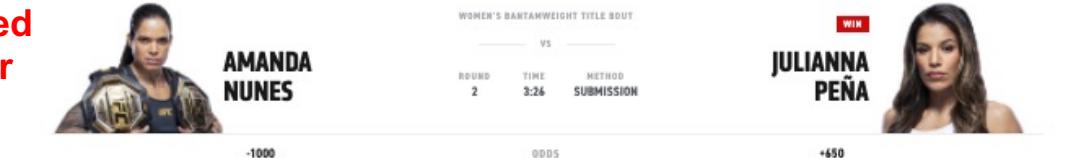
- SLpM: Strikes Landed per Minute
- Str_Def : Strikes Defence
- SApm: Strikes Absorbed per Minute

Prediction

Predicted winner (83%)



Predicted winner (80%)



Predicted winner (80%)



A horizontal banner for UFC Fight Night featuring two fighters. On the left, Kai Kara from France is shown in a red corner with 'WIN' above his name. In the center, a 'FLYWEIGHT BOUT' is listed between 'VS'. On the right, Cody Garbrandt is shown in a blue corner. Below the fighters, their names and nationalities are listed: 'KAI KARA FRANCE' and 'CODY GARBRANDT USA'. The background shows a blurred octagon.

Predicted winner (60%)

**Predicted
winner
(65%)**

A screenshot of a mobile news application. The top navigation bar has a dark background with white text. On the left is a profile icon, followed by the text "BLEACHER REPORT" and a magnifying glass icon. On the right are three small icons: a person, a gear, and a square. Below the navigation bar is a large, bold blue headline: "Julianna Pena Beats Amanda Nunes via Submission to Win Title in UFC 269". To the left of the headline is a yellow box containing the word "Upset" in black. At the bottom left is a timestamp: "2 days ago". At the bottom right is a snippet of the next article: "Amanda Nunes at UFC 269".

The image shows the ESPN logo in its signature red, slanted font. Below it, the tagline "The world do Peña believe" is written in blue, with "do" in yellow and "Peña" in blue.

2 days ago

The
Guardian

UFC 269:
upsets

More news

Part 2: Computer Vision Analysis of Strikes



Data Collection

- Video footage of MMA fights from online sources
- Crop out only the relevant fighter and apply pose estimation
- Extract pose estimation keypoints into dataframe



	attack_type	right_elbow_angle	right_shoulder_angle	right_hip_angle	right_knee_angle	right_ankle_angle	left_elbow_angle	
0	0	170.0	17.0	65.0	170.0	143.0	7.0	
1	0	168.0	15.0	66.0	173.0	141.0	9.0	
2	0	155.0	11.0	68.0	172.0	142.0	8.0	
3	0	180.0	14.0	68.0	175.0	147.0	8.0	
4	0	156.0	16.0	67.0	175.0	146.0	10.0	
...
3451	5	39.0	49.0	153.0	174.0	118.0	147.0	
3452	5	36.0	49.0	153.0	174.0	119.0	148.0	
3453	5	37.0	49.0	154.0	174.0	118.0	150.0	
3454	5	35.0	49.0	154.0	174.0	117.0	150.0	
3455	5	35.0	49.0	154.0	174.0	117.0	152.0	

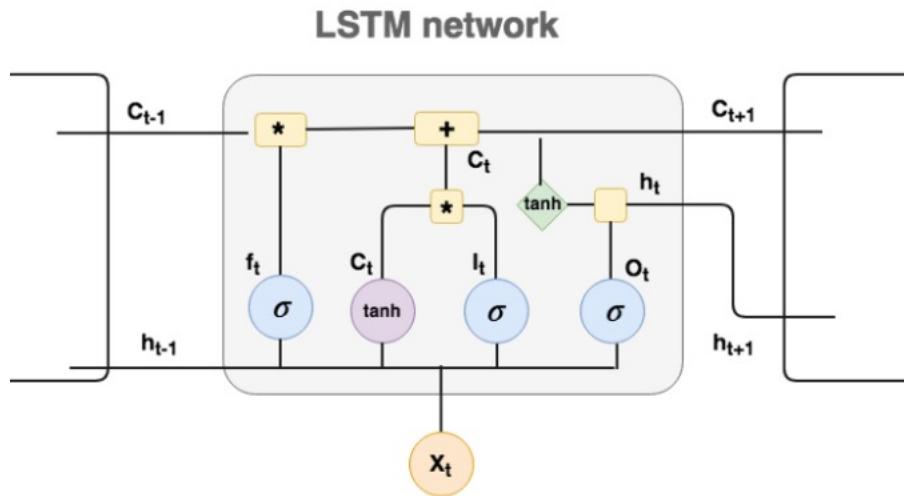
3456 rows × 11 columns



MediaPipe



Modelling (LSTM)



- Train set

```
Epoch 200/200  
34/34 - 1s - loss: 0.4114 - binary_accuracy: 0.8088 - accuracy: 0.7941  
- val_loss: 0.7596 - val_binary_accuracy: 0.5000 - val_accuracy: 0.4667
```

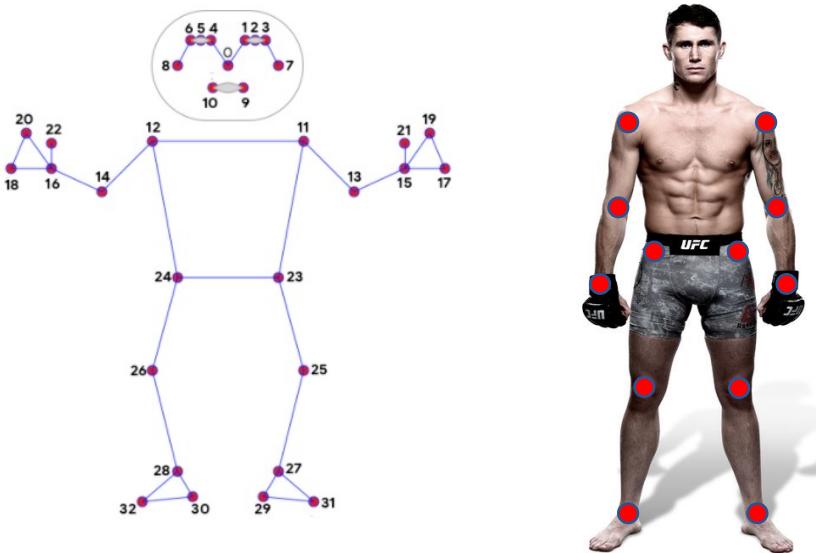
- Test set

```
2/2 [=====] - 0s 10ms/step  
- loss: 0.8901 - binary_accuracy: 0.5238 - accuracy:  
0.5238
```

LSTM: Accuracy: 52% only

Data Preprocessing

- Keypoints were dropped, as it generated too many features, potentially overfitting the model.
- 10 joints angles were feature engineered.
- Only still images of each strike type were used.
 - Total of 6 different strikes
- Video footage generated too much noise.



attack_type	right_elbow_angle	right_shoulder_angle	right_hip_angle	right_knee_angle	right_ankle_angle	left_elbow_angle	left_shoulder_angle	left_hip_ang
5	39.0	49.0	153.0	174.0	118.0	147.0	72.0	162
5	36.0	49.0	153.0	174.0	119.0	148.0	73.0	162
5	37.0	49.0	154.0	174.0	118.0	150.0	74.0	162
5	35.0	49.0	154.0	174.0	117.0	150.0	74.0	162
5	35.0	49.0	154.0	174.0	117.0	152.0	75.0	162

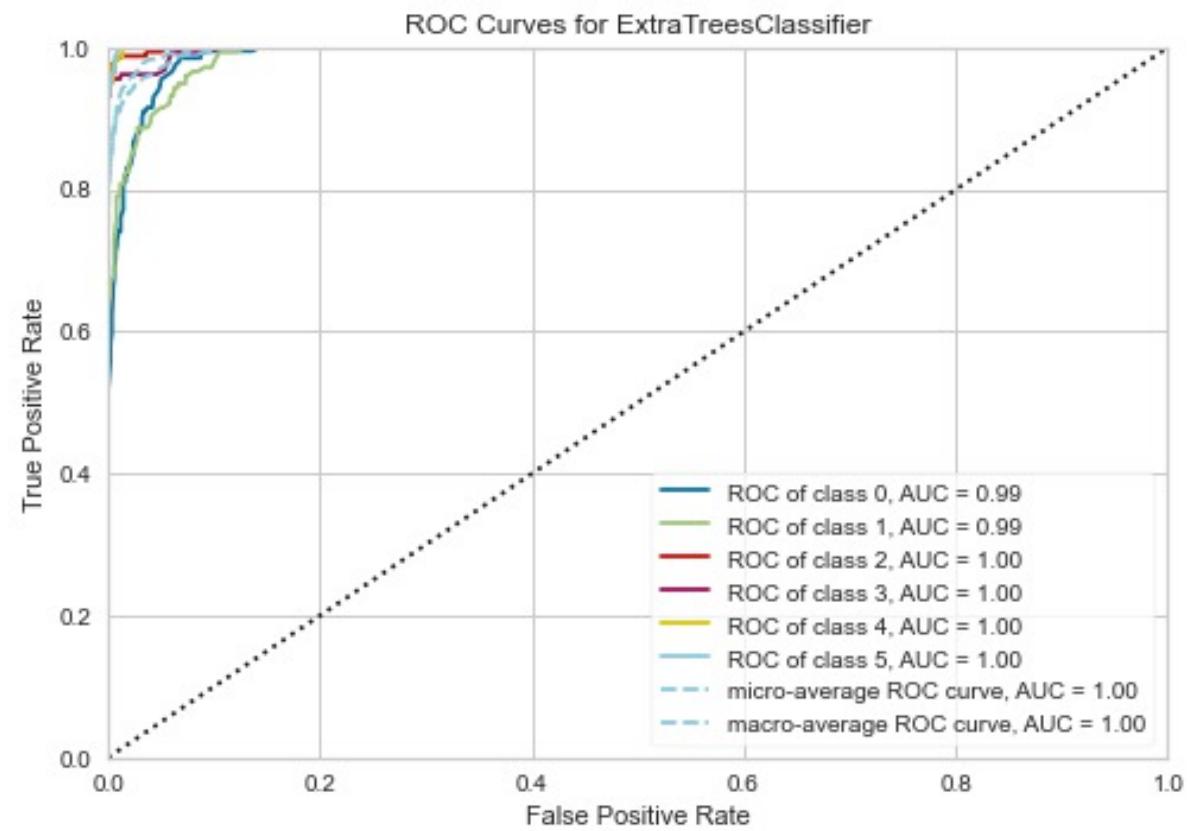
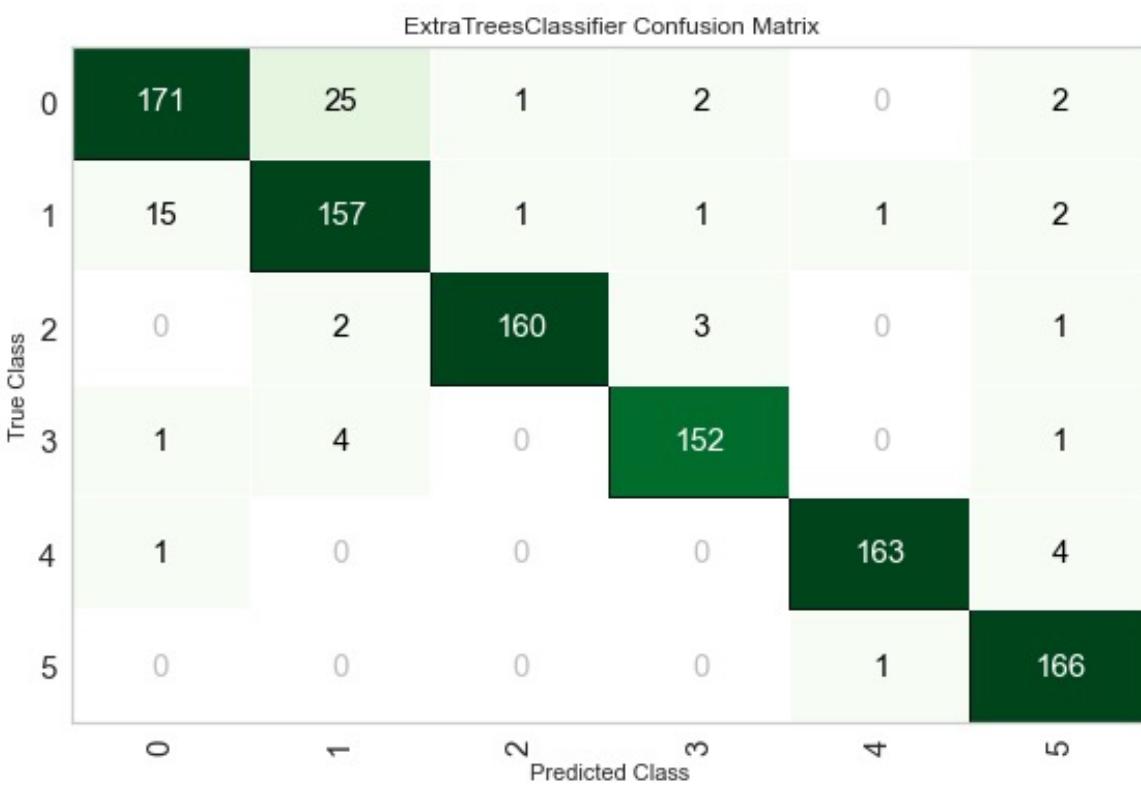
Data Preprocessing



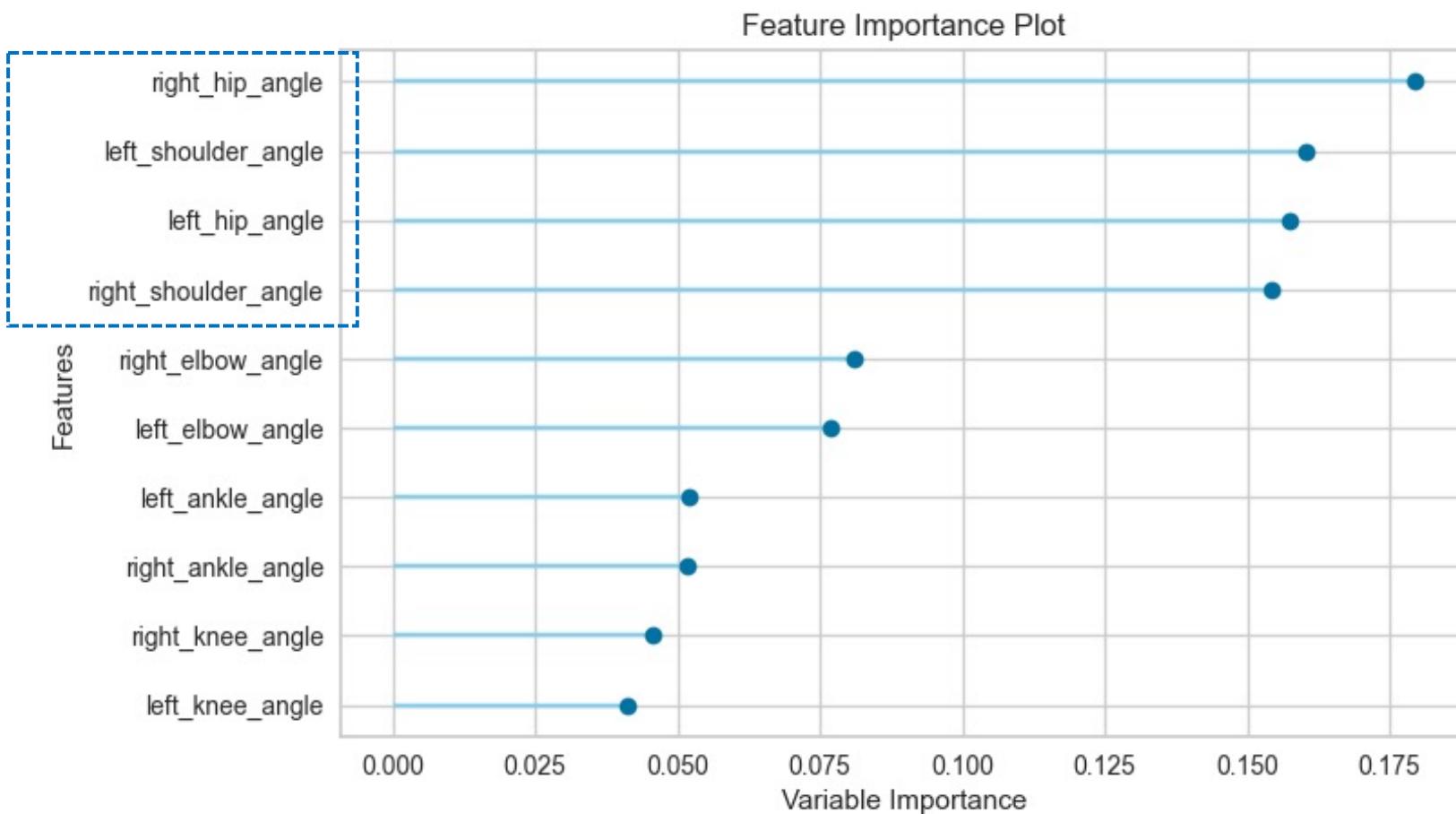
Modelling

Model		Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	TT (Sec)
et	Extra Trees Classifier	0.9512	0.9968	0.9497	0.9514	0.9508	0.9414	0.9416	0.1710
xgboost	Extreme Gradient Boosting	0.9446	0.9960	0.9431	0.9460	0.9443	0.9335	0.9339	1.3920
lightgbm	Light Gradient Boosting Machine	0.9442	0.9965	0.9429	0.9461	0.9440	0.9330	0.9335	3.9870
rf	Random Forest Classifier	0.9438	0.9959	0.9424	0.9441	0.9434	0.9325	0.9327	0.2000
knn	K Neighbors Classifier	0.9351	0.9873	0.9337	0.9359	0.9349	0.9221	0.9223	0.0500
gbc	Gradient Boosting Classifier	0.9330	0.9935	0.9314	0.9336	0.9327	0.9196	0.9199	0.4660
dt	Decision Tree Classifier	0.9190	0.9538	0.9172	0.9199	0.9185	0.9027	0.9031	0.0060
qda	Quadratic Discriminant Analysis	0.8809	0.9739	0.8791	0.8846	0.8809	0.8571	0.8579	0.0050
lr	Logistic Regression	0.8499	0.9676	0.8471	0.8522	0.8495	0.8199	0.8205	0.2740
lda	Linear Discriminant Analysis	0.8272	0.9595	0.8260	0.8311	0.8246	0.7926	0.7943	0.0050
nb	Naive Bayes	0.8214	0.9496	0.8200	0.8246	0.8182	0.7857	0.7875	0.0050
ridge	Ridge Classifier	0.8127	0.0000	0.8120	0.8200	0.8111	0.7753	0.7773	0.0050
svm	SVM - Linear Kernel	0.7995	0.0000	0.7964	0.8133	0.7973	0.7594	0.7629	0.0240
ada	Ada Boost Classifier	0.6292	0.8582	0.6253	0.6332	0.6071	0.5546	0.5721	0.0300
dummy	Dummy Classifier	0.1728	0.5000	0.1667	0.0299	0.0509	0.0000	0.0000	0.0040

Model Results



Feature Importance



Visualization of shoulder and hip angles



Left high kick



Left low kick

Potential use for detecting “striking aggressiveness”



Conclusion

- Striking is a major aspect of MMA.
- 45% of fights end in the hands of judges.
- CV tool proven to be accurate
 - Accuracy = 93%
 - F1 = 93%
- Brings objectiveness in MMA judging criteria.

Challenges faced / Limitations

- No consistent video angle for better pose estimation result
 - As such, unable to fixate pose estimation onto the same body
 - Ideally, to use this on one fixed angle
- Fights have minimally 3 people in the ring ; hence hard to dictate the pose estimation onto the person of interest.
 - Unable to ‘fix’ the detection frame by frame.
- Require multiple camera angles



FIFA's Semi-automated Video Assistance Referee (VAR)

Future Improvements

- To include an ‘impact’ component to categorize a strike as minor, regular, significant for more detailed judging criteria.
 - Can be calculated by the movement speed
- To measure other criteria of scoring such as “control of fighting area” or “effective aggressiveness”
- Potential use to evaluate safety of fighters before its too late.
 - Facial recognition tools with Neural Network.
 - Detect pain or lack of consciousness.
- Pose estimation for predicting moves.
 - Use for training or coaching.



A dynamic UFC fight scene. In the foreground, a fighter in black shorts with a Reebok logo and blue wristbands is facing away from the camera, looking towards his opponent. He has a tattoo on his left upper arm. His right arm is raised, holding a black glove. A second fighter in grey shorts with a UFC logo and red wristbands is captured mid-air, performing a high kick. The referee, wearing a black shirt, stands behind the kick, watching the action. The background shows the cage and some spectators.

THANK YOU