MMA STRIKE ANALYSIS USING COMPUTER VISION

GA DSI 25 – HAZIQ

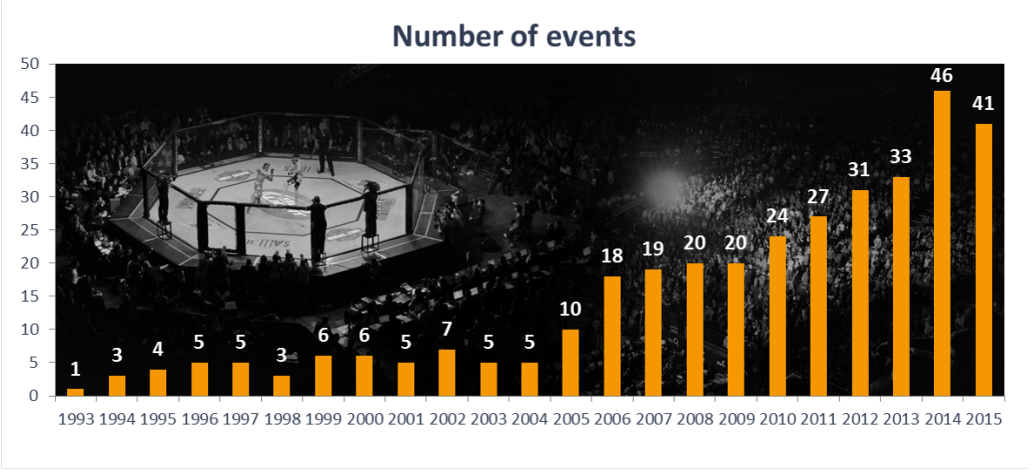
Overview

- 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



Background

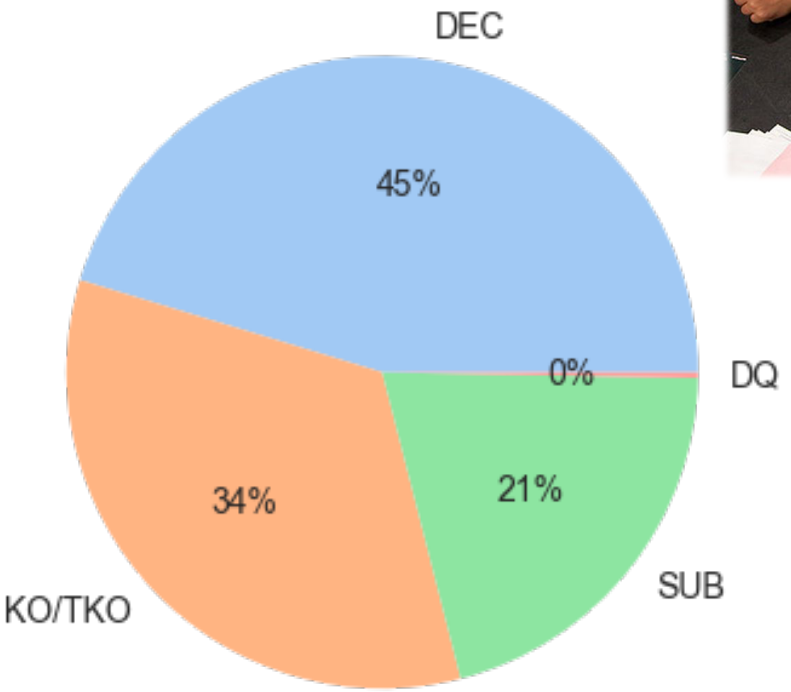
A quick introduction on MMA

- 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

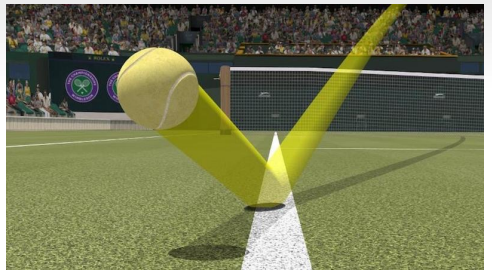
- Strikes attempted
- Significant strikes landed
- Striking accuracy

Background info

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

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

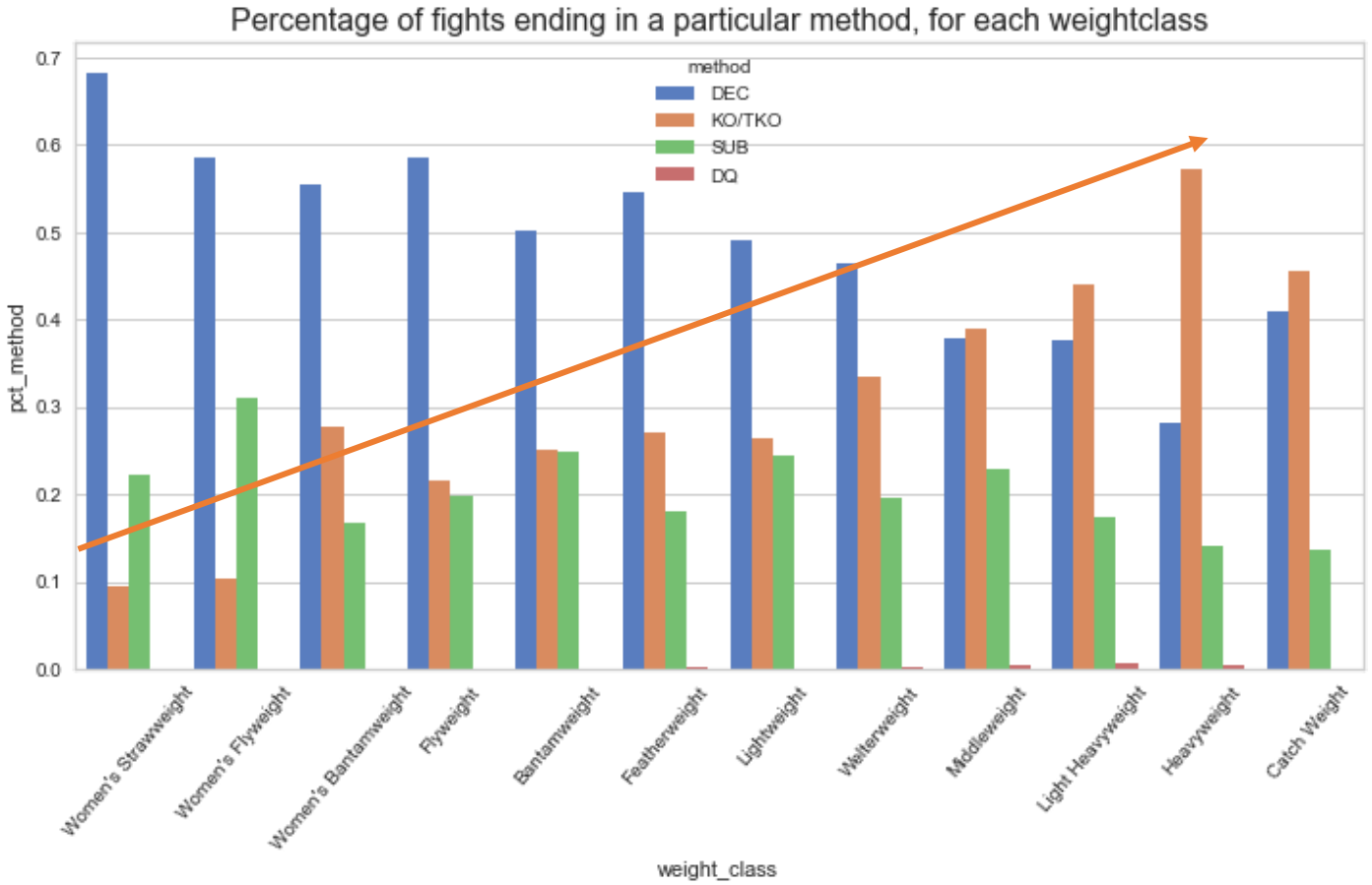
Part 1: MMA Fight Predictor

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

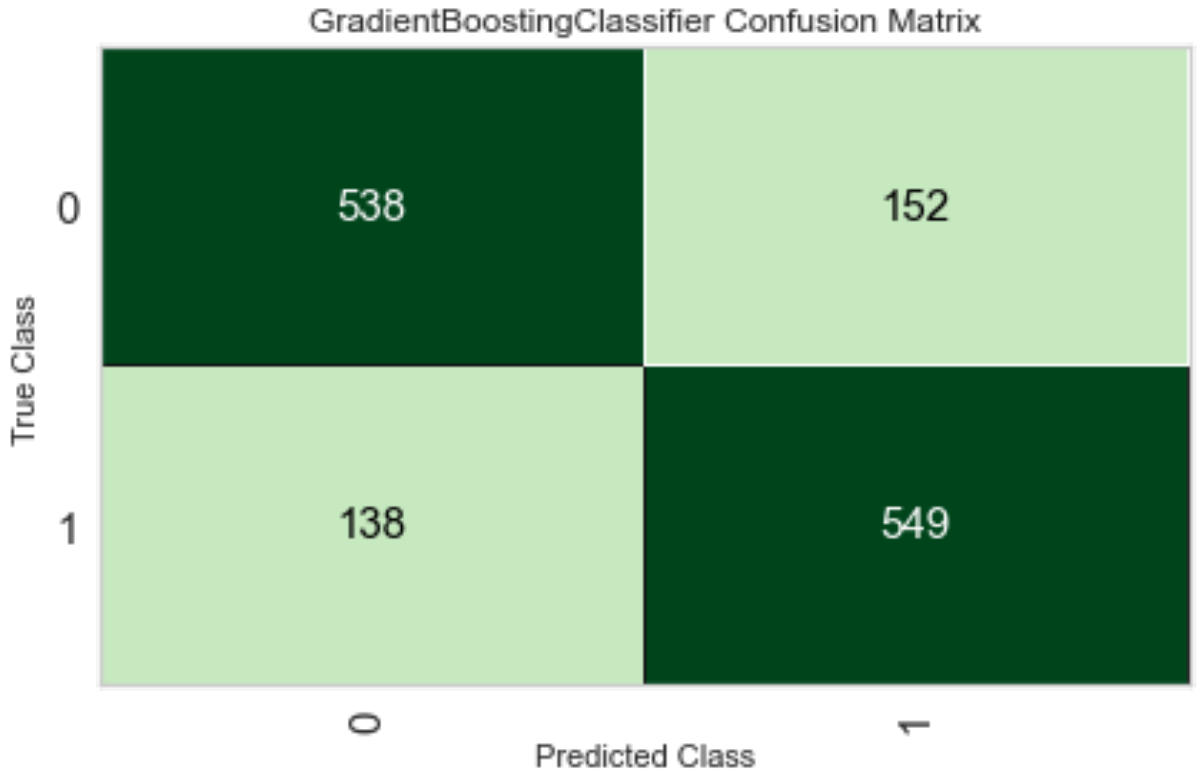
- As weight class increases, higher percentage of fights end in KO/TKO



Modelling

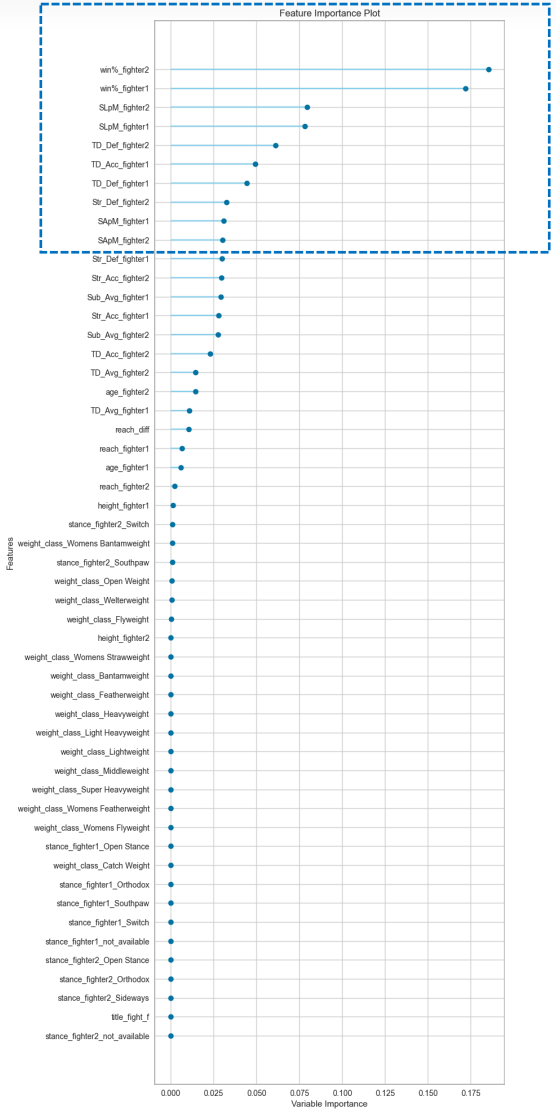
	Model	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	TT (Sec)
gbc	Gradient Boosting Classifier	0.7104	0.7857	0.7075	0.7118	0.7095	0.4207	0.4209	0.2620
lightgbm	Light Gradient Boosting Machine	0.7051	0.7773	0.6995	0.7078	0.7033	0.4102	0.4106	0.7900
ada	Ada Boost Classifier	0.6979	0.7739	0.7013	0.6974	0.6991	0.3958	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

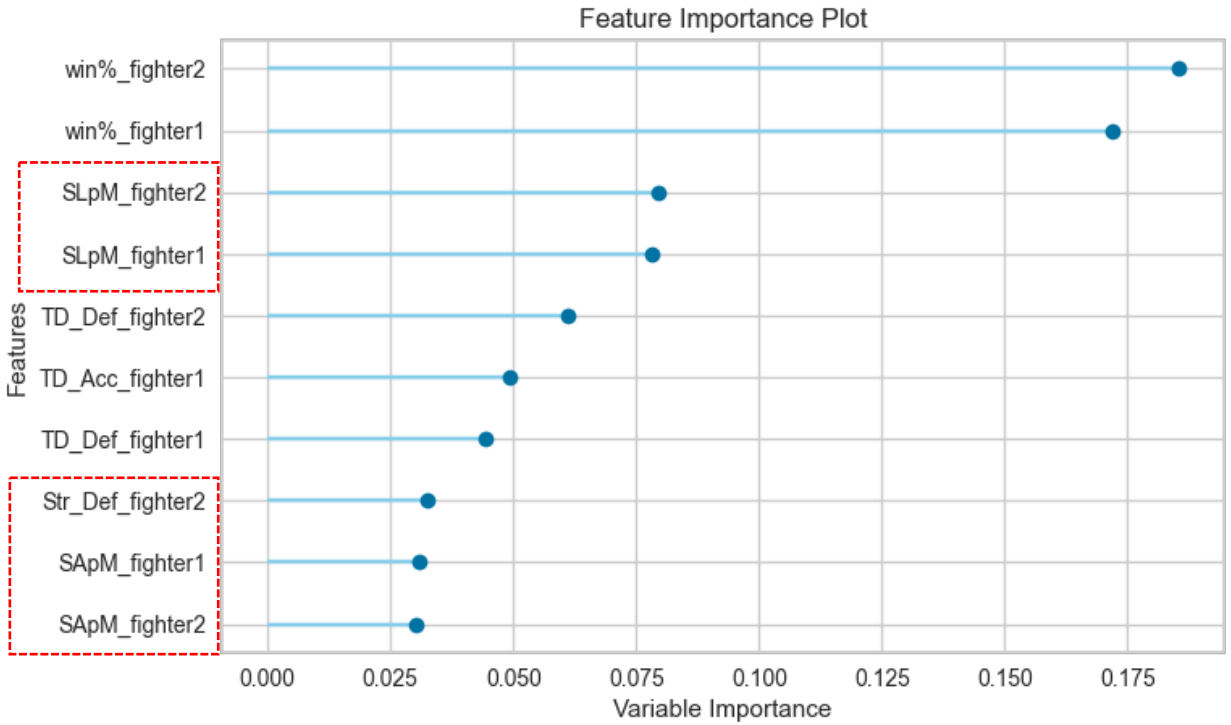


- Accuracy on Test Set: 78%

Modelling – Feature Importance



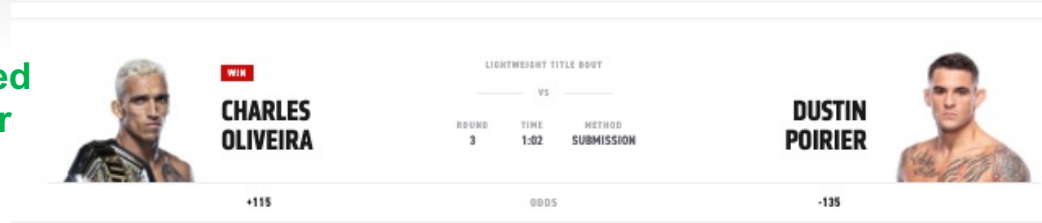
Modelling – Feature Importance



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

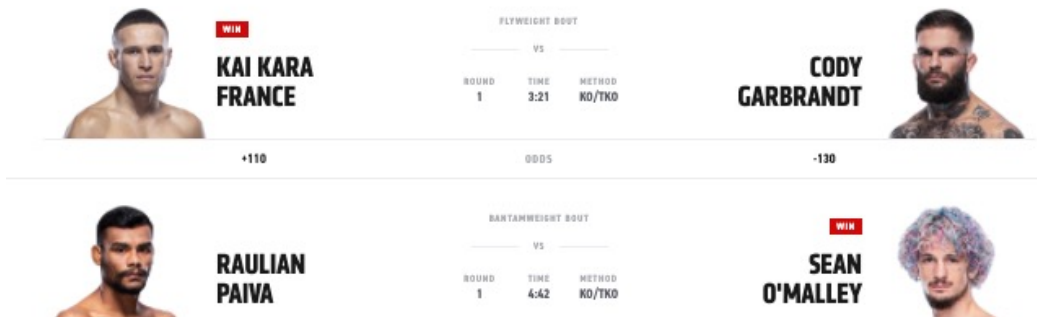
Prediction

Predicted winner (83%)



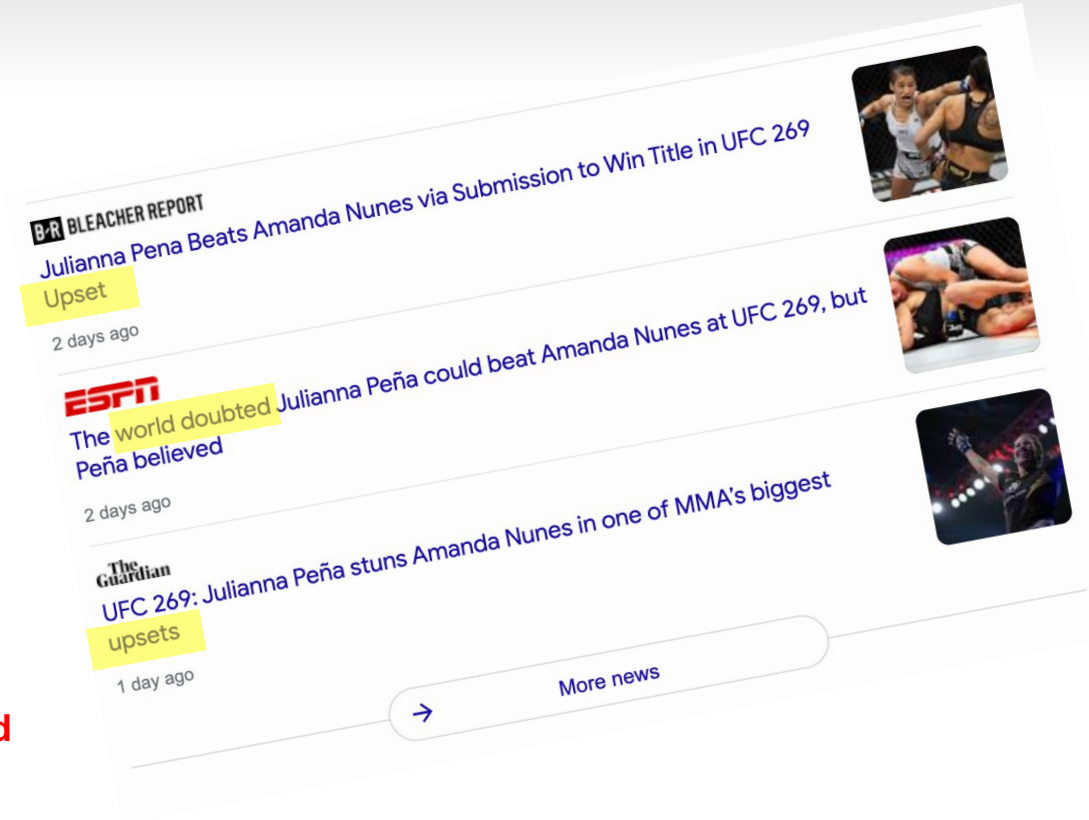
Predicted winner (80%)

Predicted winner (80%)



Predicted winner (60%)

Predicted winner (65%)

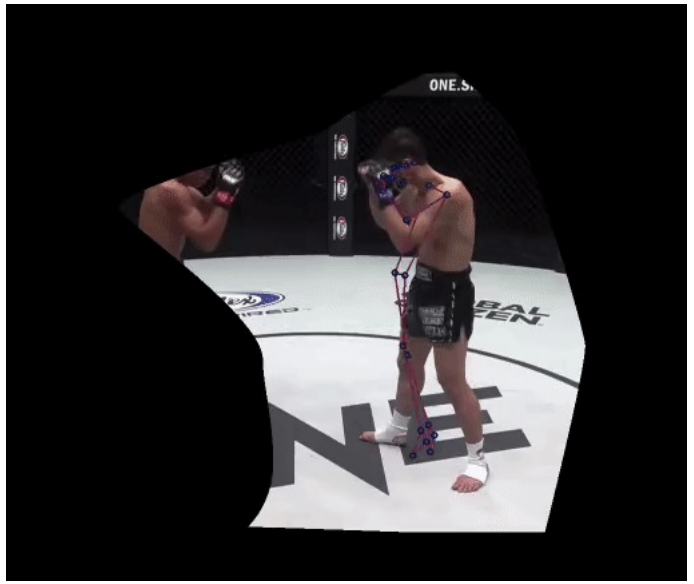


Part 2: Computer Vision Analysis of Strikes

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

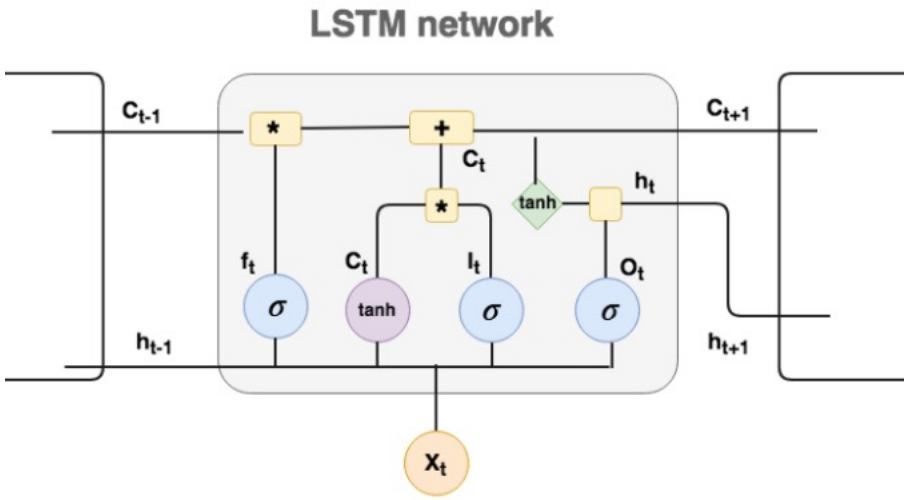
YouTube

OpenCV

MediaPipe

python

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
```

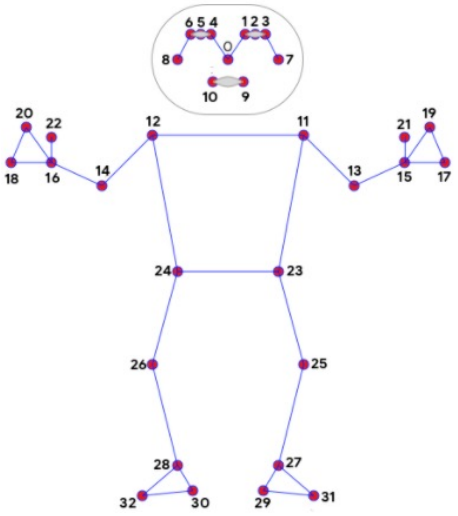
- Test set

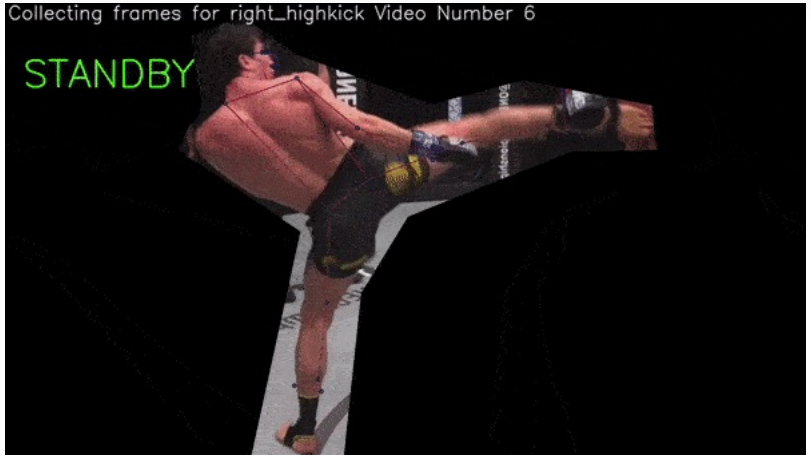
```
2/2 [==============================] - 0s 10ms/step
- loss: 0.8901 - binary_accuracy: 0.5238 - accuracy:
0.5238
```

LSTM: Accuracy: 52% only

Data Preprocessing

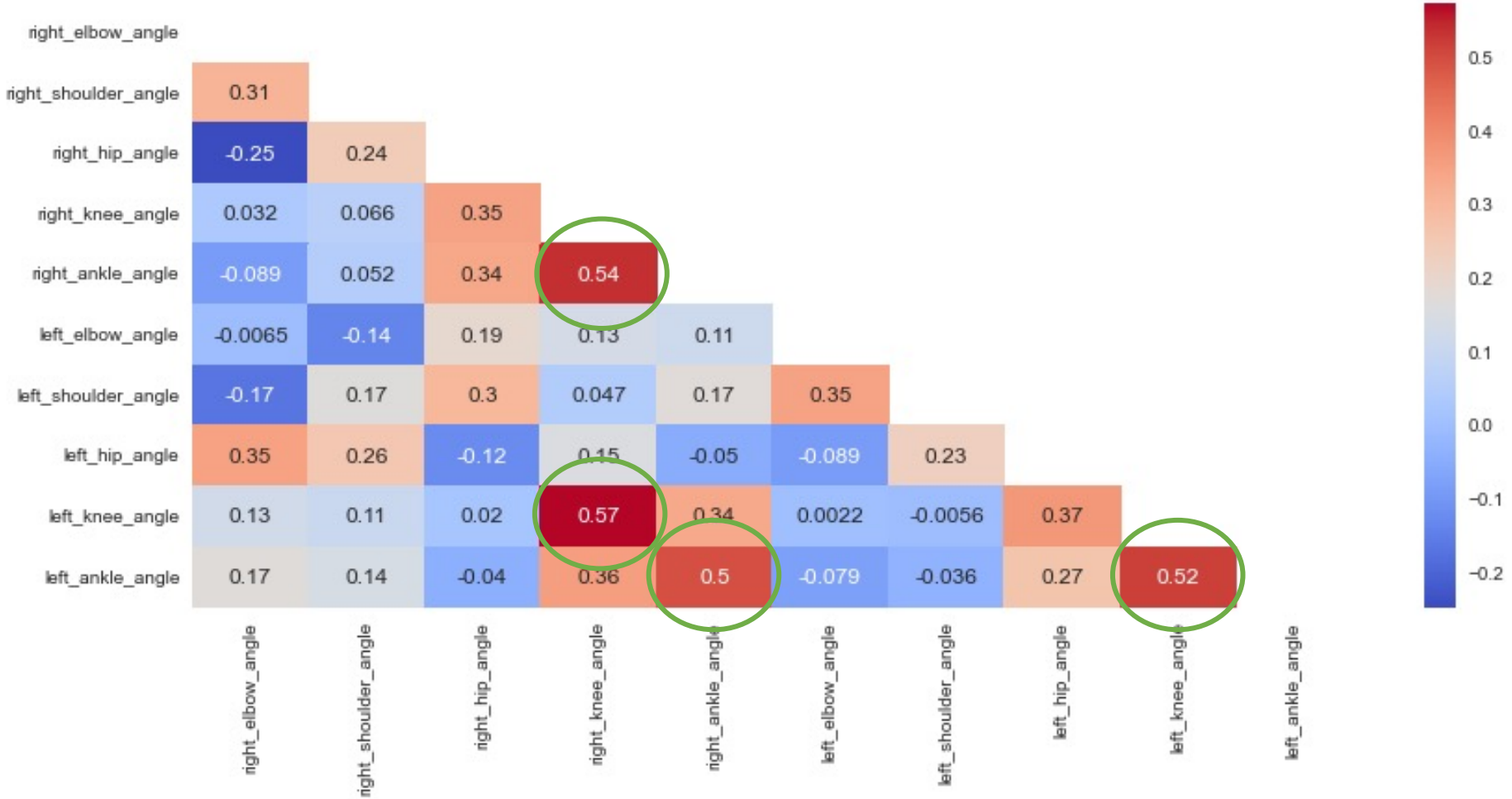
- Keypoints were dropped, as it generated too many features, potentially overfitting the model.
- 10 joints angles were feature engineered.
- Only still images of each strike type were used.
  - Total of 6 different strikes
- Video footage generated too much noise.





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	163
5	36.0	49.0	153.0	174.0	119.0	148.0	73.0	163
5	37.0	49.0	154.0	174.0	118.0	150.0	74.0	163
5	35.0	49.0	154.0	174.0	117.0	150.0	74.0	163
5	35.0	49.0	154.0	174.0	117.0	152.0	75.0	163

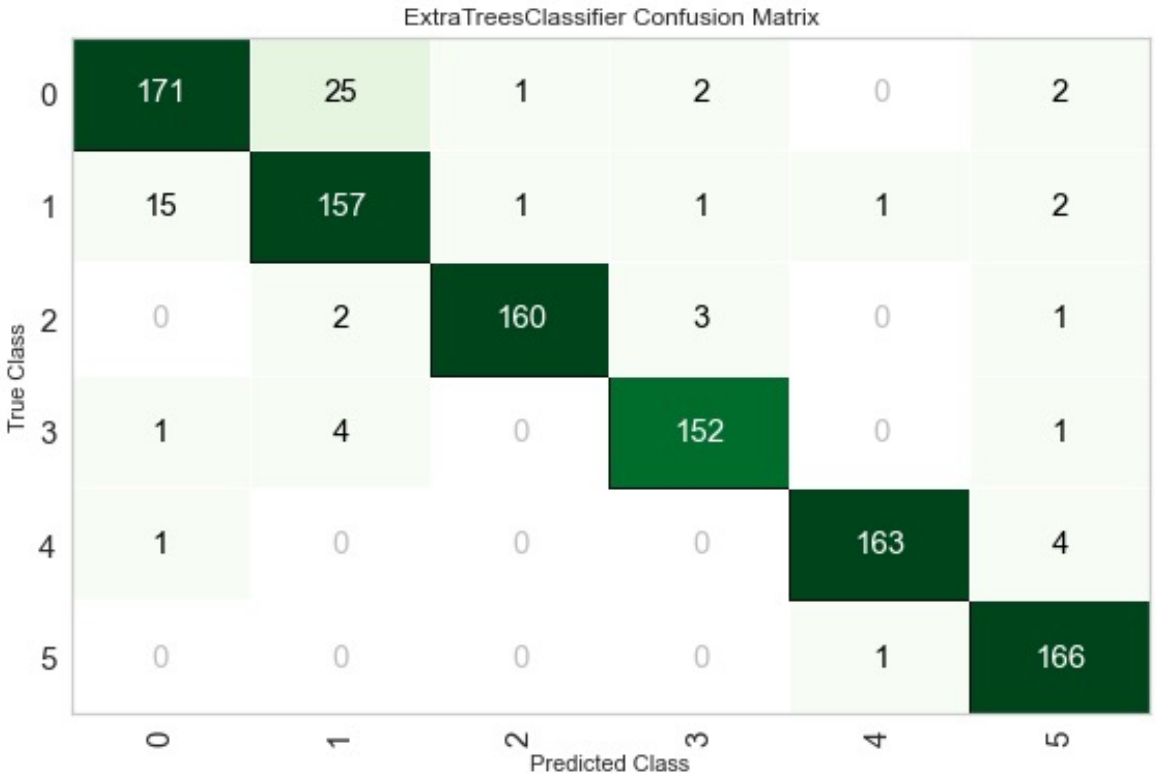
Data Preprocessing

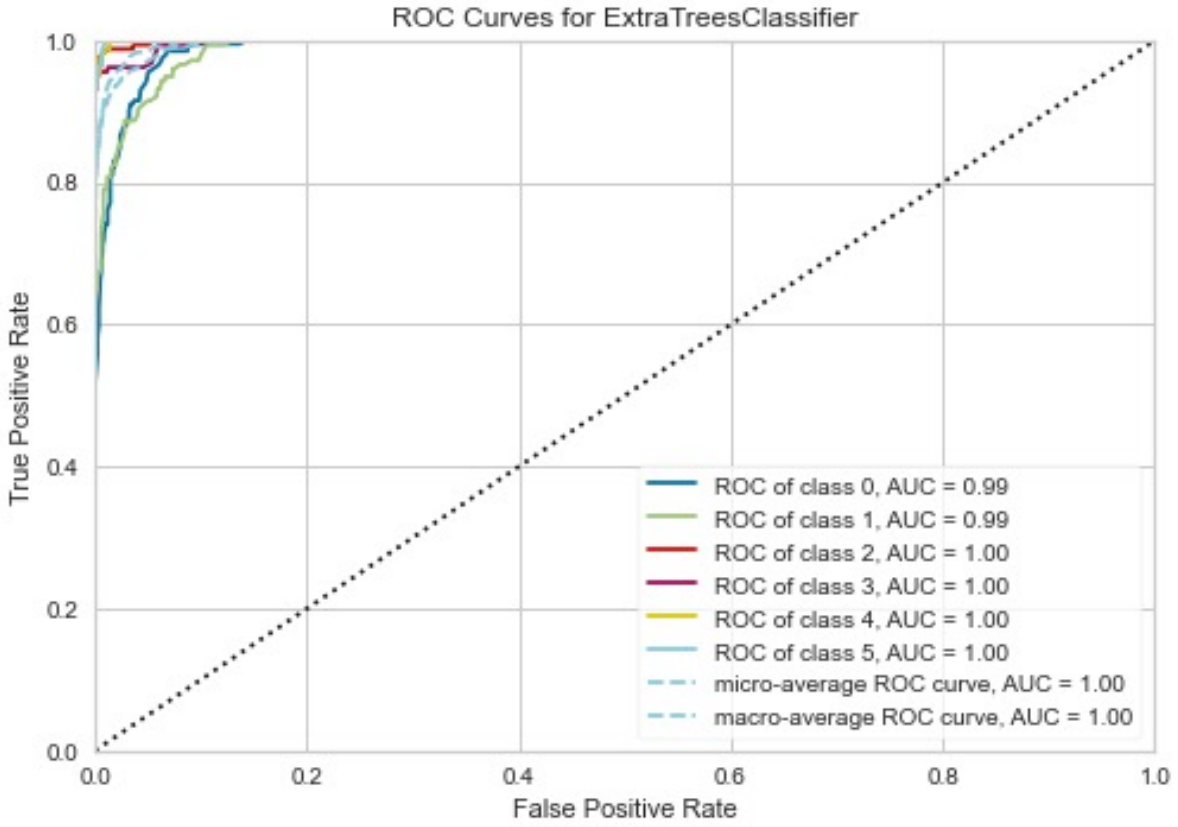


Modelling

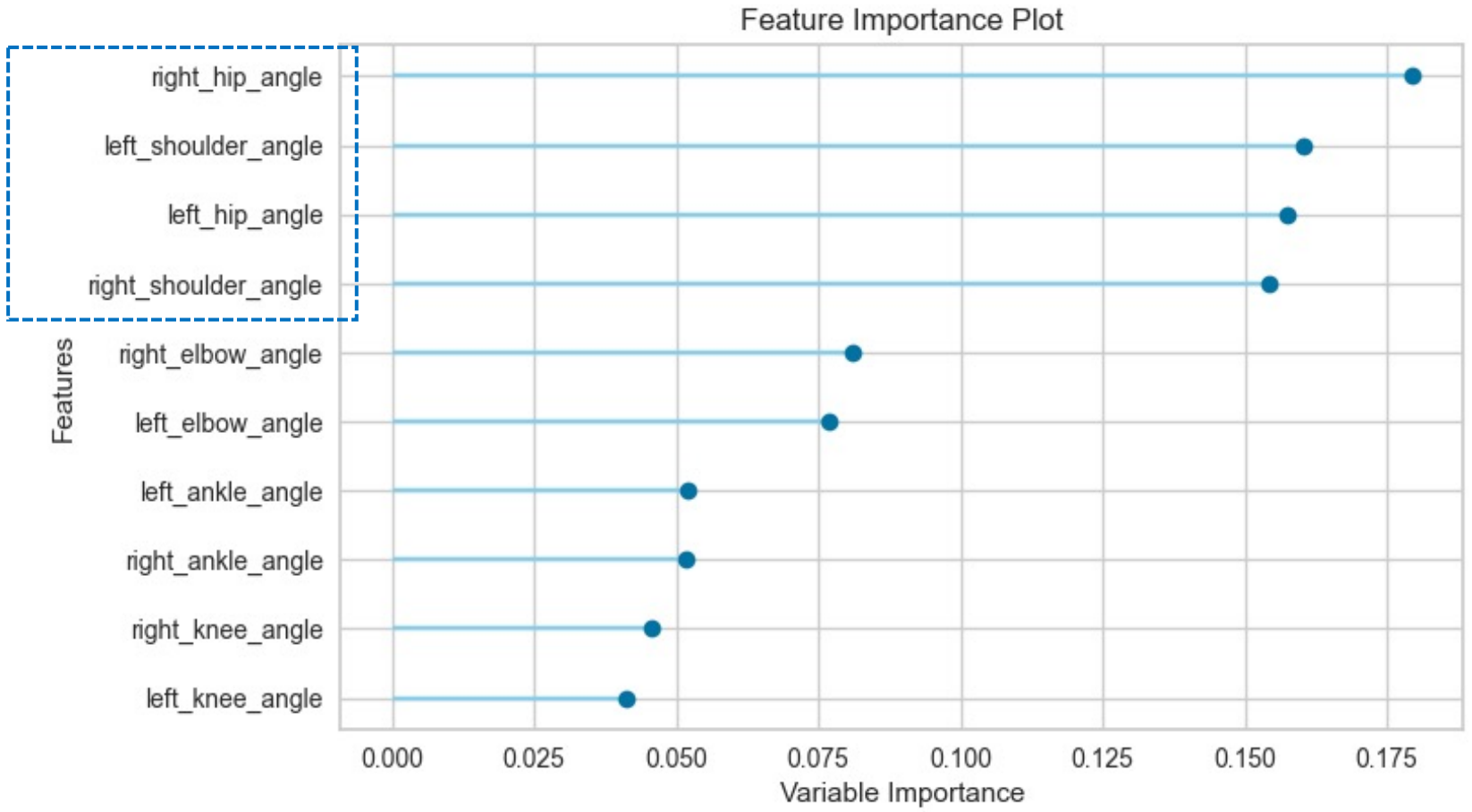
	Model	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	TT (Sec)
et	Extra Trees Classifier	0.9512	0.9968	0.9497	0.9514	0.9508	0.9414	0.9416	0.1710
xgboost	Extreme Gradient Boosting	0.9446	0.9960	0.9431	0.9460	0.9443	0.9335	0.9339	1.3920
lightgbm	Light Gradient Boosting Machine	0.9442	0.9965	0.9429	0.9461	0.9440	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

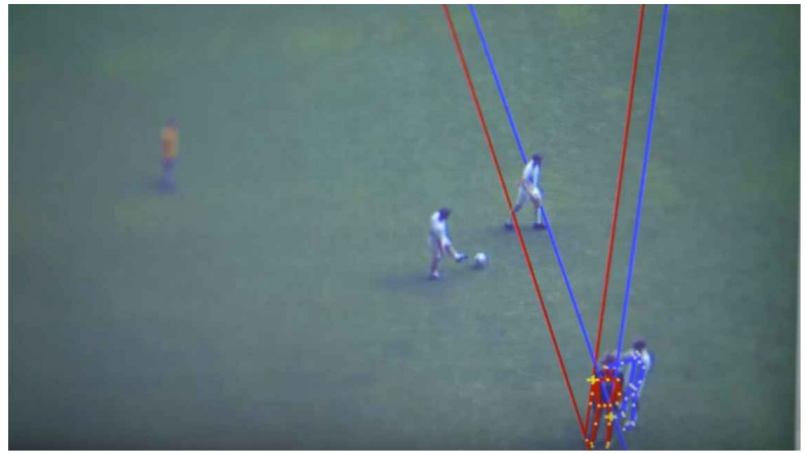
Potential use for detecting “striking aggressiveness”

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.


THANK YOU