MMA STRIKE ANALYSIS USING COMPUTER VISION

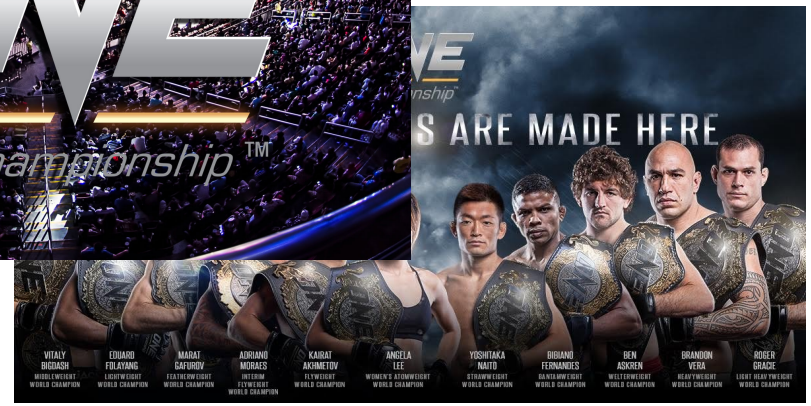
GA DSI 25 – HAZIQ

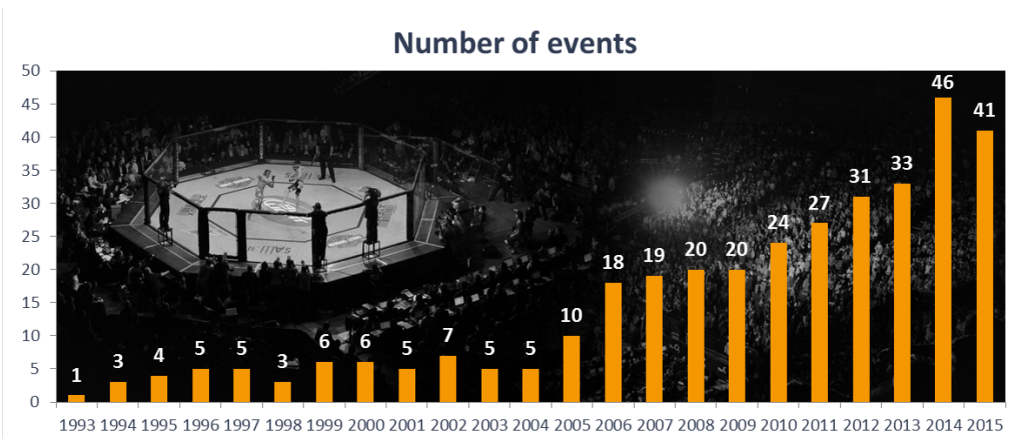
Overview

- Background
- Problem Statement
- Data Preprocessing
- EDA
- Modelling
- Future Improvements
- Conclusion

UFC: USD 7 billion

ONE Championship: USD 1 billion





Background

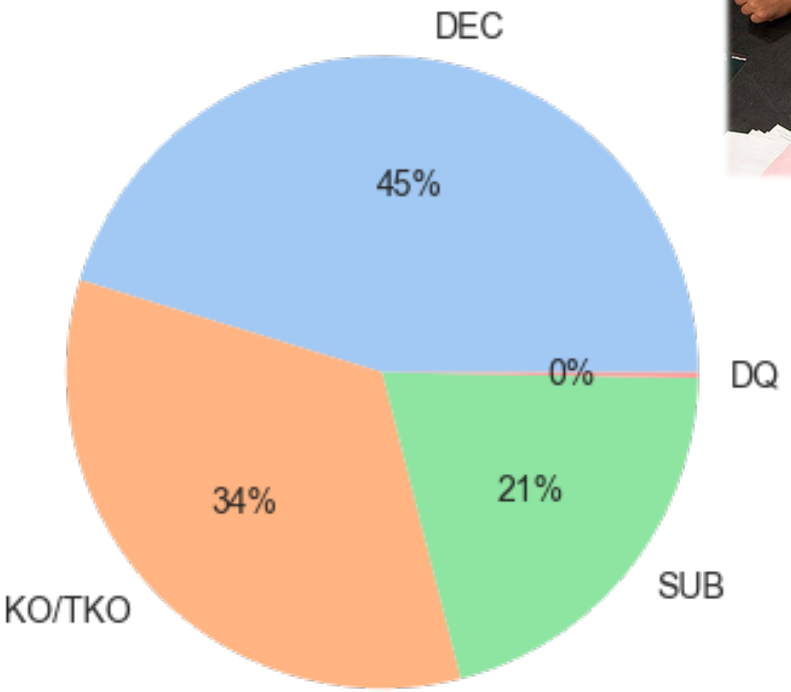
A quick introduction on MMA

- 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?

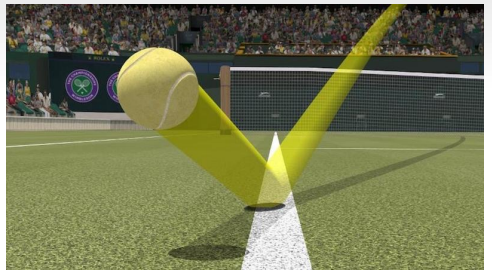
- Effective striking
- Effective grappling
- Effective aggressiveness
- Control of fighting area

- Strikes attempted
- Significant strikes landed
- Striking accuracy

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 making their decision based on striking numbers.
- **Solution**: Computer vision tool to assist judges in scoring rounds and reduce subjectivity



Tennis – Hawk Eye

Football – Goal Line Technology

Rugby – Video Refereeing

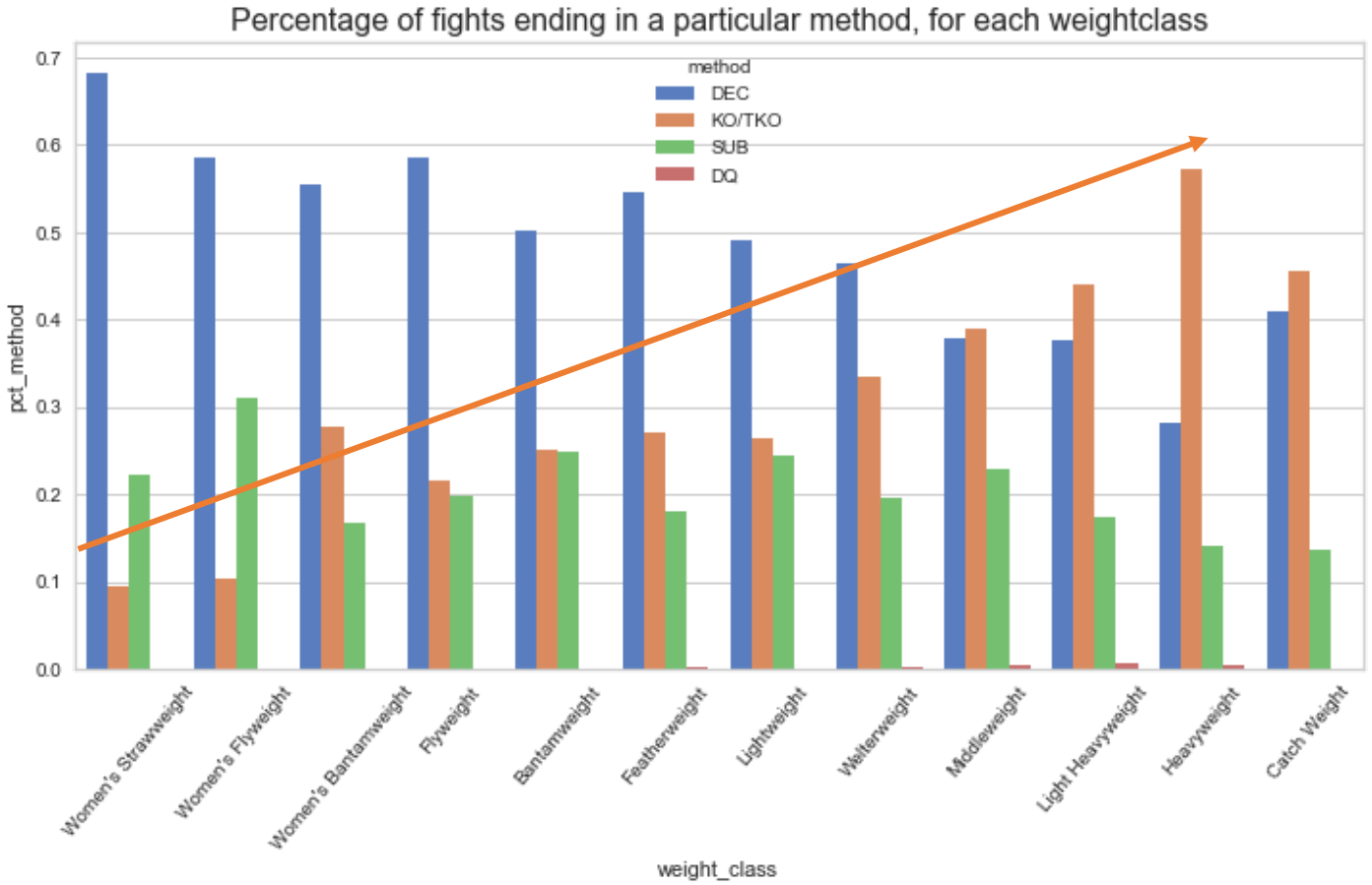
Data Cleaning (Feature Selection)

- Fighter-specific features
  - Age, Height, Reach, Stance, Weight Class
- Fight-related features
  - **Strikes**: Landed, Absorbed, Defended, Accuracy
  - Takedown: Landed, Defended, Accuracy
  - Submission: Attempted
- Other features
  - Round end, Method, Title Fight

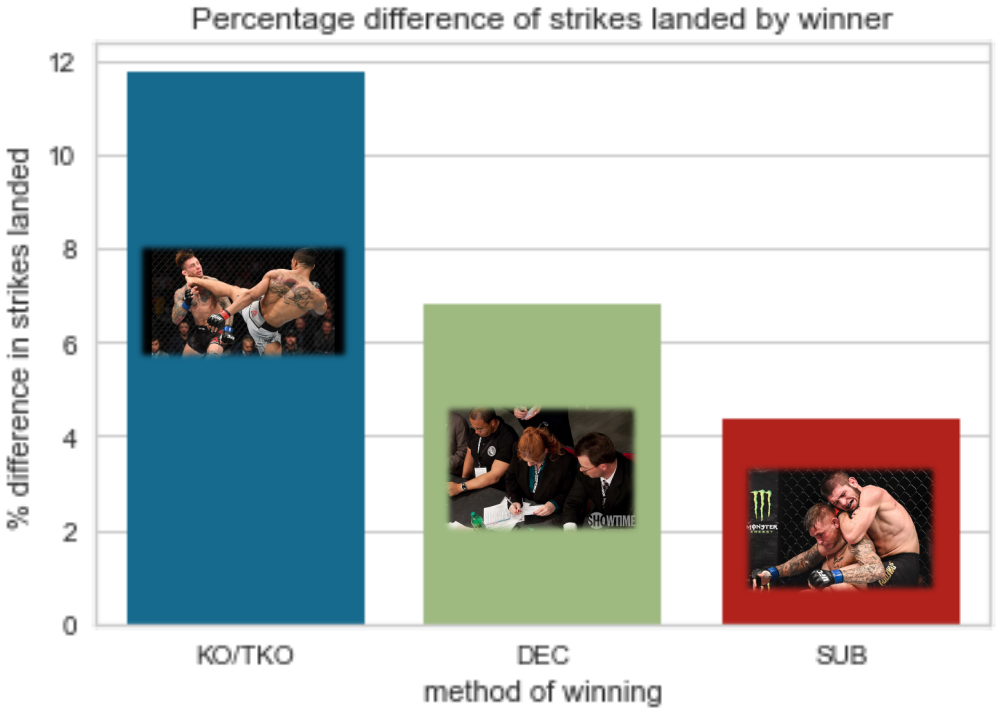
	fighter1	fighter2	winner	weight_class	title_fight	method	end_round	fight_year	win_fighter1	lose_fighter1	draw_fighter1	nc_fighter1	height_fighter1
4586	Chas Skelly	Bobby Moffett	0	Featherweight	f	SUB	2	2018	17	4	0	0	5' 11"
4587	Davi Ramos	John Gunther	1	Lightweight	f	SUB	1	2018	9	2	0	0	5' 6"
4588	Julian Erosa	Devonte Smith	0	Lightweight	f	KO/TKO	1	2018	22	7	0	0	6' 1"
4589	Eric Shelton	Joseph Morales	1	Flyweight	f	DEC	3	2018	12	5	0	0	5' 6"
4590	Mark De La Rosa	Joby Sanchez	1	Bantamweight	f	DEC	3	2018	11	1	0	0	5' 6"

EDA

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



EDA



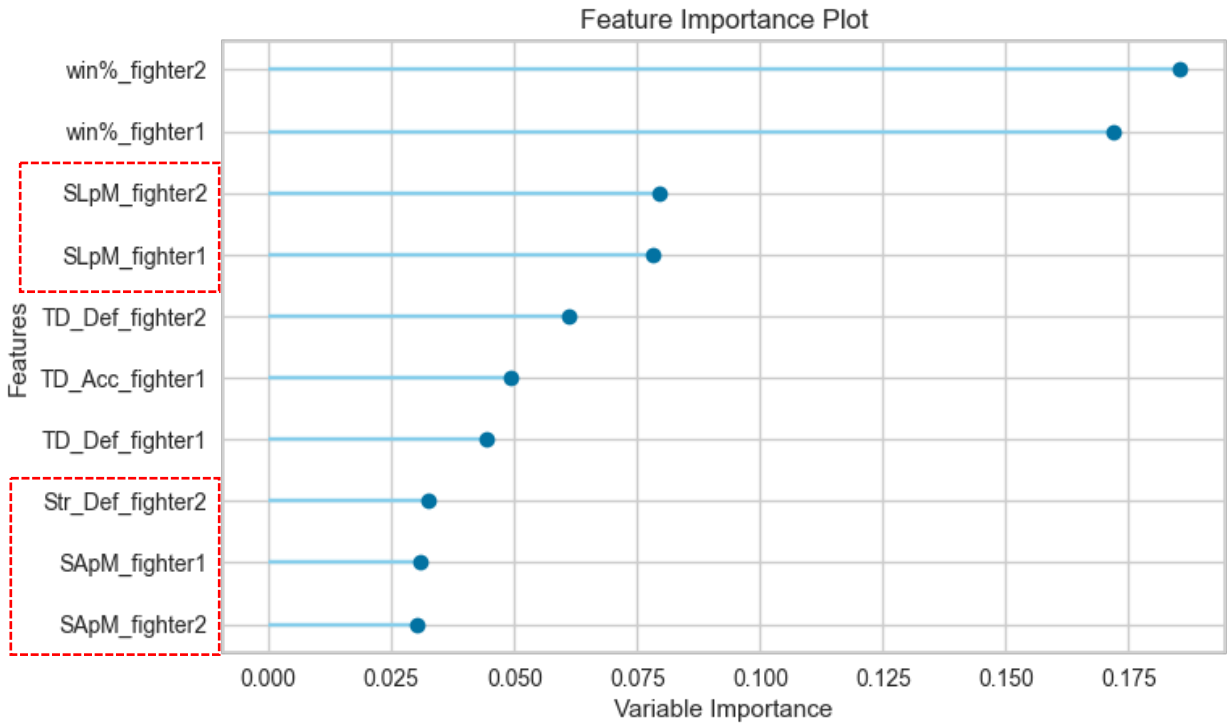
- Fighters that win by KO/TKO land more strikes against their opponents that those that win by SUBS

MMA Fight Predictor

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

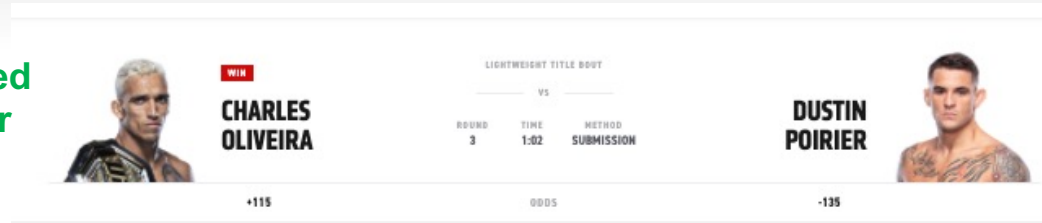
- Accuracy on Test Set: 78%



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

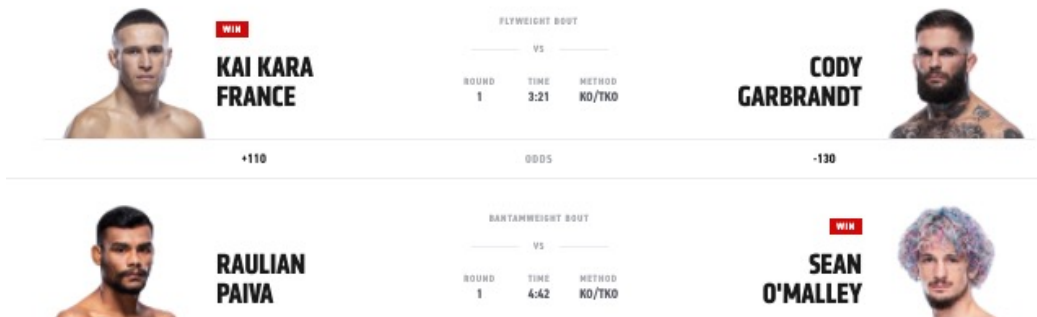
Prediction

Predicted winner (83%)



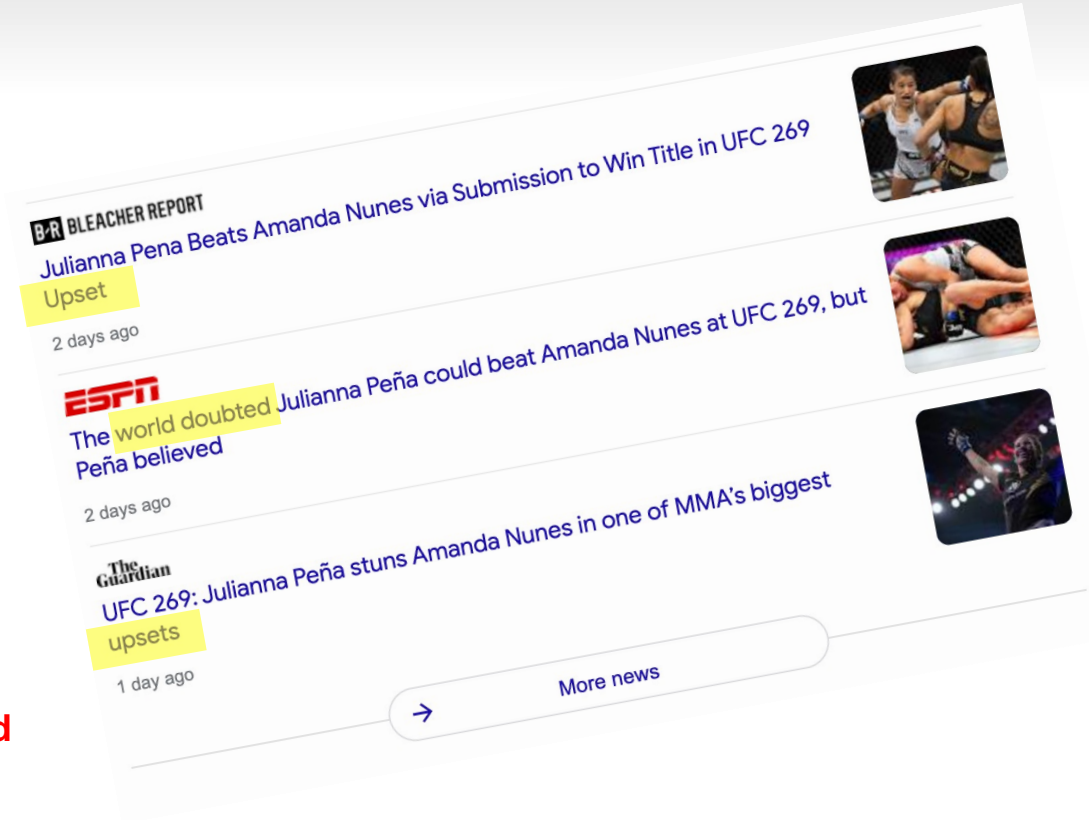
Predicted winner (80%)

Predicted winner (80%)



Predicted winner (60%)

Predicted winner (65%)



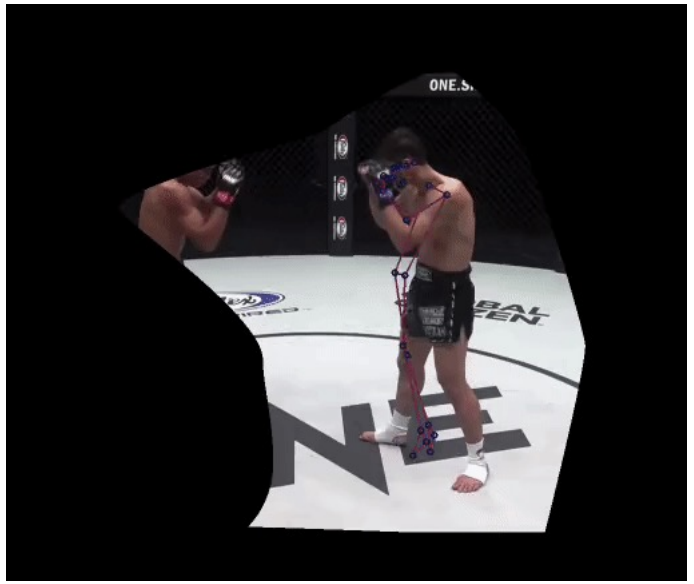
Computer Vision Analysis of Strikes

Data Collection

- Video footage of MMA fights from online sources

YouTube

- Crop out only the relevant fighter and apply pose estimation



OpenCV

MediaPipe

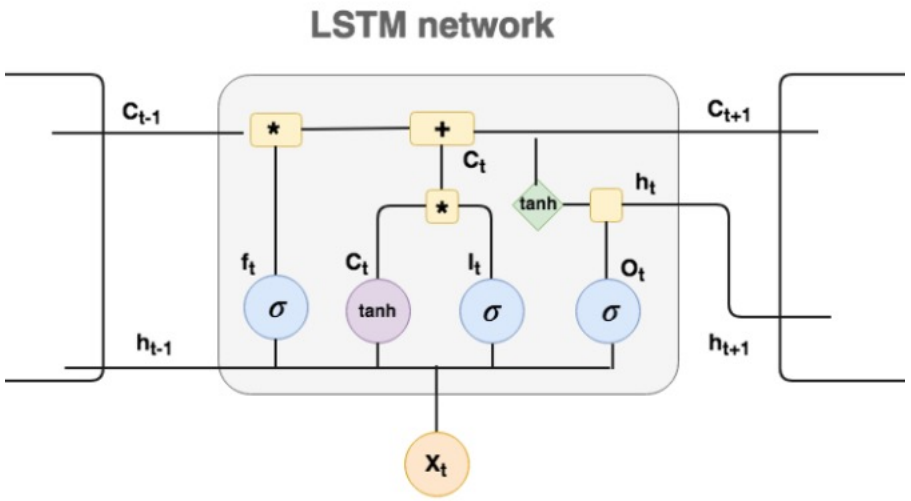
python

- Extract pose estimation keypoints into dataframe

	attack_type	frame_num	nose_x	nose_y	nose_z	left_eye_inner_x	left_eye_inner_y	left_eye_inner_z	left_eye_x	left_eye_y	left_eye_z	left_eye_outer_
0	0	0	0.578093	0.122442	-0.040693	0.590232	0.118591	-0.033230	0.593823	0.122611	-0.033219	0.5975
1	0	1	0.582941	0.120818	-0.051595	0.594627	0.118439	-0.044298	0.597939	0.122459	-0.044334	0.6013
2	0	2	0.584567	0.121887	-0.066308	0.595633	0.119053	-0.059041	0.599057	0.122886	-0.059042	0.6026
3	0	3	0.584130	0.121001	-0.076620	0.595297	0.118088	-0.066506	0.598848	0.121771	-0.066535	0.6025
4	0	4	0.584493	0.121604	-0.066044	0.596268	0.118704	-0.055056	0.599892	0.122532	-0.055091	0.6036
...	...	...	...	...	...	...	...	...	...	...	...	
3451	5	19	0.538360	0.096936	0.119413	0.535498	0.083333	0.081952	0.532861	0.082931	0.081933	0.5304
3452	5	20	0.537787	0.097246	0.117007	0.535080	0.083731	0.079740	0.532514	0.083370	0.079726	0.5301
3453	5	21	0.537535	0.097313	0.120358	0.534762	0.083770	0.083794	0.532224	0.083438	0.083782	0.5298
3454	5	22	0.537890	0.097986	0.129107	0.535075	0.084356	0.092177	0.532517	0.084020	0.092178	0.5301
3455	5	23	0.538068	0.098495	0.133983	0.535200	0.084829	0.096888	0.532638	0.084514	0.096893	0.5302

Modelling (LSTM)

	attack_type	frame_num	nose_x	nose_y	nose_z	left_eye_inner_x	left_eye_inner_y	left_eye_inner_z	left_eye_x	left_eye_y	left_eye_z	left_eye_outer_
0	0	0	0.578093	0.122442	-0.040693	0.590232	0.118591	-0.033230	0.593823	0.122611	-0.033219	0.59754
1	0	1	0.582941	0.120818	-0.051595	0.594627	0.118439	-0.044298	0.597939	0.122459	-0.044334	0.60135
2	0	2	0.584567	0.121887	-0.066308	0.595633	0.119053	-0.059041	0.599057	0.122886	-0.059042	0.60261
3	0	3	0.584130	0.121001	-0.076620	0.595297	0.118088	-0.066506	0.598848	0.121771	-0.066535	0.60254
4	0	4	0.584493	0.121604	-0.066044	0.596268	0.118704	-0.055056	0.599892	0.122532	-0.055091	0.60366
...	...	...	...	...	...	...	...	...	...	...	...	...
3451	5	19	0.538360	0.096936	0.119413	0.535498	0.083333	0.081952	0.532861	0.082931	0.081933	0.53043
3452	5	20	0.537787	0.097246	0.117007	0.535080	0.083731	0.079740	0.532514	0.083370	0.079726	0.53015
3453	5	21	0.537535	0.097313	0.120358	0.534762	0.083770	0.083794	0.532224	0.083438	0.083782	0.52985
3454	5	22	0.537890	0.097986	0.129107	0.535075	0.084356	0.092177	0.532517	0.084020	0.092178	0.53015
3455	5	23	0.538068	0.098495	0.133983	0.535200	0.084829	0.096888	0.532638	0.084514	0.096893	0.53027



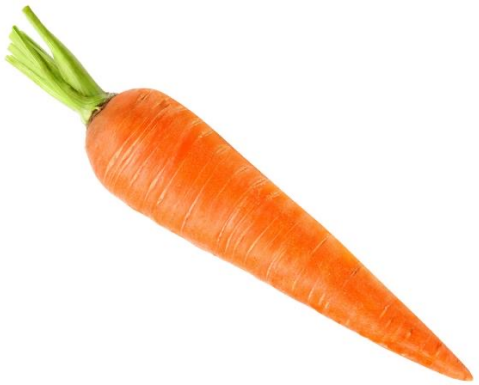
- Train set

```
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
```

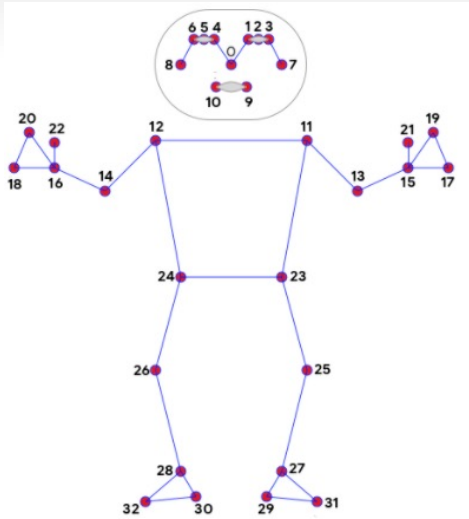
	attack_type	frame_num	nose_x	nose_y	nose_z	left_eye_inner_x	left_eye_inner_y	left_eye_inner_z	left_eye_x	left_eye_y	left_eye_z	left_eye_outer_
0	0	0	0.578093	0.122442	-0.040693	0.590232	0.118591	-0.033230	0.593823	0.122611	-0.033219	0.59754
1	0	1	0.582941	0.120818	-0.051595	0.594627	0.118439	-0.044298	0.597939	0.122459	-0.044334	0.60139
2	0	2	0.584567	0.121887	-0.066308	0.595633	0.119053	-0.059041	0.599057	0.122886	-0.059042	0.60261
3	0	3	0.584130	0.121001	-0.076620	0.595297	0.118088	-0.066506	0.598848	0.121771	-0.066535	0.60254
4	0	4	0.584493	0.121604	-0.066044	0.596268	0.118704	-0.055056	0.599892	0.122532	-0.055091	0.60366
...	...	...	...	...	...	...	...	...	...	...	...	
3451	5	19	0.538360	0.096936	0.119413	0.535498	0.083333	0.081952	0.532861	0.082931	0.081933	0.53043
3452	5	20	0.537787	0.097246	0.117007	0.535080	0.083731	0.079740	0.532514	0.083370	0.079726	0.53015
3453	5	21	0.537535	0.097313	0.120358	0.534762	0.083770	0.083794	0.532224	0.083438	0.083782	0.52989
3454	5	22	0.537890	0.097986	0.129107	0.535075	0.084356	0.092177	0.532517	0.084020	0.092178	0.53015
3455	5	23	0.538068	0.098495	0.133983	0.535200	0.084829	0.096888	0.532638	0.084514	0.096893	0.53027



Extra Trees Classifier
Accuracy = 90%

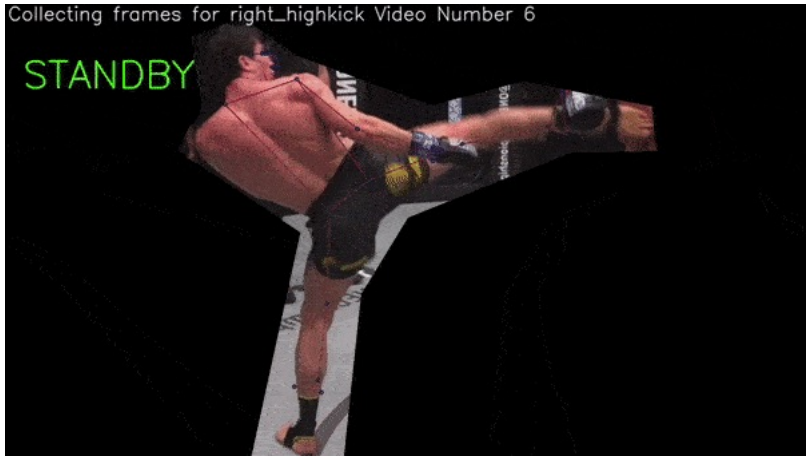
Data Preprocessing

- Remove frames before a strike.
- 10 joints angles kept, other keypoints removed.
- Only still images of each strike type were used.
  - Total of 6 different strikes

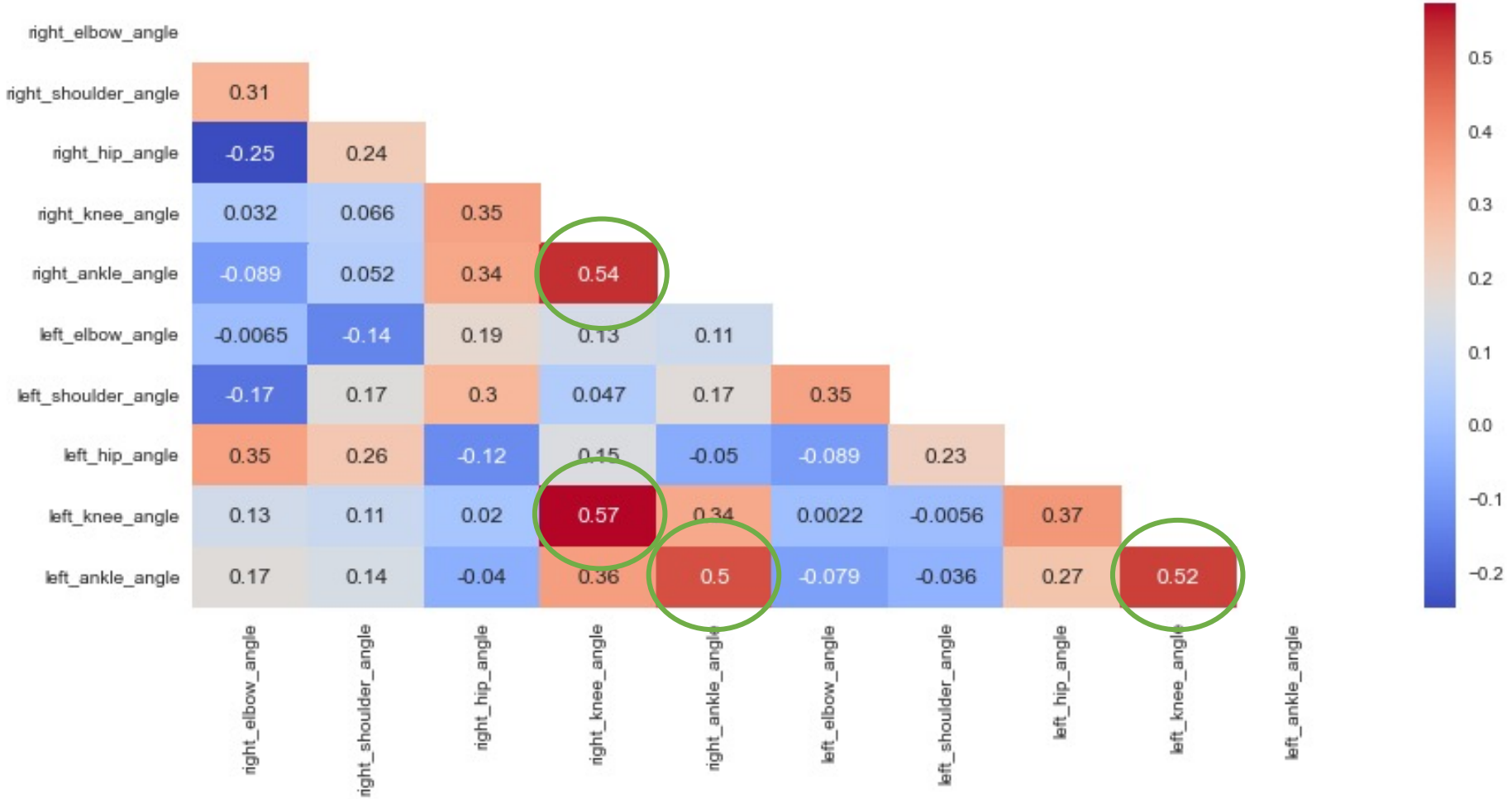


	attack_type	right_elbow_angle	right_shoulder_angle	right_hip_angle	right_knee_angle	right_ankle_angle	left_elbow_angle	left_shoulder_angle
0	0	170.0	17.0	65.0	170.0	143.0	7.0	35.0
1	0	168.0	15.0	66.0	173.0	141.0	9.0	36.0
2	0	155.0	11.0	68.0	172.0	142.0	8.0	33.0
3	0	180.0	14.0	68.0	175.0	147.0	8.0	31.0
4	0	156.0	16.0	67.0	175.0	146.0	10.0	33.0
...	...	...	...	...	...	...	...	...
3451	5	39.0	49.0	153.0	174.0	118.0	147.0	72.0
3452	5	36.0	49.0	153.0	174.0	119.0	148.0	73.0
3453	5	37.0	49.0	154.0	174.0	118.0	150.0	74.0
3454	5	35.0	49.0	154.0	174.0	117.0	150.0	74.0
3455	5	35.0	49.0	154.0	174.0	117.0	152.0	75.0

3456 rows × 11 columns



EDA


right_elbow_angle
right_shoulder_angle
right_hip_angle
right_knee_angle
right_ankle_angle
left_elbow_angle
left_shoulder_angle
left_hip_angle
left_knee_angle
left_ankle_angle
0.31
-0.25 0.24
0.032 0.066 0.35
-0.089 0.052 0.34 0.54
-0.0065 -0.14 0.19 0.13 0.11
-0.17 0.17 0.3 0.047 0.17 0.35
0.35 0.26 -0.12 0.15 -0.05 -0.089 0.23
0.13 0.11 0.02 0.57 0.34 0.0022 -0.0056 0.37
0.17 0.14 -0.04 0.36 0.5 -0.079 -0.036 0.27 0.52
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2

Modelling

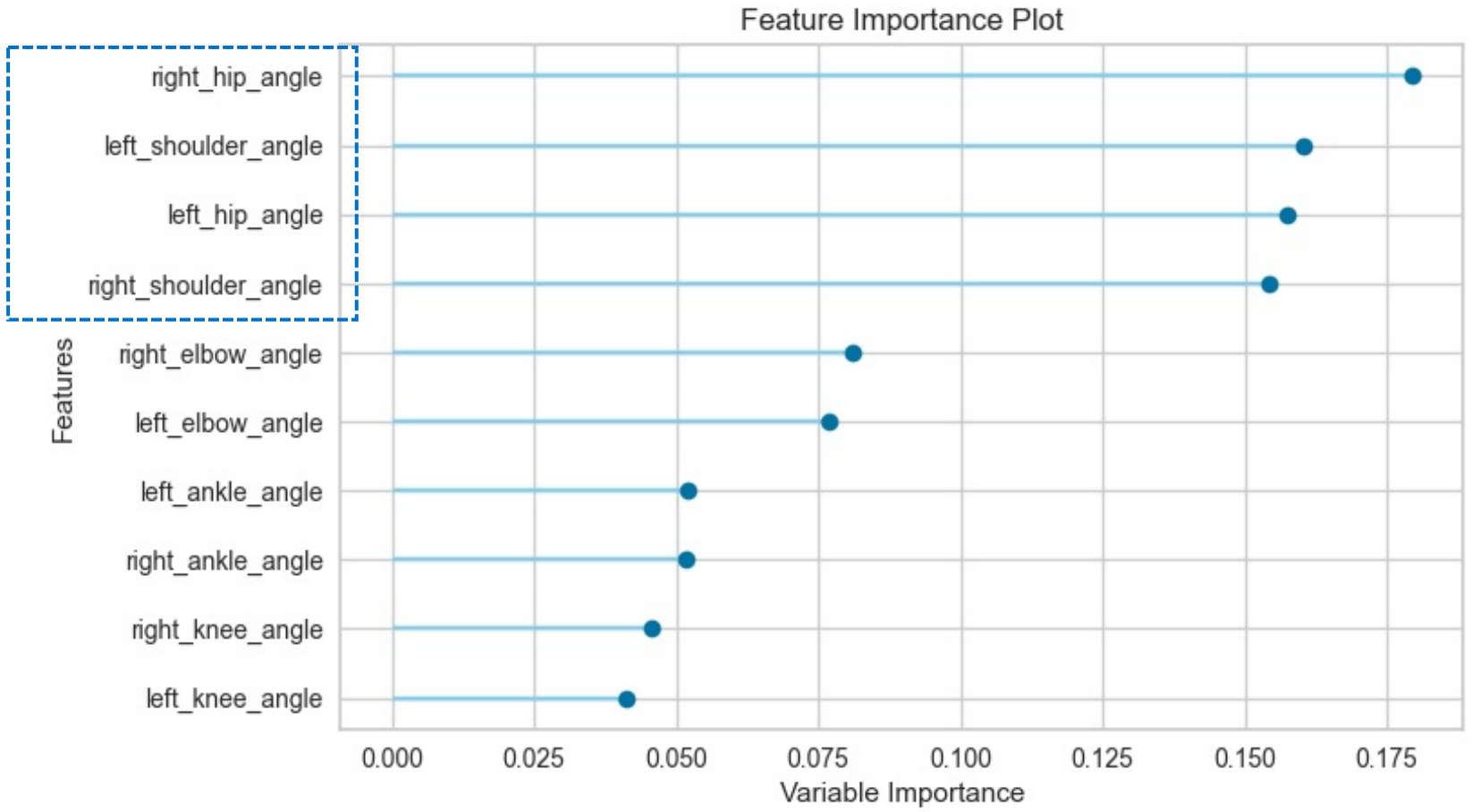
Train set

	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

Test set

	Model	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC
0	Extra Trees Classifier	0.9344	0.9956	0.9380	0.9355	0.9345	0.9212	0.9214

Feature Importance



Visualization of shoulder and hip angles

Left high kick

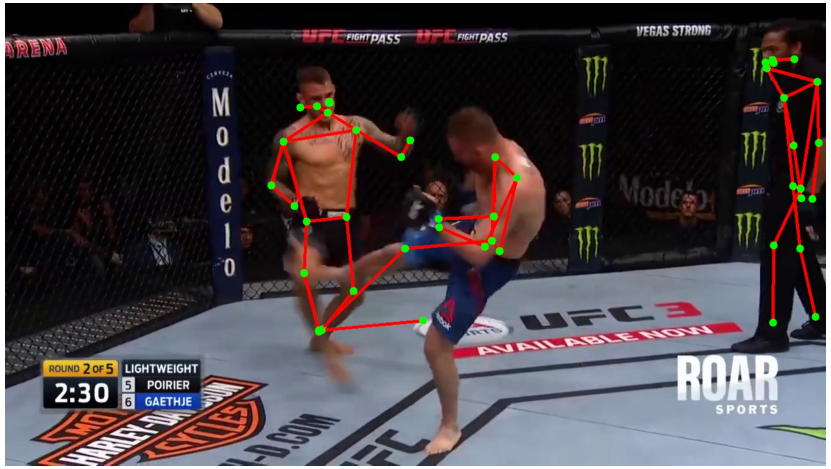
Left low kick

Potential use

Potential use

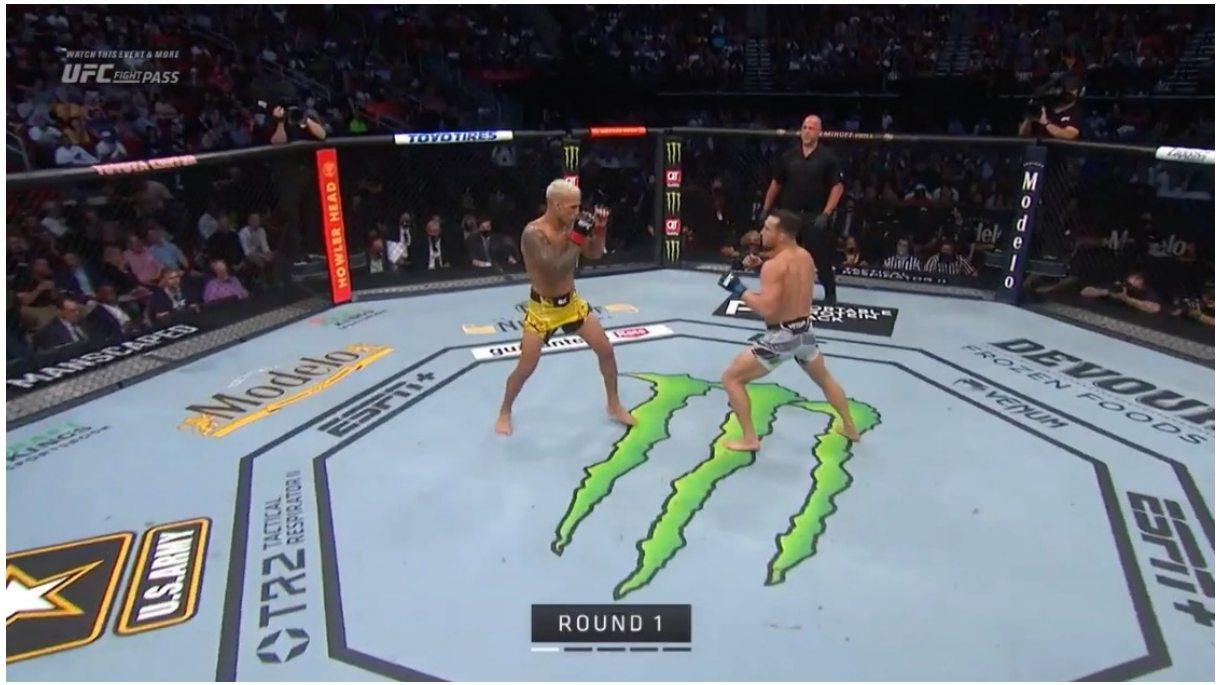
Challenges faced / Limitations

- No consistent camera angle.
- Unable to ‘fix’ the detection to one person.
- Editing each video is not feasible.



Future Improvements

- To include an ‘impact’ component
  - Minor, normal, significant
- Measuring other aspects
  - Ring control, aggressiveness
- Potential use to evaluate safety of fighter
  - Facial recognition.
  - Detect pain or lack of consciousness.



Conclusion

- Striking is a major aspect of MMA fights.
- 45% of fights are decided by judges.
- CV tool proposed to classify different types of strikes.
  - Accuracy = 93%
  - F1 = 93%
  - Assist MMA judges in scoring each round.


UFC
UFC
UFC


THANK YOU