Action spotting on SoccerNet Challenge

Advanced techniques

Presentation

MSc Artificial Intelligence for Science and Technology

Advanced techniques

Submitted by **Daniele Cecca Mat.914358**

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

Introduction

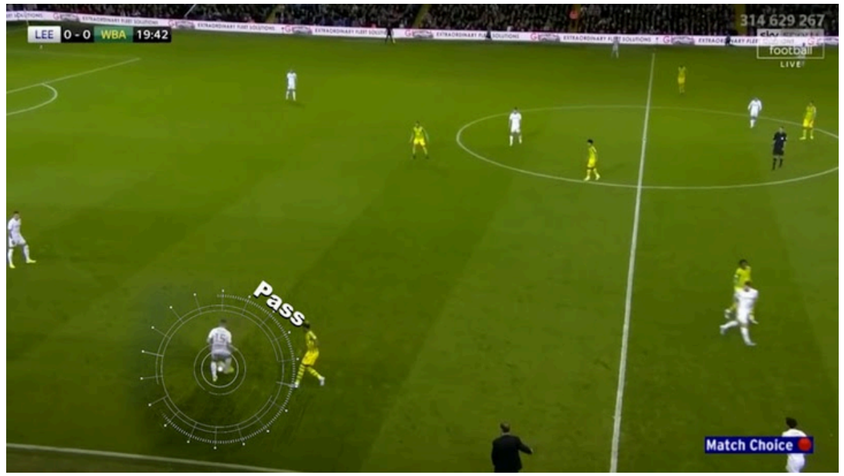
This project focuses on the development and implementation of **classification system for ball events in a football match**, also called ball **action spotting**.

It utilizes the **SoccerNet dataset** and draws inspiration from previously proposed solutions

PROJECT STRUCTURE

1. Load create and explore the **dataset**
2. Create the **ActionRecognitionDataset**
3. Design and develop the **architecture of the network.**
4. Train the network using different **hyperparameters**.
5. Select the **best-performing network** and train it for additional epochs.
6. **Evaluate** the network's performance.
7. Implementation of a web app with **Streamlit**

SoccerNet Dataset



The dataset is composed of **7 videos of English Football League games**, and to each video a **JSON** with the **timestamp** and the **label** is associated.

In total we have have **12 different types of action**

Pass	**Drive**	**Header**	**High Pass**
Out	**Cross**	**Throw in**	**Shot**
Ball Player Block	**Player Successful Tackle**	**Free Kick**	**Goal**

SoccerNet Dataset

CREATION OF THE DATASET

01

Divide the videos matches into segments

02

Create the dataframe

I will apply label encoding on the label

Since defining precise **temporal boundaries** for actions is challenging because it's hard to fix the exact **start** and **end** times, and knowing what occurs after the action can be beneficial, I **extend** the interval by one **second beyond** the defined action times in the JSON file.

	clip_filename	label	clip_duration
0	/content/data/new_val_data/2019-10-01 - Middle...	PASS	1
1	/content/data/new_val_data/2019-10-01 - Middle...	DRIVE	2
2	/content/data/new_val_data/2019-10-01 - Middle...	PASS	3
3	/content/data/new_val_data/2019-10-01 - Middle...	DRIVE	4
4	/content/data/new_val_data/2019-10-01 - Middle...	HIGH PASS	7

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SoccerNet Dataset

EXPLORATION OF THE DATASET

Training Set

skimpy summary

Data Summary

dataframe	Values
Number of rows	6845
Number of columns	3

Data Types

Column Type	Count
int64	2
string	1

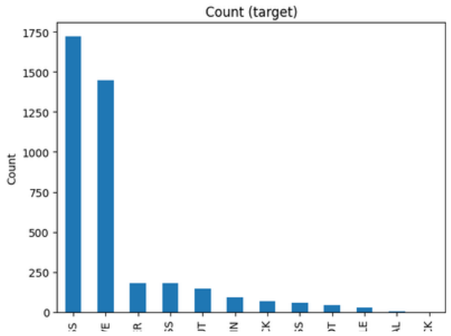
number

column_name	NA	NA %	mean	sd	p0	p25	p50	p75	p100	hist
label	0	0	5.408	3.014	0	2	6	8	11	
clip_duration	0	0	4.366	7.357	1	2	3	4	149	

string

column_name	NA	NA %	words per row	total words
clip_filename	0	0	6.7	46101

End



Validation set

skimpy summary

Data Summary

dataframe	Values
Number of rows	1603
Number of columns	3

Data Types

Column Type	Count
int64	2
string	1

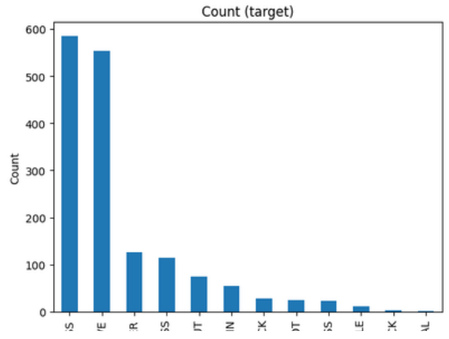
number

column_name	NA	NA %	mean	sd	p0	p25	p50	p75	p100	hist
label	0	0	5.379	2.987	0	2	6	8	11	
clip_duration	0	0	4.662	8.153	1	2	3	4	104	

string

column_name	NA	NA %	words per row	total words
clip_filename	0	0	7	11221

End



Test set

skimpy summary

Data Summary

dataframe	Values
Number of rows	3978
Number of columns	3

Data Types

Column Type	Count
int64	2
string	1

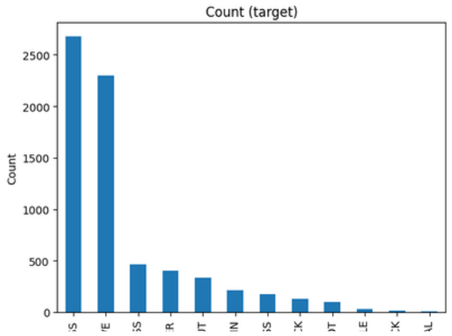
number

column_name	NA	NA %	mean	sd	p0	p25	p50	p75	p100	hist
label	0	0	5.404	3.019	0	2	7	8	11	
clip_duration	0	0	4	7.68	1	2	3	3	177	

string

column_name	NA	NA %	words per row	total words
clip_filename	0	0	5.9	23576

End



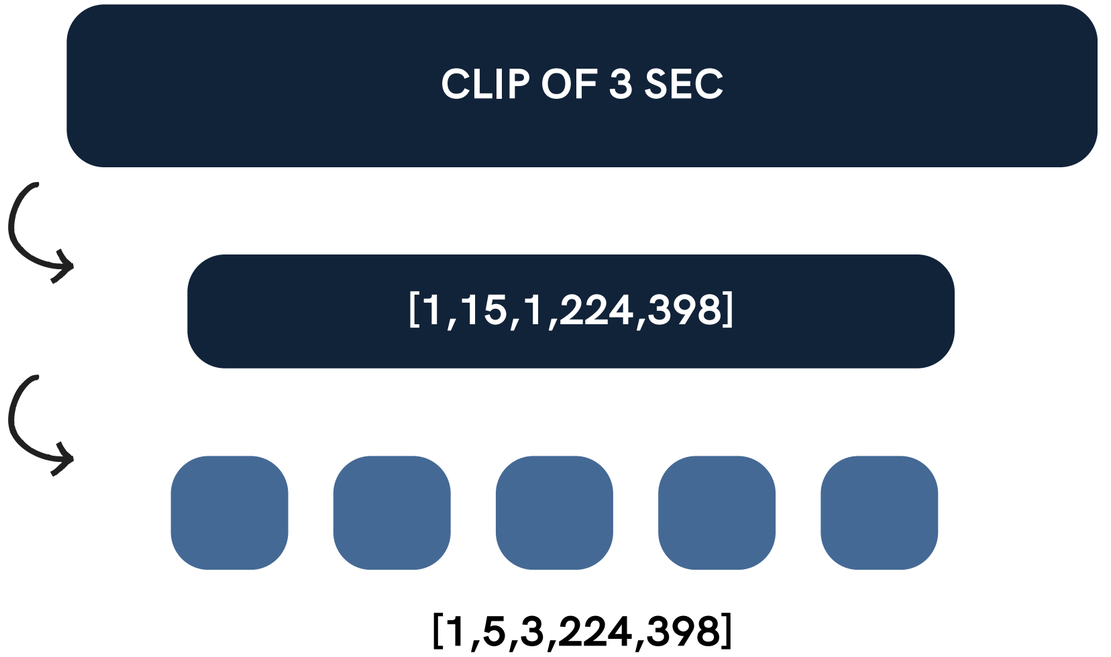
ActionRecognition Dataset class

The main idea is to take for each clip **15 frames**, one every 12 frames (because the mean length is 4), and then divide these frames into **stacks of 3 frames**.

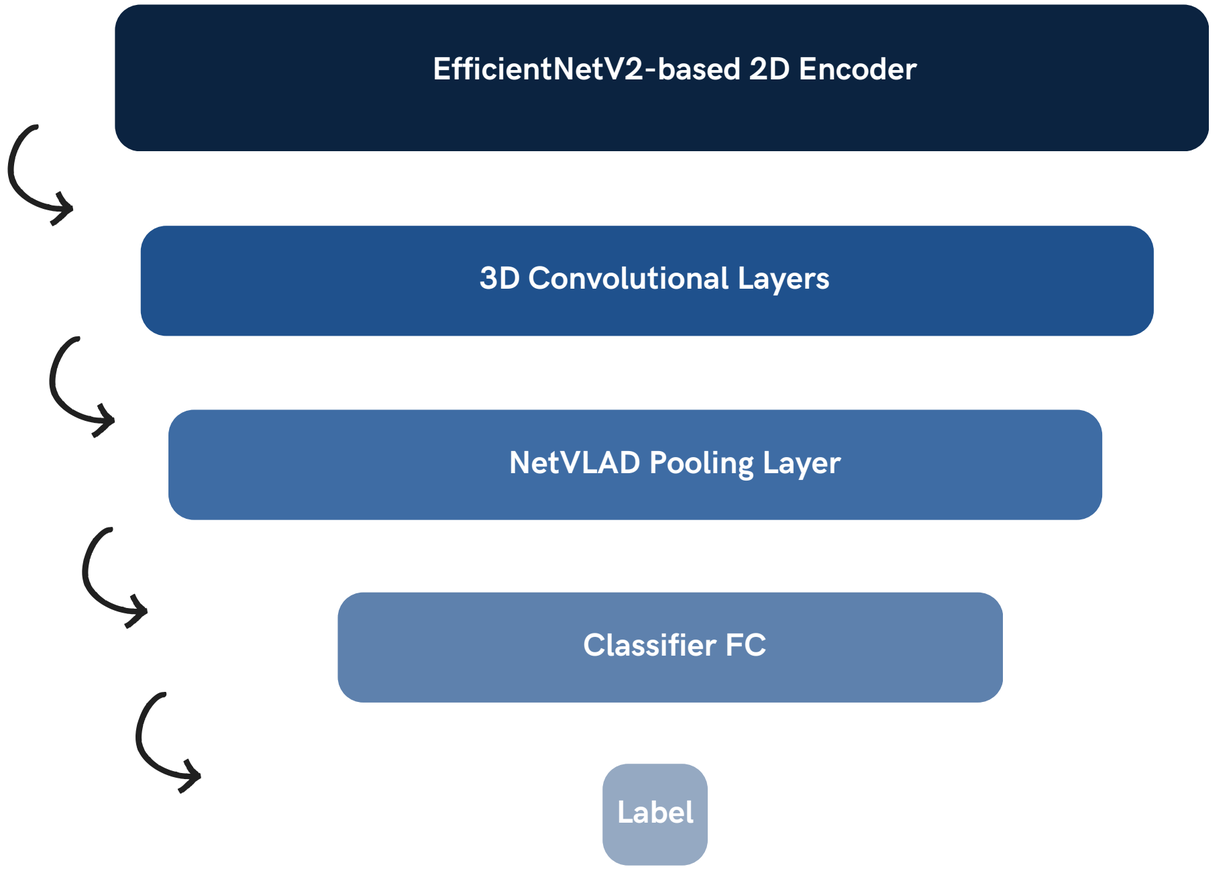
So in the end we will have a vector of **[1, 5, 3, 224, 398]** where **[B, T, C, H, W]**.

This will be useful to stack temporal information that will be processed by the network.

Videos will be transformed into **grayscale**



Network architecture



[1, 5, 3, 224, 398] [5, 192, 7, 13]	Input (B, T, C, H, W)
[1, 5, 192, 7, 13] [1, 192, 5, 7, 13]	Permute to [B, C, T, H, W] for 3D convolution
[1, 256, 5, 7, 13] [1, 1280, 7, 13]	Reshape for NetVLAD [B,T*C,H,W]
[1, 327680]	Input of the dense layer
[1, 12]	Output

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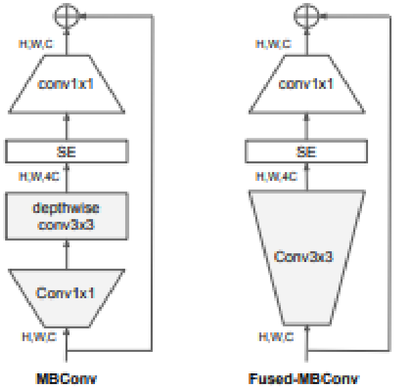
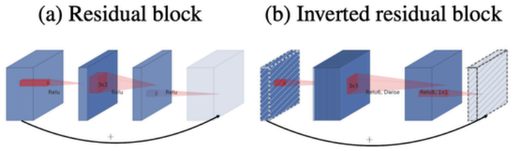
Building blocks

NETWORK

EfficientNetV2

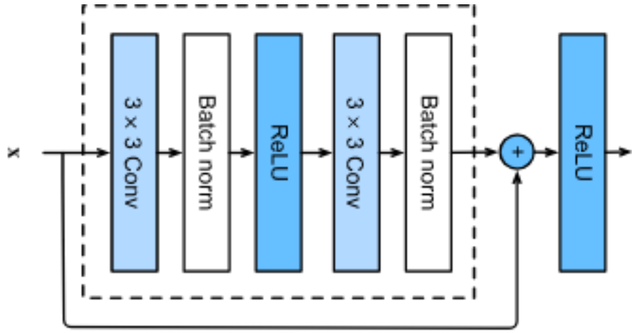
Inverted residual network

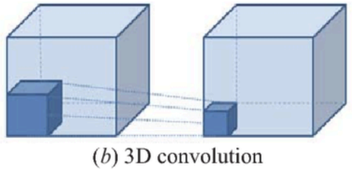




Residual block

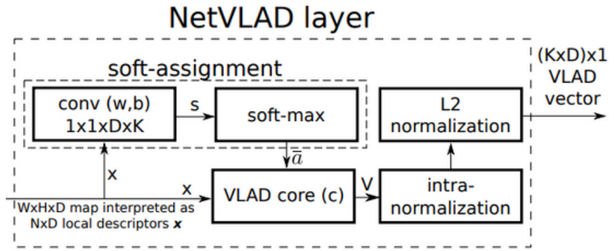
3D Convolution





(*b*) 3D convolution

NetVLAD



$$V(j,k) = \sum_{i=1}^{N} a_k(\mathbf{x}_i)\left(x_i(j) - c_k(j)\right),$$

$$V(j,k) = \sum_{i=1}^{N} \frac{e^{\mathbf{w}_k^T \mathbf{x}_i + b_k}}{\sum_{k'} e^{\mathbf{w}_{k'}^T \mathbf{x}_i + b_{k'}}} \left(x_i(j) - c_k(j)\right)$$

HyperParameters Tuning

NETWORK

I create a configuration that will be used by the **Weights and Biases agent** to set the different **hyperparameters** during various experiments. I used the simplest agent which chose the combination of the **parameters randomly**.

Parameters	Values
epochs	5
learning rate	[0.01, 0.001, 0.0001]
dropout	[0.4, 0.5]
Batch Size	[1,3,5]
loss function	focal loss
optimizer	adam

Focal Loss

NETWORK

Focal Loss is a loss function designed to address the challenge of class imbalance in tasks such as object detection.
Focal Loss is a modified version of the standard **Cross-Entropy Loss** that down-weights the contribution of easy-to-classify examples and focuses more on hard-to-classify examples. It is defined as

$$\mathrm{FL}(p_t) = -\alpha_t (1 - p_t)^{\gamma} \log(p_t)$$

- p_t is the model's estimated probability for the true class.
- α_t is a weighting factor for the class, balancing the importance of positive/negative example
- γ is a focusing parameter that adjusts the rate at which easy examples are down-weighted.

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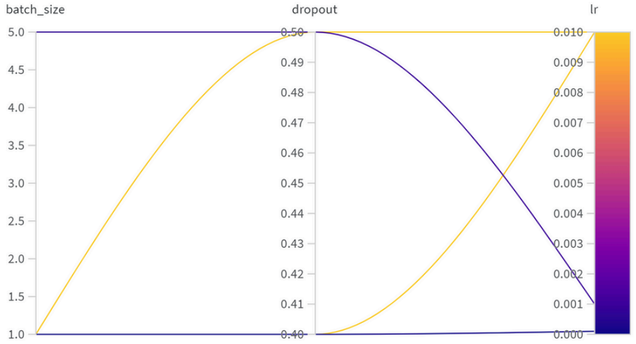
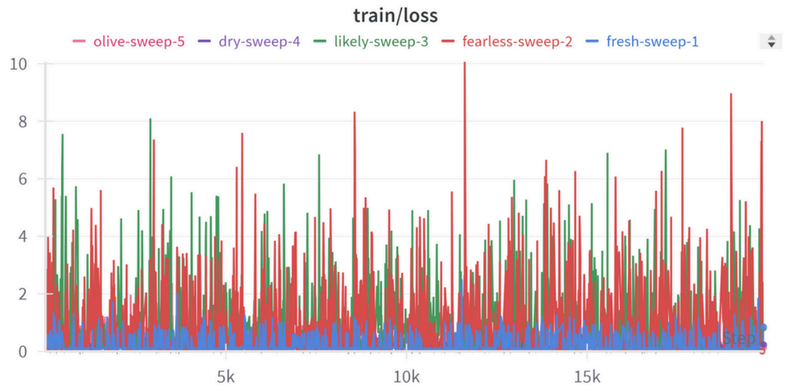
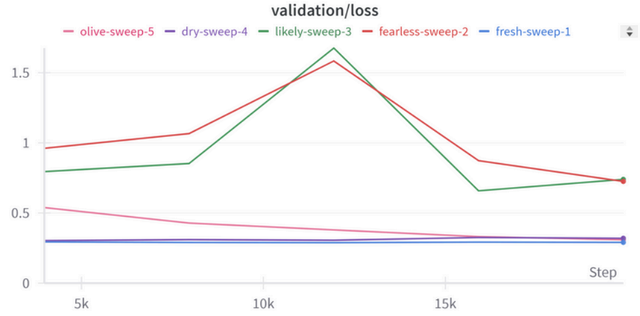
Training

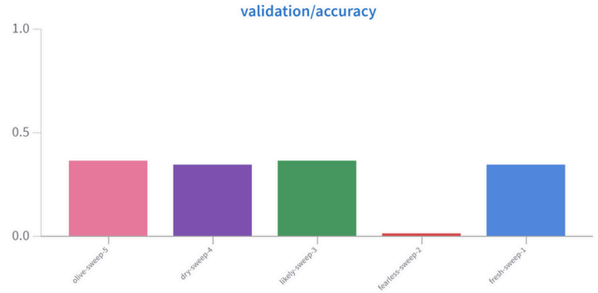
NETWORK



Parameter	Value
Batch Size	1
Drop Out	0.4
Epochs	5
Learning Rate	0.0001







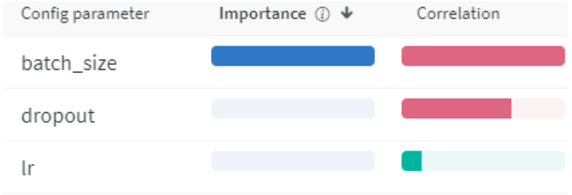
Training the best model

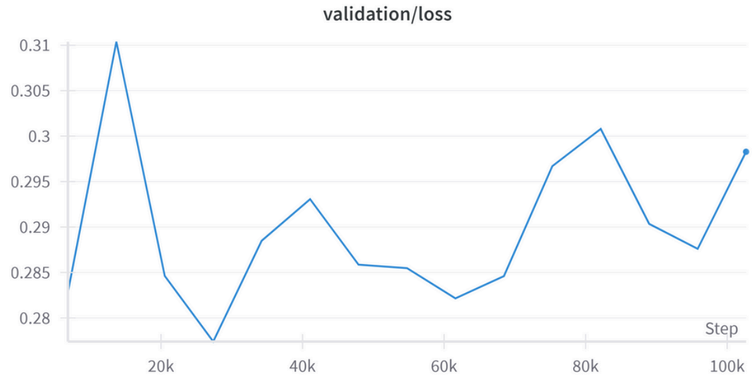
NETWORK

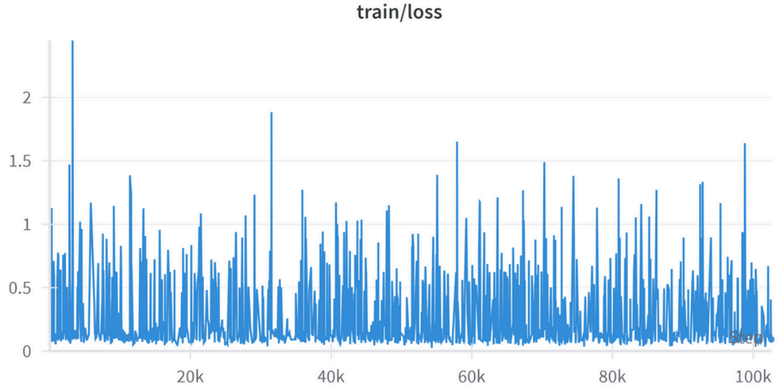
The behavior of the model is a little bit strange because both the **training loss** and the **validation** loss are **volatile.**

Despite it all I think the model is becoming better at generalizing because both validation and training losses are **decreasing on average**.

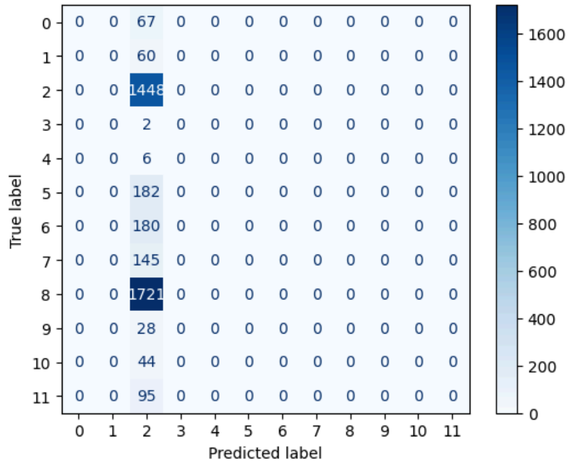
So in this case, it is difficult to talk about **overfitting** and **underfitting**.







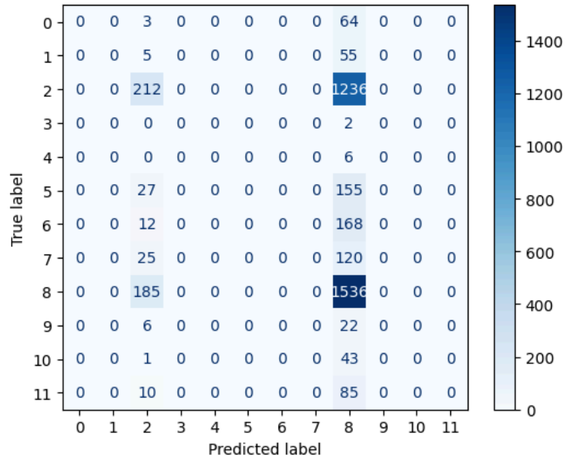
5 epochs model



- accuracy micro: 0.36
- precision micro: 0.36
- recall micro: 0.3
- f1 micro: 0.36

- accuracy macro: 0.36
- precision macro: 0.03
- recall macro: 0.08
- f1 macro: 0.045

20 epochs model



- accuracy macro : 0.44
- precision macro : 0.08
- recall macro : 0.09
- f1 macro: 0.07

- accuracy micro: 0.44
- precision micro: 0.44
- recall micro: 0.44
- f1 micro: 0.44

Evaluation

NETWORK

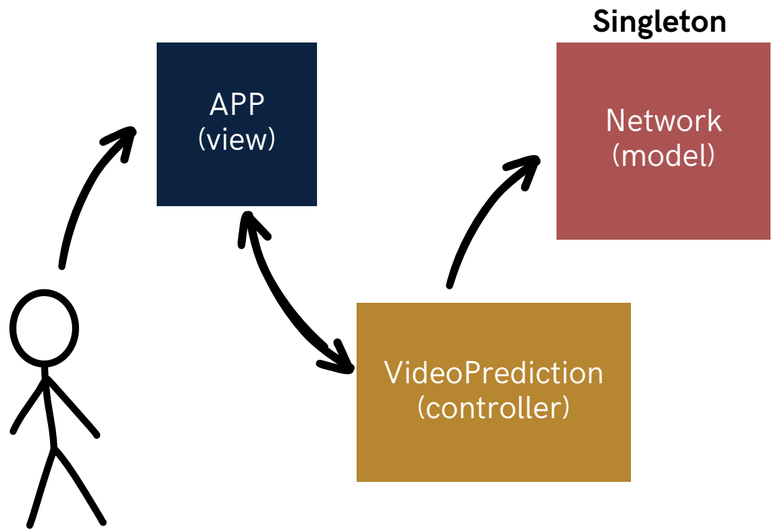
$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

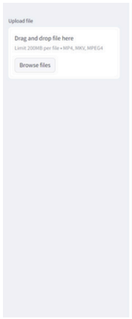
$$\text{Precision} = \frac{TP}{TP + FP}$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

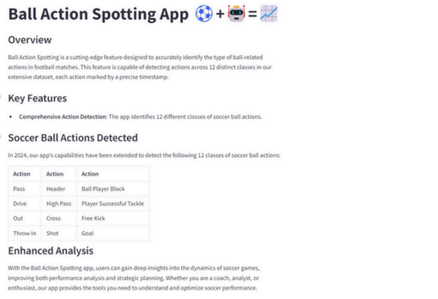
$$\text{F1 Score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

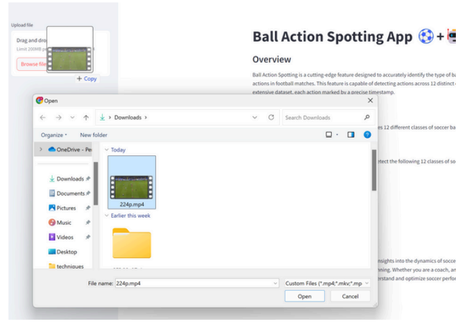
Streamlit app

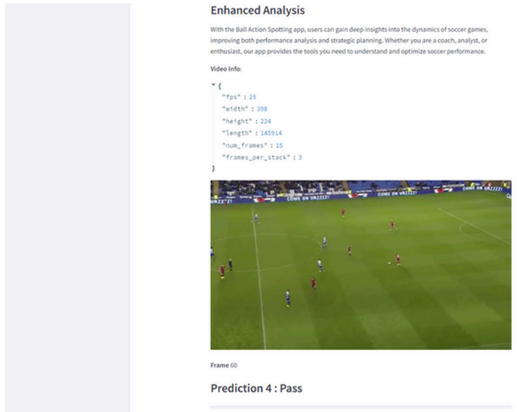




Load the file







Start classification

FUTURE WORKS

Network

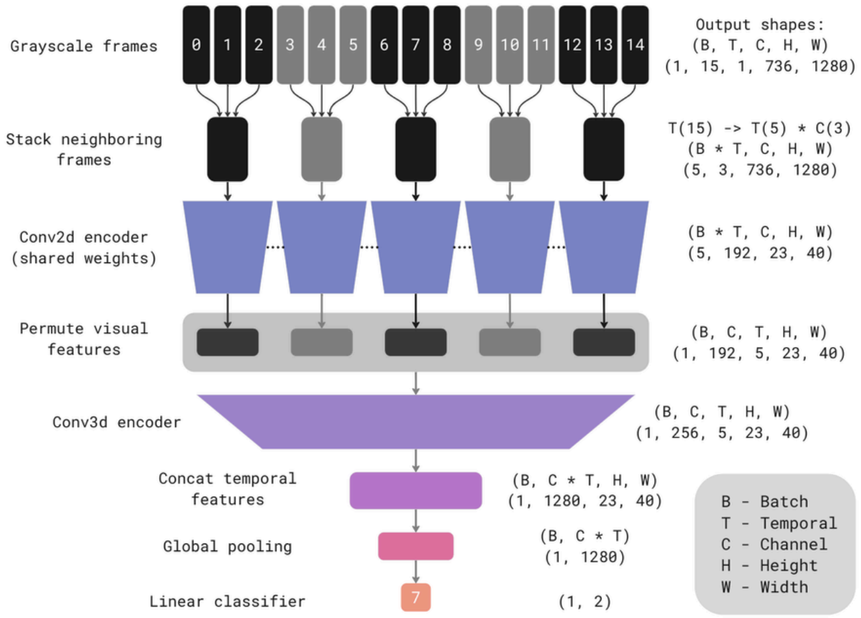
- Increase the dataset
- FineTune the model on the dataset of the task of action spotting
- Train for more epochs
- Try other hyperparameters
- Use high quality video
- Use RGB video
- Try other architectures

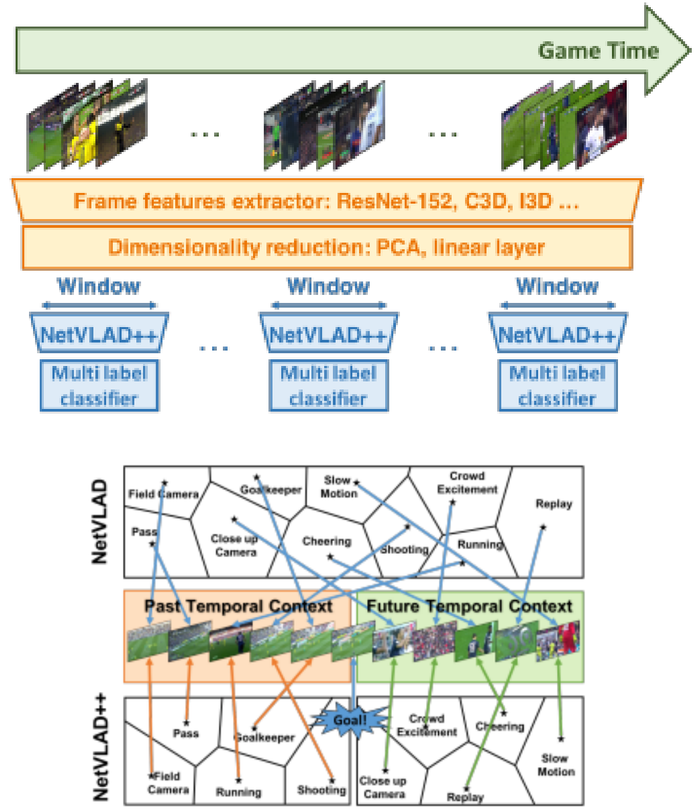
Streamlit

- Add a trigger to start the video when the classification begins.
- Use YOLO or another object detection model to assign the event to each player and compute some statistics relevant to the players.

State of art

INSPIRATION





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State of art

INSPIRATION-BIBLIOGRAPHY

- NetVlad ++
- Encoder2D3DLateFusion
- EfficientNetV2
- SoccerNet
- NetVlad
- Vlad
- DatasetSoccerNet
- OverviewTrends
- InvertedResidualBlocks
- LibraryActionSpotting
- FocalLoss

THANKS FOR ATTENTION

DANIELE CECCA MAT 914358

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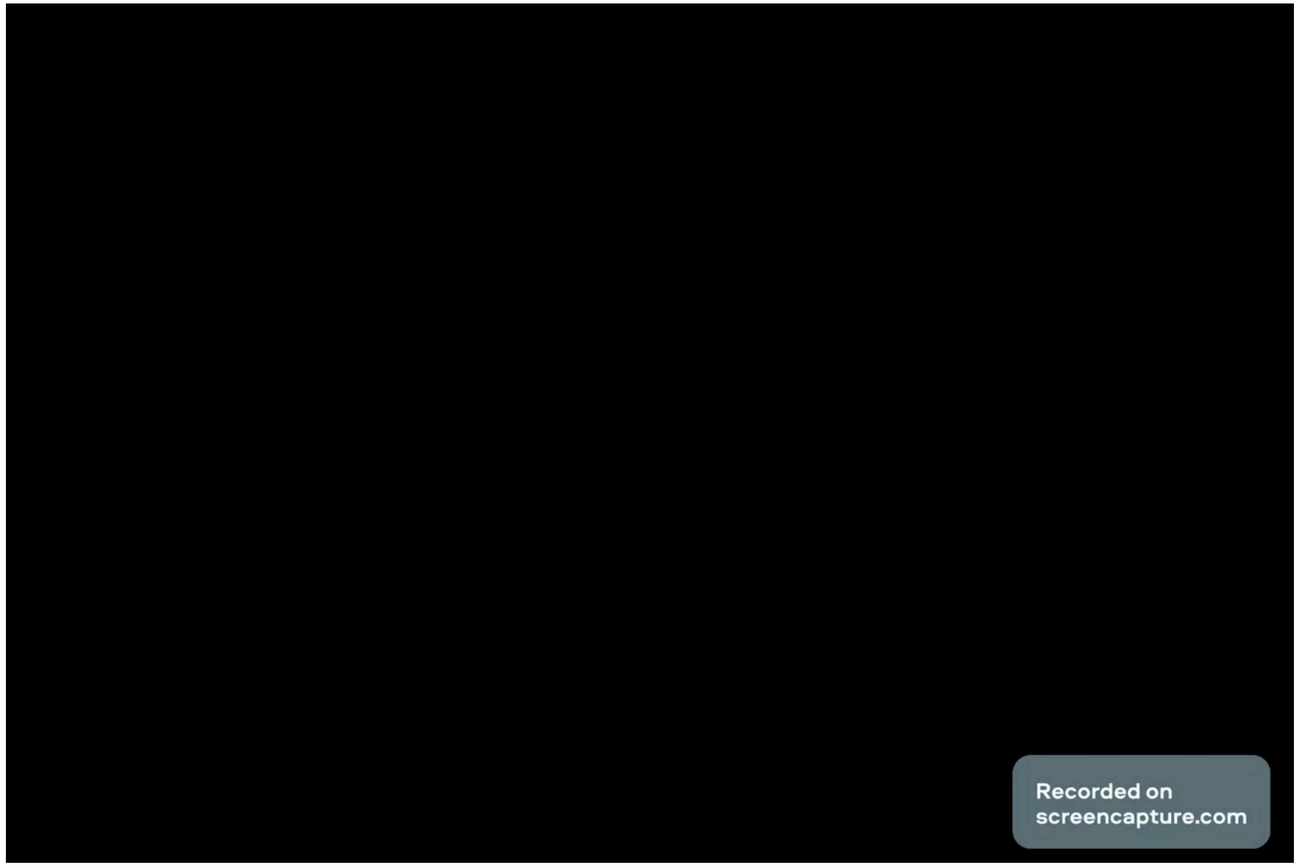
DEMO



DEMO

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