Video Classification with Convolutional Neural Network

A lite version of the Stanford White Paper

Riccardo Zuliani 875532

University Ca'Foscari of Venice
Department of Environmental Sciences, Informatics and Statistics

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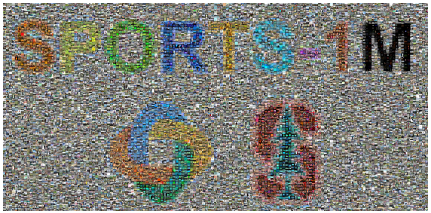
Ca' Foscari
University
of Venice

Goal:

Given a sequence of frame from a YouTube video predict the correct sport label

- Two models types, with different input size
  - **Time Information Fusion Models**, takes *multiple frames*:
    - Early Fusion
    - Late Fusion
    - Slow Fusion
  - **Multi-Resolution Models**, takes a *single frame*:
    - Context Only
    - Fovea Only
    - Context + Fovea

- 1 million YouTube videos links annotated with 487 classes [2]
- 1000-3000 videos per class
- 7% (as of 2016) of the videos have been removed by the YouTube uploaders since the dataset was compiled
- 5% of the videos are annotated with more than one class
- Possible noise:
  - Data manually weakly annotated
  - Video may includes nonsense frames
- **Multi-Label Classification Problem**



- Huge Dataset
- Choose **10 sports classes** →
- Consider all the videos of the chosen classes
- **Multi-Class Classification Problem**

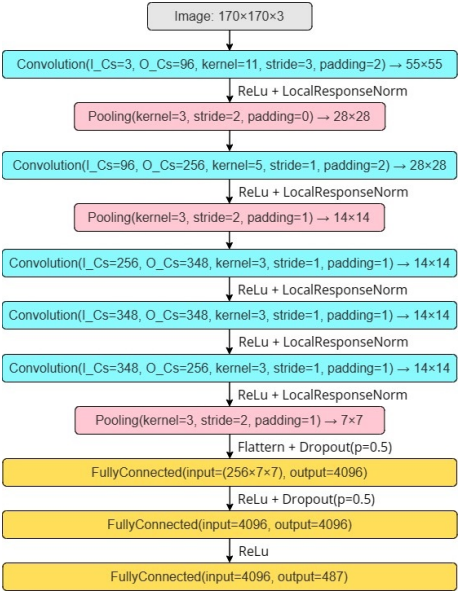
- rugby
- formula racing
- beach volleyball
- basketball
- karate
- motocross
- kitesurfing
- motorcycle racing
- horse racing
- bodybuilding

Frames Download Strategy

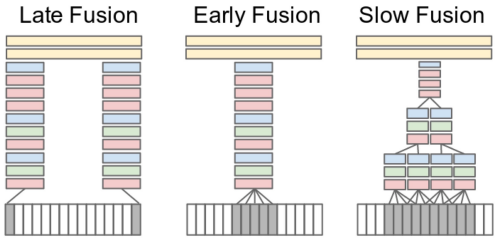
- Use **yt-dlp** is a youtube-dl fork to obtain video info
- Download only video with at least 20 FPS, that have **144p resolution** and the URL different from the manifest
- Remove the **10%** of the *initial* and *final* video frames
- Sample the **1%** of contiguous and equidistant **half FPS** frames (aka bag of shots) for the remaining frames of each video
- Use **OpenCV** to download the contiguous bag of shots
- Zip and upload the dataset in **Google Drive**

YT-DLP *A youtube-dl fork with additional features and fixes*

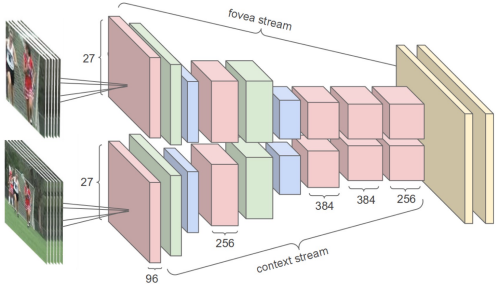
Primile CNN Architecture



Time Information Fusion (aka Multi Frames) Models



- **Late Fusion:** two separate single-frame network with only the first FC layer be able to compute global motion characteristics
- **Early Fusion:** combines information across an entire time window immediately on the pixel level
- **Slow Fusion:** it slowly fuses temporal information throughout the network such that higher layers get access to progressively more global information in both spatial and temporal dimensions



- The **context stream** receives the downsampled frames at half the original spatial resolution (89 x 89 pixels)
- The **fovea stream** receives the center 89 x 89 region at the original resolution
- Since the input is half the spartial size, the last pooling layer is removed to ensure both streams terminating in a layer of 7 x 7 x 256

Train & Test Approach

- 251038 training frames and 54247 testing frames
- 18287 training *bags of shots* and 3868 testing *bags of shots*
- **20%** of the train set assigned as **validations set**
- All models are trained up to **80 Epochs**
- **Stochastic Gradient Descent** as optimizer with *learning rate* $1e^{-3}$, *momentum term* 0.9 and *weight decay* $5e^{-5}$
- **ReduceLROnPlateau** as scheduler
- **Early stopping** with patience of 15 epochs

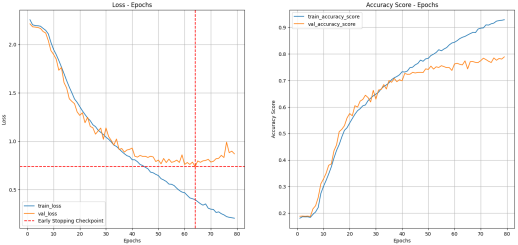
Also using a subset of 10 classes the results were subject to the **previous cited problems**.

- *Wrong manually labelled video*
- *Useless sequence of frames due to pseudo-random bag of shots sampling*

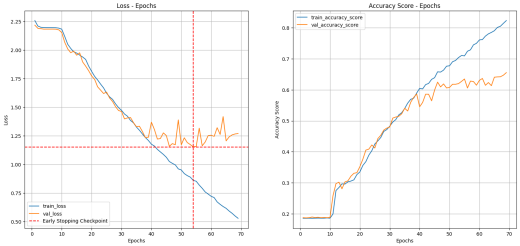
Therefore the results are to be considered as a test since to deal with these problems there would needed **manual work** which would be **enormously time consuming**.

Single Frame Results

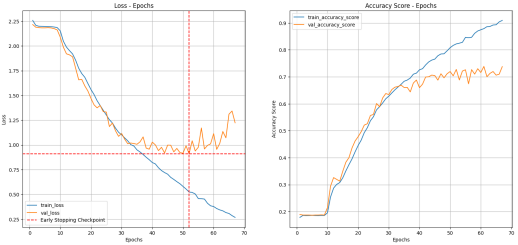
SingleResCNN-Stream_Type_None



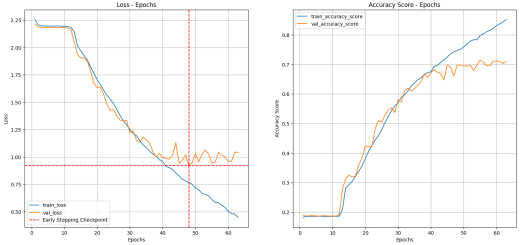
SingleResCNN-Stream_Type_fovea



SingleResCNN-Stream_Type_context

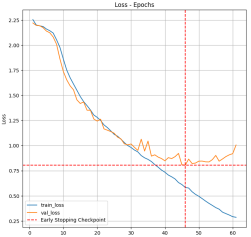


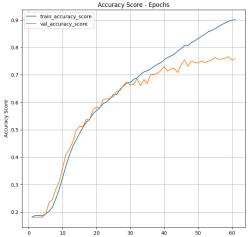
MultiResCNN



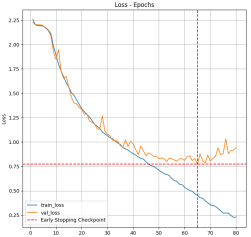
Multi Frame Results

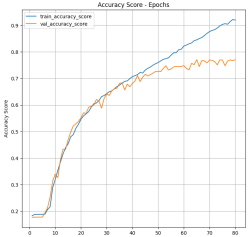
EarlyFusionCNN



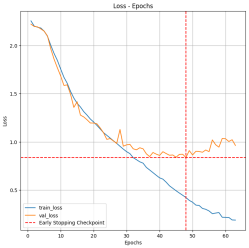


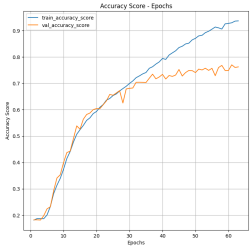
LateFusionCNN





SlowFusionCNN





Model Name	Test Loss	Test Acc	Test time min	Train time hr
SingleRes	0.96767	0.71325	0.37903	1.53495
SingleRes_F	1.26127	0.58379	0.17914	1.20548
SingleRes_C	1.17831	0.65533	0.16217	1.16977
MultiRes	1.12028	0.63378	0.13316	1.52294
LateFusion	1.05671	0.69669	0.37975	3.01682
EarlyFusion	1.08308	0.67226	0.67731	3.79941
SlowFusion	1.27412	0.6623	1.42234	7.80681

Table 1: Obtained Results [3]

Model Name	*SingleRes*	*SingleRes_F*	*SingleRes_C*	*MultiRes*	*LateFusion*	*EarlyFusion*	*SlowFusion*
Test Acc	0.411	0.3	0.381	0.424	0.407	0.389	0.419

Table 2: Stanford Results over the whole set of 1 million video [1]

References

[1] Andrej Karpathy et al. "Large-scale Video Classification with Convolutional Neural Networks". In: *CVPR*. 2014.

[2] Andrej Karpathy et al. *The YouTube Sports-1M Dataset*. URL: https://github.com/gtoderici/sports-1m-dataset.

[3] Riccardo Zuliani. *VideoClassification-CNN*. URL: https://github.com/zuliani99/VideoClassification-CNN.