Video Classification with Convolutional Neural Network

A lite version of the Stanford White Paper

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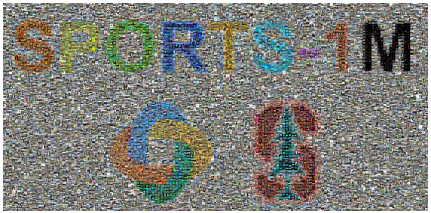
Goal:

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

Today's Topics:

- Sports 1 Million Youtube Video Dataset
- Dataset & Problem Simplification
- Frames Download Strategy
- Two models types, with different input size
  - **Time Information Fusion Models**, takes *multiple frames*
  - **Multi-Resolution Models**, takes a *single frame*
- Results

- 1 million sport 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**



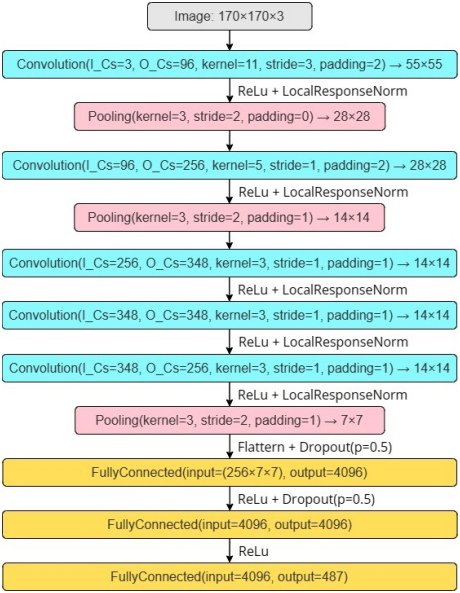
- Huge Dataset
- Choose **10 sports classes** →
- Consider all videos from the chosen classes
- **Multi-Class Classification Problem**

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

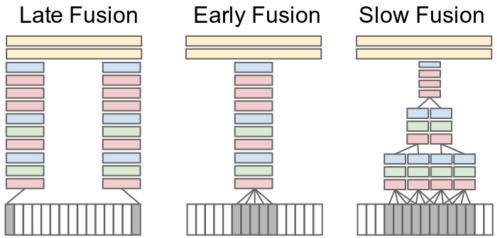
- **yt-dlp** a youtube-dl fork to obtain video info
- Download frames from videos with at least 20 FPS, that have **144p resolution** and the URL different from the manifest file
- Remove the **10%** of the *initial* and *final* video frames
- Sample the **1%** of contiguous and equidistant **half FPS**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

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

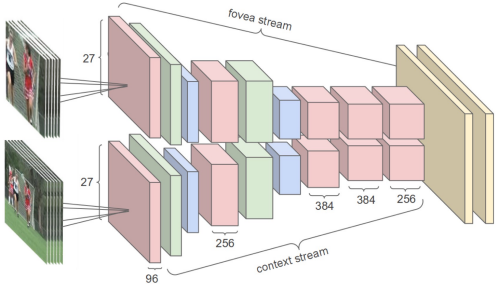
Primile CNN Architecture



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

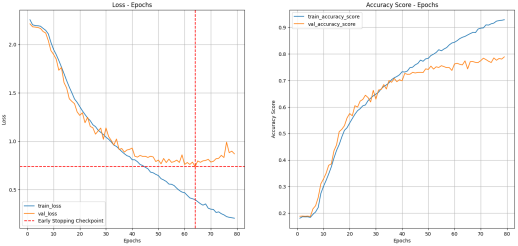
Also using a subset of 10 classes the results were subject to the **previous cited problems**.

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

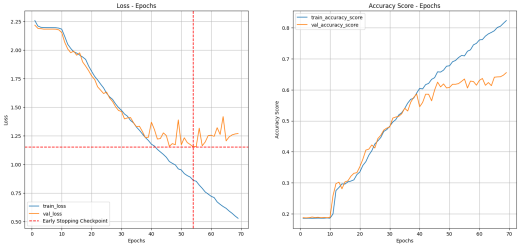
Therefore the results have to be taken with a pinch of salt since dealing with these problems would require a lot of **manual work and thus too much time**.

Single Frame Results (Single Frame, Fovea Stream, Context Stream, MultiRes)

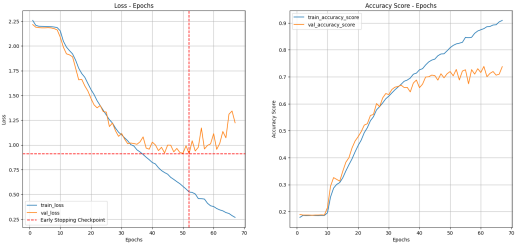
SingleResCNN-Stream_Type_None



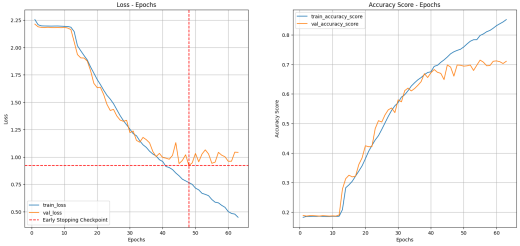
SingleResCNN-Stream_Type_fovea



SingleResCNN-Stream_Type_context

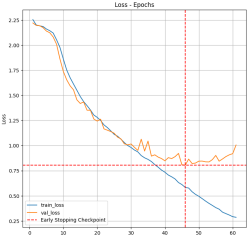


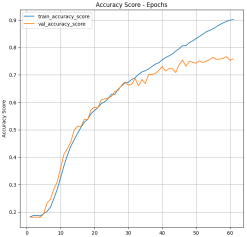
MultiResCNN



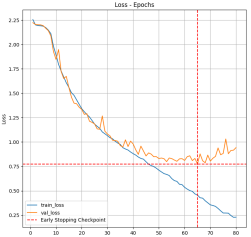
Multi Frame Results (Early Fusion, Late Fusion, Slow Fusion)

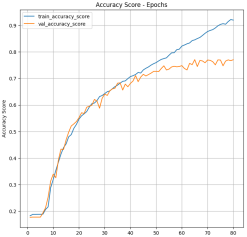
EarlyFusionCNN



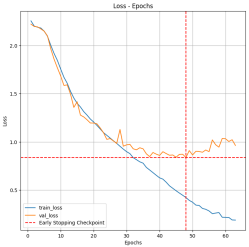


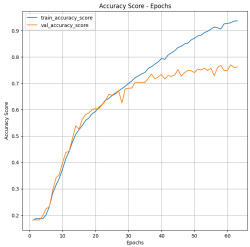
LateFusionCNN





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.