

Video Classification with Convolutional Neural Network

A lite version of the Stanford White Paper

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May 6, 2023



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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 include 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

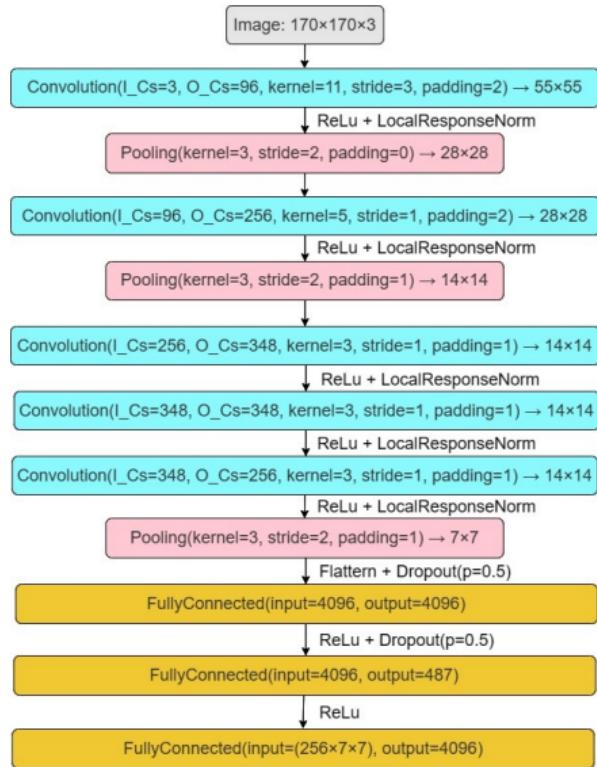
- Use **yt-dlp** is a youtube-dl fork to obtain video info
- Download only video with at least 20 FPS, that have **144p resolution** and the URL different from the manifest
- Remove the **10%** of the *initial* and *final* video frames
- Sample a percentage of contiguous and equidistant **half FPS** 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**



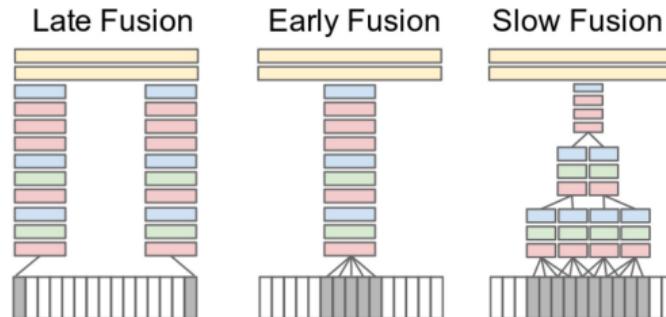
YT-DLP A youtube-dl fork with additional features and fixes



Primile CNN Architecture

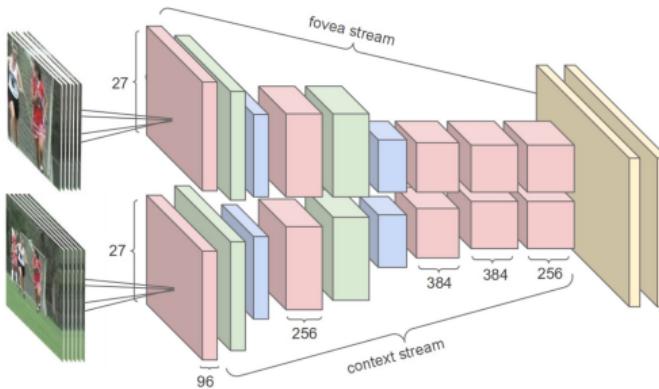


Time Information Fusion (aka Multi Frames) Models



- **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

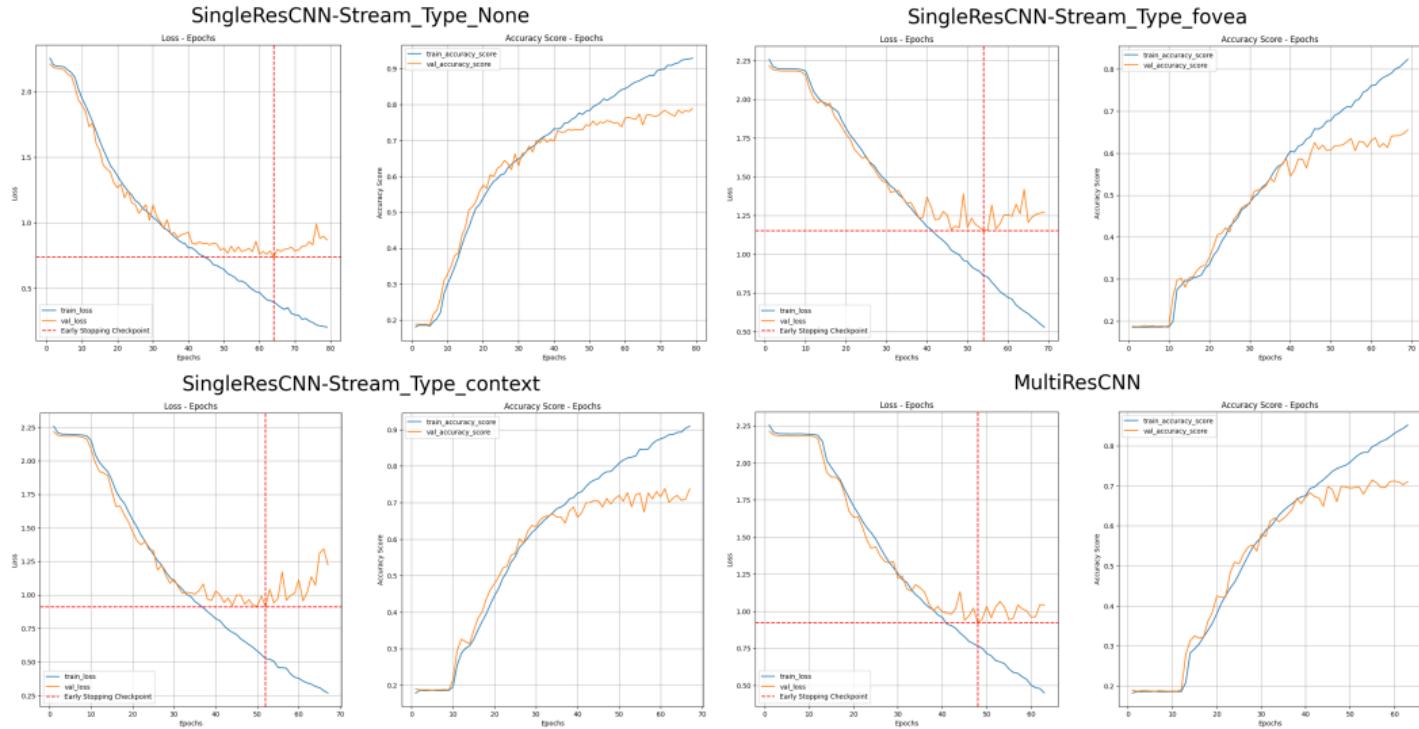
Multi-Resolution Models (Fovea, Context, Fovea + Context)



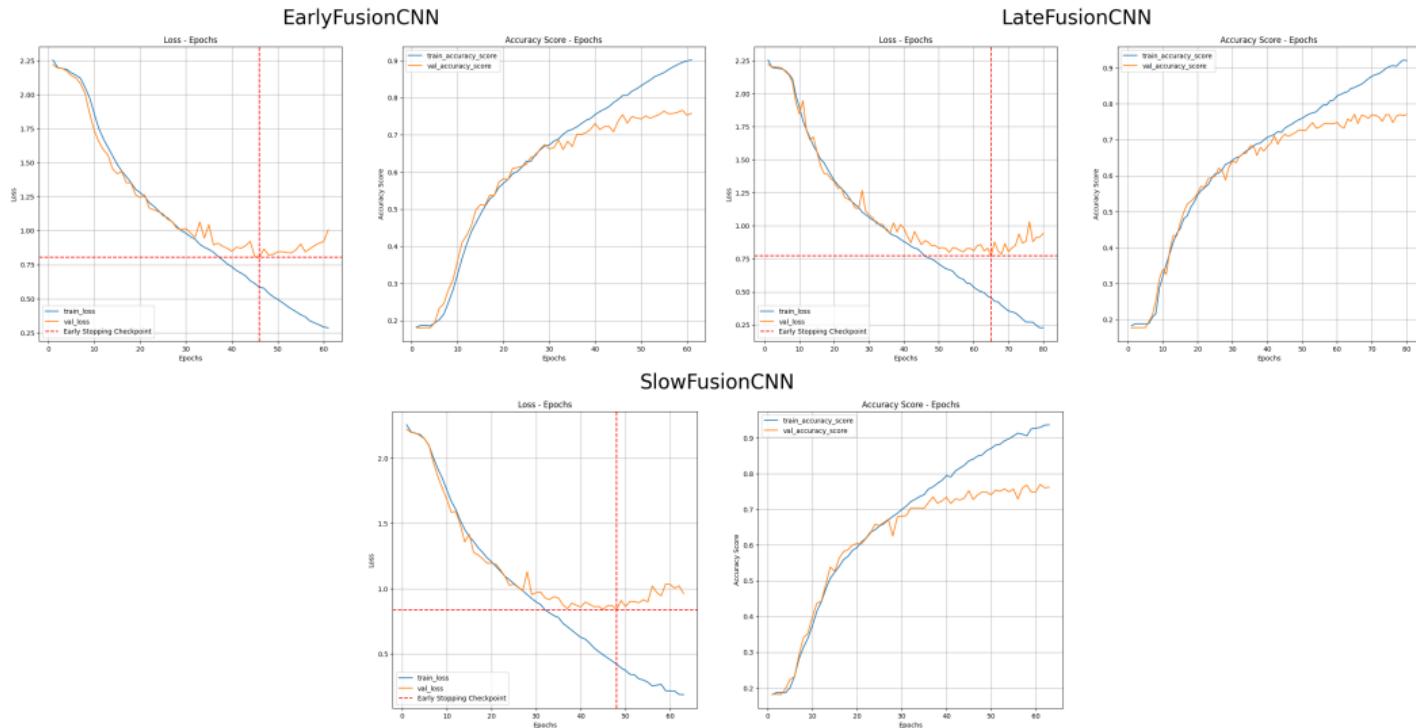
- The **context stream** receives the downsampled frames at half the original spatial resolution (89×89 pixels)
- The **fovea stream** receives the center 89×89 region at the original resolution
- Since the input is half the spartial size, the last pooling layer is removed to ensure both streams terminating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

- 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

Single Frame Results



Multi Frame Results



Summary

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

Table 1: Obtained Results [3]

Model Name	<i>SingleRes</i>	<i>SingleRes_F</i>	<i>SingleRes_C</i>	<i>MultiRes</i>	<i>LateFusion</i>	<i>EarlyFusion</i>	<i>SlowFusion</i>
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]

- [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>.