M2CAI Workflow Challenge: Convolutional Neural Networks with Time Smoothing and Hidden Markov Model for Video Frames Classification

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Context

Goal: Surgical video frames classification

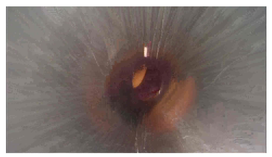
▷ Videos of size 1920x1080 Shot at 25 frames per second at IRCAD research center in Strasbourg, France

▷ 27 training videos

▷ 15 testing videos

▷ 8 classes

Clean image



Noisy image

▷ Online prediction: $P(y|x_i, x_{i-1}, x_{i-2}, ...)$

▷ Usefull to

- ▷ Monitor surgeons
- ▷ Trigger automatic actions

Deep Learning Methods

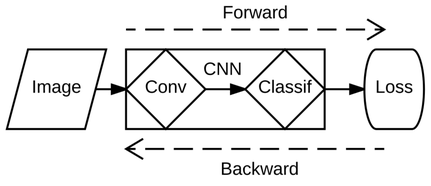
Random split + sampling (1f/s):

▷ Training set: 22 videos (59,493 images)

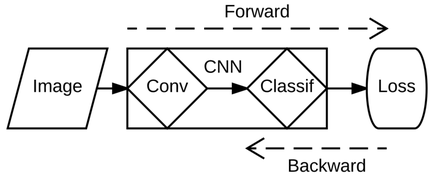
▷ Validation set: 5 videos (8,062 images)

▷ Testing set: 15 videos (28,732 images)

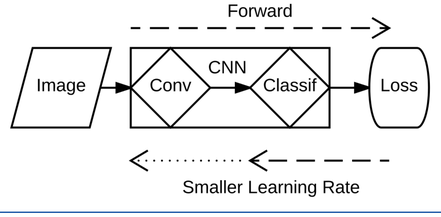
"From Scratch" : End-to-End Learning



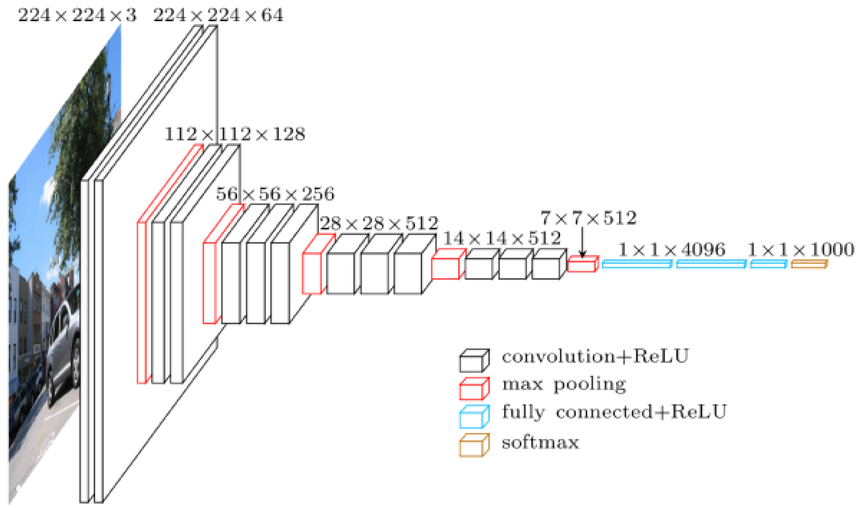
"Extraction" : Pre-trained CNN



"Fine-Tuning" : Both approaches !



Deep Learning architecture and scores



Model	Type	Accuracy (%)
InceptionV3	Extraction (repres. of ImageNet)	60.53
InceptionV3	From Scratch (repres. of M2CAI)	69.13
InceptionV3	Fine-tuning (both representations)	79.06
ResNet200	**Fine-tuning (both representations)**	**79.24**

Experiments

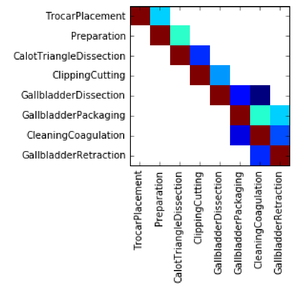
Temporal Method	Accuracy Val (%)	Jaccard Val	Jaccard Test
No Smoothing	79.24	–	–
Avg Smoothing	85.97	74.67	–
Avg + HMM Online	**88.90**	**81.60**	**71.9**
Avg + HMM Offline	93.47	87.59	–

Hidden Markov Model

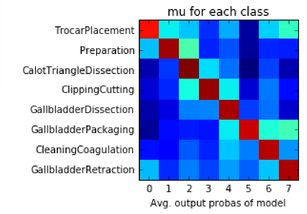
▷ Initial state probabilities

▷ Matrix of probabilities of transition between states

▷ Gaussian parameters for emissions of observations (mean and co-variance matrix)



(b)



(c mean)

Conclusion

Results are reproductible:

`github.com/Cadene/torchnet-m2caiworkflow`

[1] Oquab et al. Is object localization for free? *CVPR*, 2015.
[2] Durand et al. MANTRA. *ICCV*, 2015.
[3] Parizi et al. Automatic discovery of parts. *ICLR*, 2015.
[4] Gong et al. Multi-scale orderless pooling. *ECCV*, 2014.