A Combined Neural and Temporal Approach for Tracking Anatomical Features in Liver

Mélanie Bernhardt, May 2019

1 Introduction

Ultrasound (US) is a non-invasive, low cost, widespread medical imaging technology. It provides high temporal resolution measurement and is thus well suite for tracking of anatomical landmarks over time. As various medical applications require tissue motion tracking, it is of prime interest to develop accurate algorithms allowing precise tracking over time. In this project, based on the CLUST Challenge [1], a combined CNN-temporal approach is proposed for anatomical feature tracking in the liver during respiratory movements.

2 Related work

Siamese Convolutional networks have been used by [2] to learn a template-to-image similarity map as the cross-correlation of the result from the CNNs.

The best score on the leaderboard is obtained via a two-step procedure [3]. First, a "global" template containing the feature is extracted via Block Matching. Secondly, the search of the features is refined via Multiple Localized Template search.

3 Method overview

The goal of the CLUST Challenge, is to track several features on a sequence of US B-Images over time. For each sequence, the location of each feature is given for the first frame. Additionally, for the training set only, some subsequent frame annotations are given for tuning of the algorithm. In this project, a Siamese Convolutional Network performs a local feature search on a template extracted from the current frame and based on a reference template extracted from the initial frame. The template location is determined by the feature location at the previous frame. Additionally, a very simple temporal model is trained to correct for errors from the Network. This temporal model consists of a Ridge Regression model trained using the five previous locations of the tracked features as input. More over, for some sequences, the network can fail to accurately track the feature or can 'jump' from one feature to another, thus losing track of the feature. In this extreme case, the location of the predicted feature often lies in a region far from the initial location of the feature, the 'absurd prediction region'. If the prediction lie in this region for 50 frames in a row, it is concluded that the network has list track of the feature, hence the prediction is reset to the initial (known) location of the feature. This step, allows the network to come back to a plausible region and to retrieve the feature to track in the next frames.

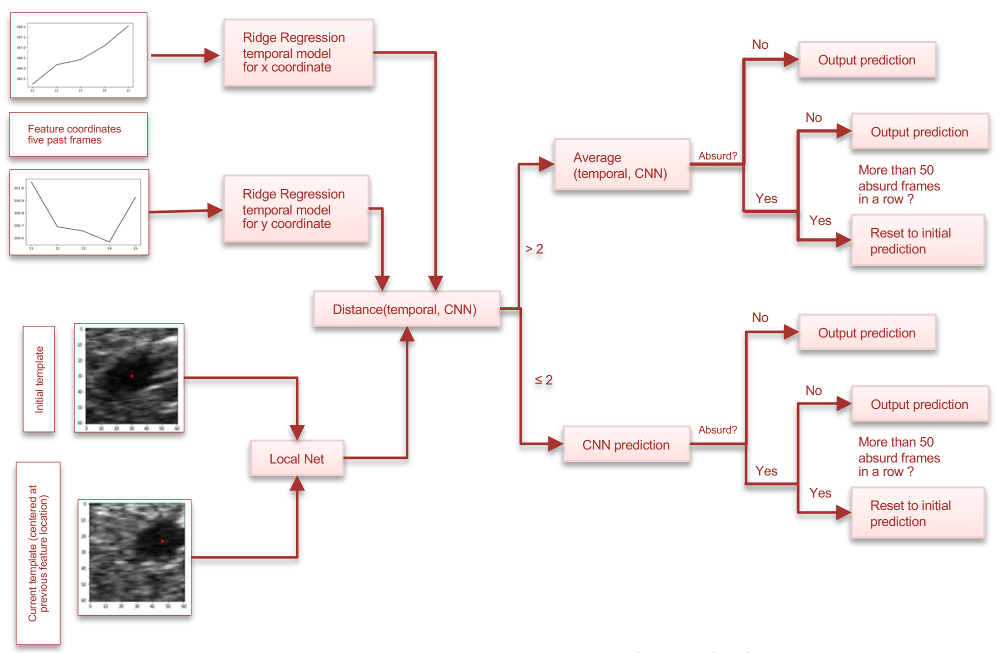


Fig. 1. Overview of the feature location prediction procedure

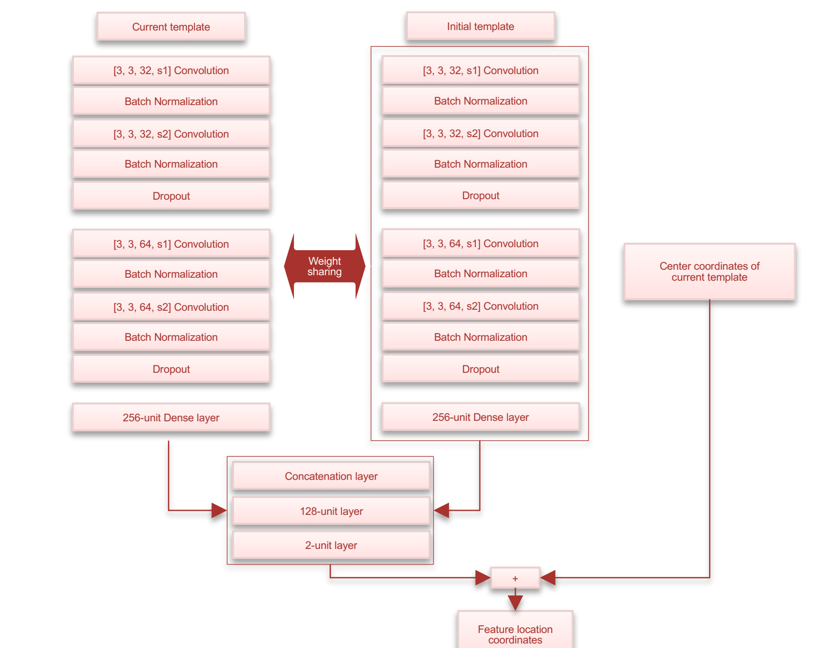
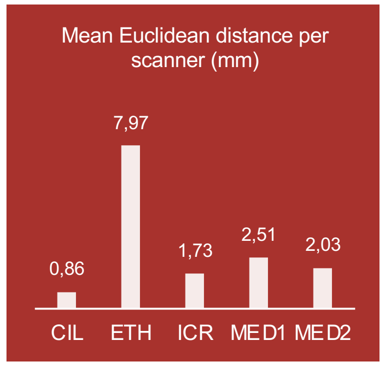


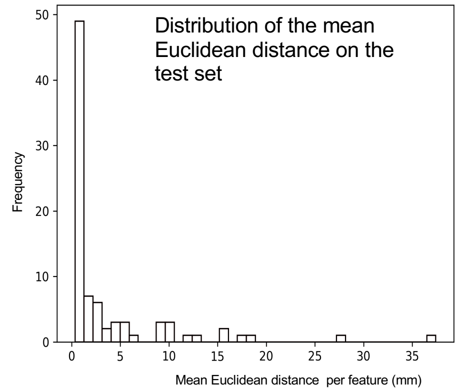
Fig. 2. Architecture of the Local Net

4 Results

An across-sequence 5-fold cross-validation procedure was used to tuned the procedure using the mean Euclidean distance as the evaluation metric. The best model was the model using a template of 60x60 pixels, 50 frames in the critical region and that uses the temporal model only if the network and the temporal model predictions differ by more than 2 pixels. However, the final model had a mean Euclidean distance of 5.32 mm on the test set, being heavily penalized by some outliers where the network failed to detect the feature (see distribution plot of the errors). Nevertheless, for most of the test features the error is very small (less than 1mm).

Model	Temporal model threshold	Number of suspicious frames allowed	Mean Euclidean distance across folds
60NetP30T5	5	30	1.82
60NetP40T5	5	40	1.51
60NetP50T5	5	50	1.48
60NetP50T2	2	50	1.31
60NetP50T0	0	50	1.70
60NetOnlyP50	-	50	1.51
60NetT2 NoSafeguard	2	-	2.70





5 References

1. V. De Luca et al., "The 2014 liver ultrasound tracking benchmark,"Physics in medicine and biology, vol. 60, pp. 5571–5599, 07 201
2. A. Gomariz, W. Li, E. Ozkan, C. Tanner, and O. Goksel, "Siamese Networks with Location Prior for Landmark Tracking in Liver Ultrasound Sequences," arXiv e-prints, arXiv:1901.08109, Jan 2019
3. A. J. Shepard, B. Wang, T. Foo, and B. Bednarz, "A block matching based approach with multiple simultaneous templates for the real-time 2d ultrasound tracking of liver vessels,"Medical Physics, vol 44, 09 2017.