Image segmentation based on convolutional neural networks is proving to be powerful for medical applications. However this field faces several challenges: lack of annotated data, presence of artifacts and variability in appearance, which can result in inconsistencies during the inference.

We choose to take advantage of the invariant nature of anatomical structures, by enforcing a semantic constraint to improve the robustness of the segmentation. This criteria is introduced during the training through an original penalization loss named NonAdjLoss.

We define the adjacency loss as a measure of label connectivity:

\[
\begin{align*}
    \alpha_{ij}(f) &= \sum_x \sum_{v \in V} f_i(x) f_j(x-v), \\
    \bar{f} &= f \ast 1_V \\
    f^p(p) &= p^\beta \\
    f^{\text{norm}}(p) &= \left( \frac{p}{\max_k p_k} \right)^\beta
\end{align*}
\]

(When \( f_i(x) = \delta_{i,\text{argmax}_k p_k(x)} \rightarrow \alpha_{ij}(f) = A_{ij} \))

Enforcing the adjacency loss does not require ground truth, thus optimization can be extended to a semi-supervised setting.

Global loss function composed of weighted cross-entropy, dice loss, NonAdjLoss and optimized with SGD. Elastic deformation is performed for data augmentation.

Novel loss constraint based on a label connectivity prior. Can be applied to any image segmentation problem where invariance in the label space is ensured, without needing to modify the network’s architecture.

While no segmentation quality measure was impaired, the Hausdorff and MSD were clearly improved. The higher the number of labels, the more constrained the problem is, which leads to a potentially better efficiency of the method.

Semi-supervised Learning for Segmentation under Semantic Constraint. Pierre-Antoine Ganaye, Michaël Sdika, Hugues Benoit-Cattin, accepted to MICCAI 2018

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