U-NET FOR PANCREAS SEGMENTATION IN ABDOMINAL CT SCANS

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Abstract

We propose a U-Net based approach for pancreas segmentation. Under the same setting where bounding boxes are provided, this method outperforms previously reported results with a mean Dice Coefficient of 86.70 for the NIH dataset with 4-fold cross validation. **Results show that a network designed specifically for and trained from scratch with biomedical images can achieve a better performance with much less training time compared to fine-tuning the models that are designed for and pretrained on natural images.**

The code for this project is available at https://github.com/snapfinger/pancreas-seg, or scan the QR code at the bottom right

Background

Pancreas segmentation is difficult compared to other abdominal organs due to its high variability in shape [1]. The fixed-point model [1] which fine-tuned an ensemble of networks with three views of CT volumes achieved the best result so far on the NIH pancreas segmentation dataset [2] while obtaining 83.18 ± 4.81% Dice Coefficient (DSC) given the pancreas bounding boxes. Our study shows that a single network trained only on axial view slices can push this limit to 86.70 ± 3.51% with much less training time.

Method

1. Preprocessing

slices → crop with bounding boxes → add margins filled with original image data → clip between [−100,240] HU → scale to [0, 1] → If >100 pancreas pixels → train

2. Fully Convolutional Network

- *Network Architecture*

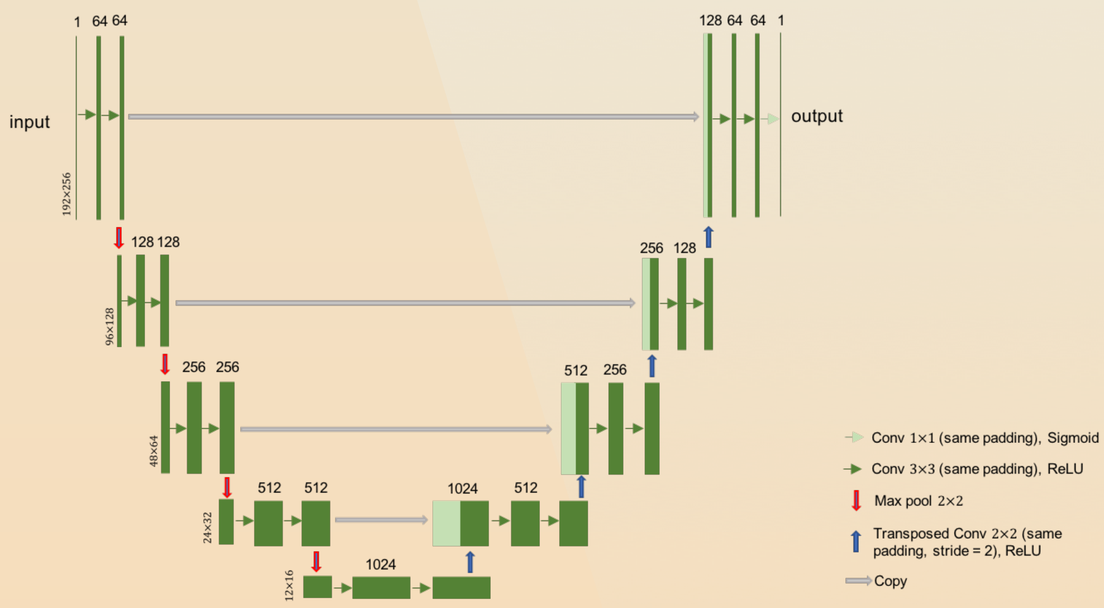
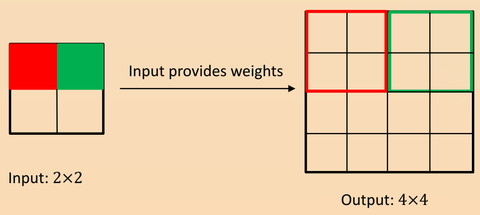


Fig. 1. Architecture of the modified U-Net

- *Transposed Convolution: Learnable Upsampling*



- *Loss Function*

A softly defined Dice Coefficient is used as the loss function during network training, similar to the one applied in [1]. The loss is defined as

$$L(Y,\hat{Y}) = -\frac{2\sum_i y_i \hat{y}_i}{\sum_i y_i + \sum_i \hat{y}_i}$$

where $y_i \in Y$, $\hat{y}_i \in \hat{Y}$, and Y is the ground truth, $\hat{Y}$ is the prediction.

- *Other Training Settings*
  - Optimizer: Adam
  - Learning rate: 10^{-5}
  - Epoch: 10
  - Batch size: 1 slice

Experiments

- *Implementation*
  - Keras with *Tensorflow* backend
  - ~ 3 hours training with 1 Tesla K40c GPU (less than 1/3 needed by approach in [1])
- *Dataset*
  - Pancreas segmentation dataset [2] which contains 82 abdominal contrast enhanced 3D CT scans provided by NIH Clinical Center
- *Evaluation*
  - 4-fold cross validation
  - Dice Coefficient: $\mathrm{DSC}(X,Y) = \frac{2|X\cap Y|}{|X|+|Y|}$
  - In 3D volume
- *Results*

Table 1. Experiment Results

Method	DSC (%)	Minimum DSC
Fixed-Point [1] (Fine-tune FCN-8s w/ pretrained weights)	83.18 ± 4.81	65.10
Proposed Method (U-Net from scratch)	86.70 ± 3.51	73.67
FCN-8s from scratch	Doesn't converge during training	

Input Image — Segmentation output

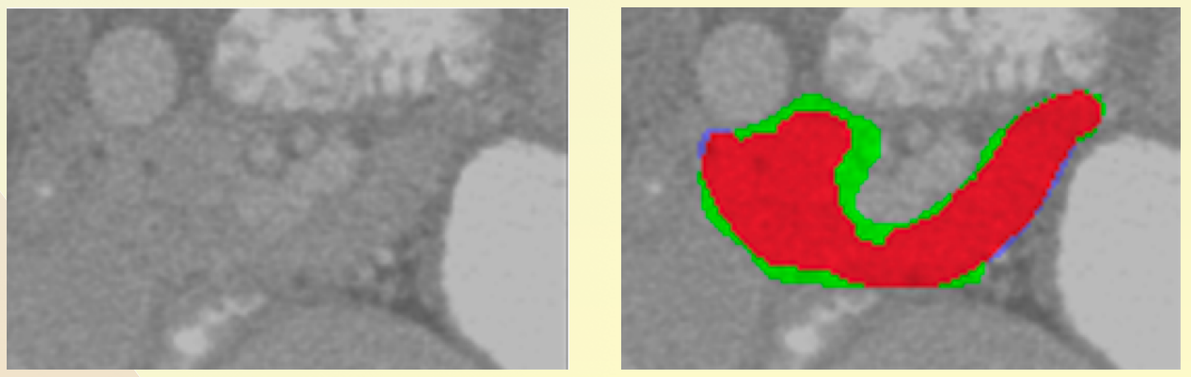


Fig. 2. Sample segmentation result (Green, blue and red indicate prediction, ground-truth and overlapped regions)

Conclusion

With a model designed specifically for biomedical images, training from scratch using biomedical images can achieve better results compared to using a pretrained network that is designed for natural images. In the future, a detection system is to be built to incorporate this segmentation model.

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References

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[2] H. Roth, L. Lu, A Farag, H-C Shin, J Liu, E. Turkbey, and R. M. Summers, "DeepOrgan: Multi-level deep convolutional networks for automated pancreas segmentation", Proc. MICCAI, 2015.

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Project code

https://github.com/snapfinger/pancreas-seg

Wechat

Code repo