Semantic Segmentation of Left Ventricles with Deep Learning

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Introduction

MOTIVATION:

- Semantic segmentation of cardiac structure is an important task in clinical application. For example, segmentation of left ventricles can contribute in computation of cardiac functional indices, such as ejection fraction
- **Traditional segmentation methods are tedious and slow**
- **An effective deep learning solution will shorten the time of creating a segmentation and may yield better accuracy**

APPROACH:

- A **fully convolution network (FCN) based on U-Net** was chosen as a backbone semantic segmentation networks
- **Deep Stack Transformation** served as a data augmentation technique (it adjusts the image while preserving the high-level features)

RESULTS:

- Model gives **93% segmentation accuracy** on test set
- Producing a segmentation in miliseconds

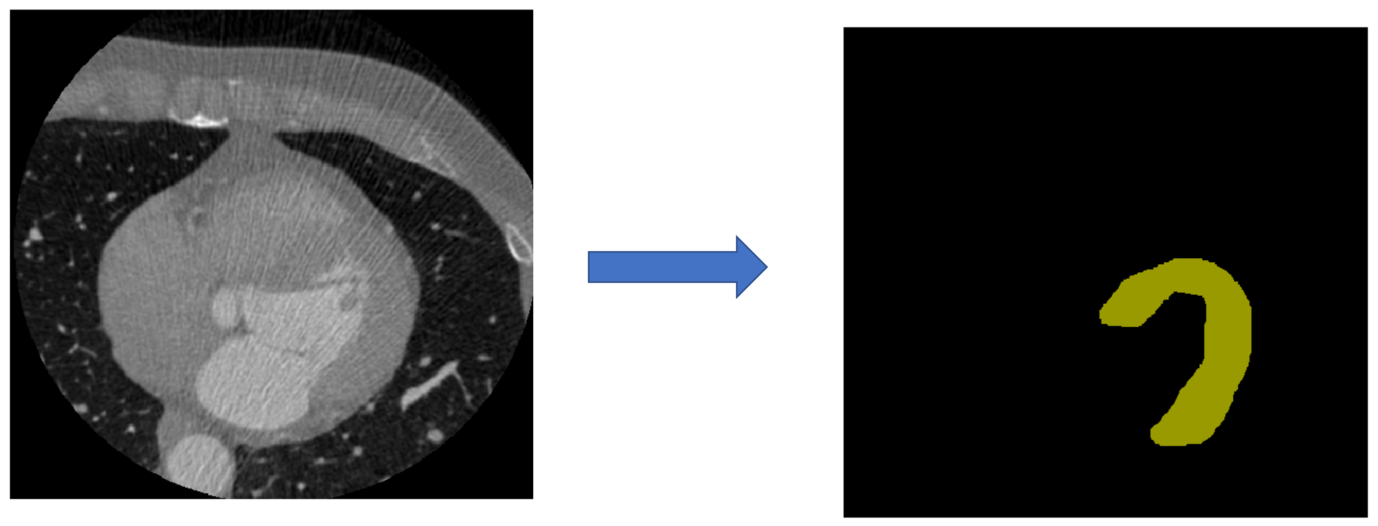

Figure 1. Axial view of a heart and its correct segmentation of left ventricle (Input and Output in **Figure 3**)

Dataset

SOURCE:

- 62359 2D slices from 4D CT images from Shadden Research Group
- 1019 2D images from www.ctisus.com

PREPROCESSING:

- Images are converted into **one channel** (for example, Red Green Blue images have three channels)
- Images are resized into images with **resolution of 256 x 256**
- Images are applied normalization per image such that each **pixel value ranges between [-1, 1]**

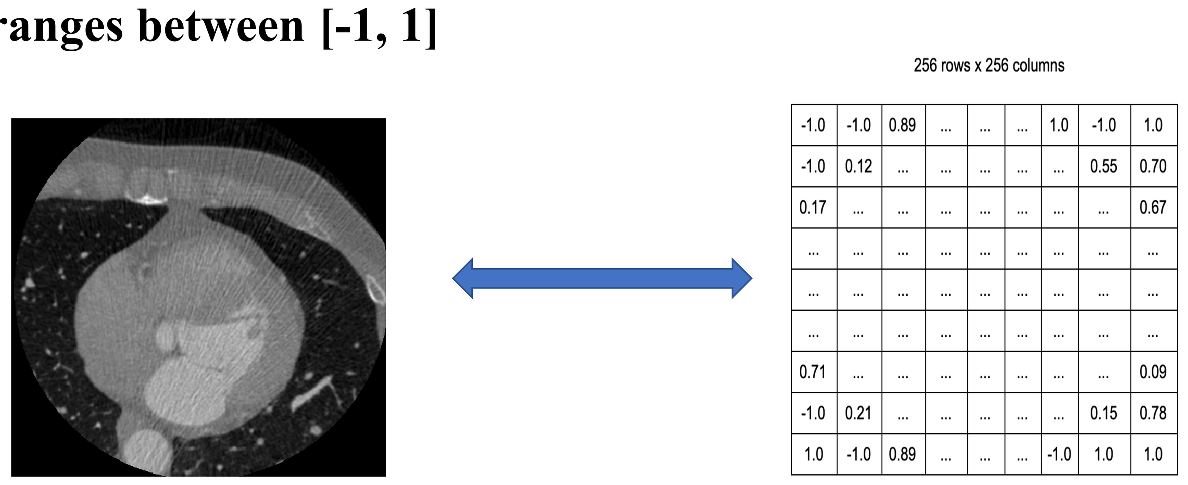

Figure 2. How human and machine see images.

SPLIT:

- 44364 images in training set, 9506 images in validation set, and 9508 images in test set

Methods

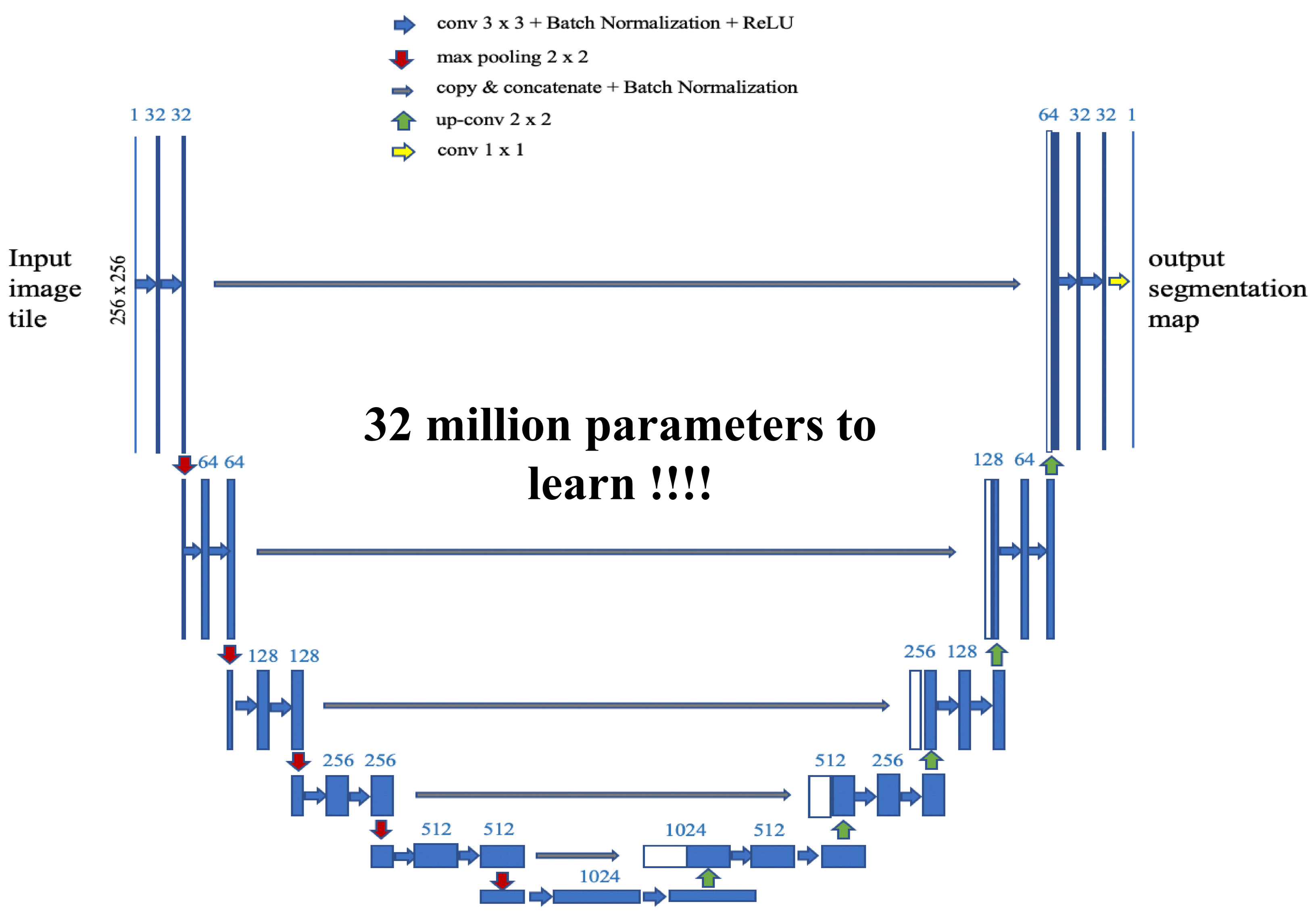

Figure 3. Network Architecture based on U-Net

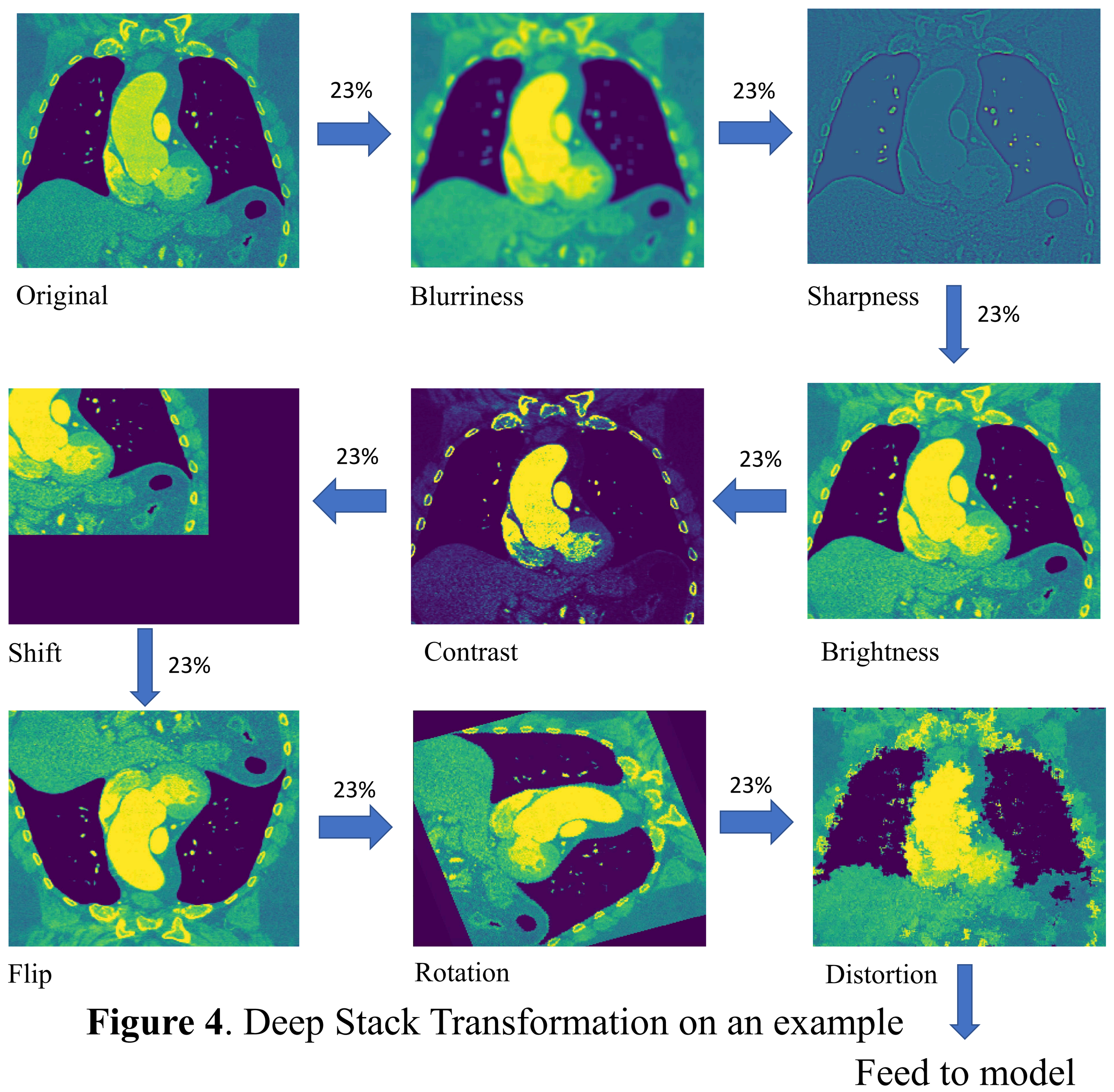

Figure 4. Deep Stack Transformation on an example

Hey machine, all of these images have left ventricles !!!!

References

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3. S. Ioffe and C. Szegedy, *Batch Normalization: Accelerating deep network by reducing internal covariate shift.* arXiv: 1502.03167, 2015.

Results

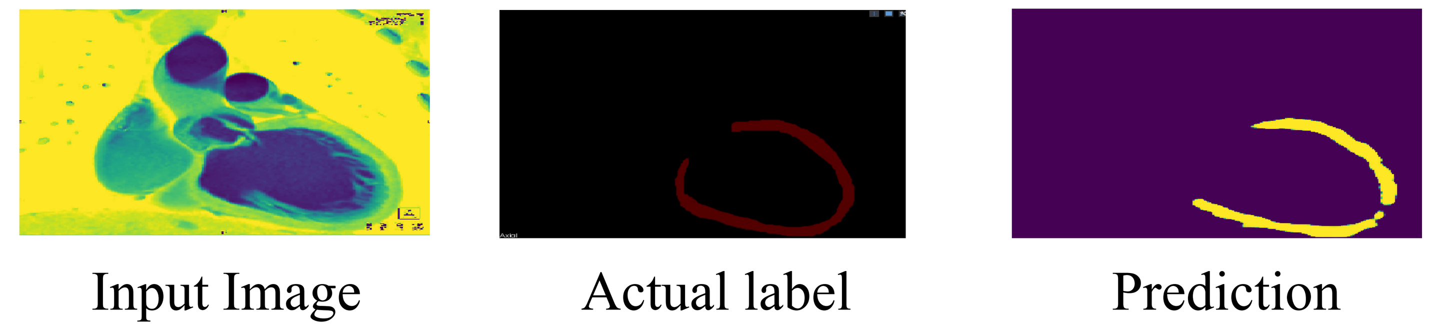

Figure 5. Model prediction on a ctisus image

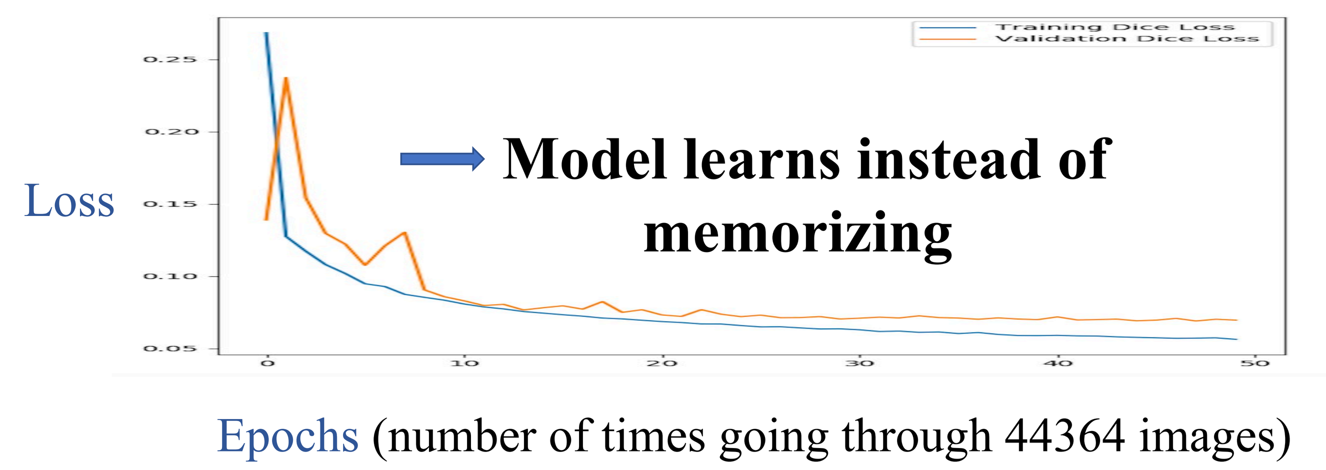

Figure 6. Dice Loss of U-Net with DST

Model	Training Loss	Validation Loss	Validation Accuracy	Test Accuracy
U-Net	0.0522	0.0691	93.09%	92.86%
U-Net with DST	0.0479	0.0690	93.10%	93%

Figure 7. Comparision of two models

Conclusion & Future Work

- By applying U-Net based architecture and Deep Stack Transformation, the model gives a very high overall prediction accuracy on unseen data (93%). This result suggests that deep learning has a very high potential in replacing tedious traditional segmentation method
- The next immediate work would be to apply the procedure to other parts of the heart other than the left ventricle
- Collecting more diverse data because the prediction accuracy on ctisus images is only 66.7% compared to 93%

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