

Automatic Segmentation of Cardiac MR Data Using Convolutional Neural Networks



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Geisinger

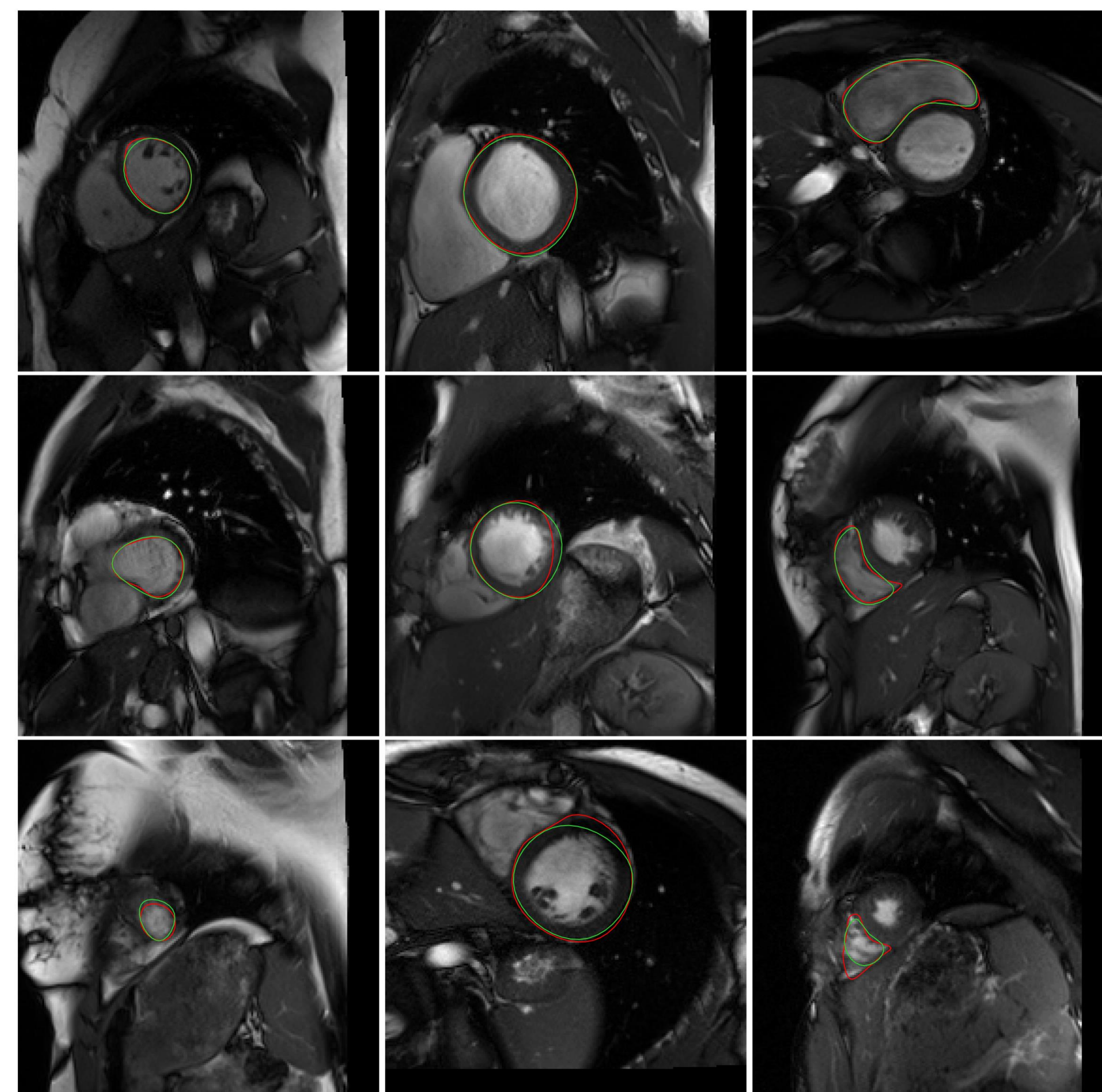
CARDIAC IMAGING TECHNOLOGY LAB

Motivation

- Cardiovascular diseases are one of the leading causes of death worldwide.
- Doctors can quantitatively assess the effects of heart disease using Cardiac MRI results.
- It is a time-consuming and error-prone process to manually segment the Cardiac MR images.
- We automate segmentation using machine learning with a Convolutional Neural Network.

Data Pipeline

- Goal:** Create a data pipeline to facilitate the learning process.
- Extract the Cardiac MR images and the manual contours from the data files provided by the Geisinger Health System.
- Create extensible code that can be easily modified for new data.
- Minimize I/O operations to increase the speed of the learning process.
- Use TFRecords and TensorFlow Data API to increase efficiency.

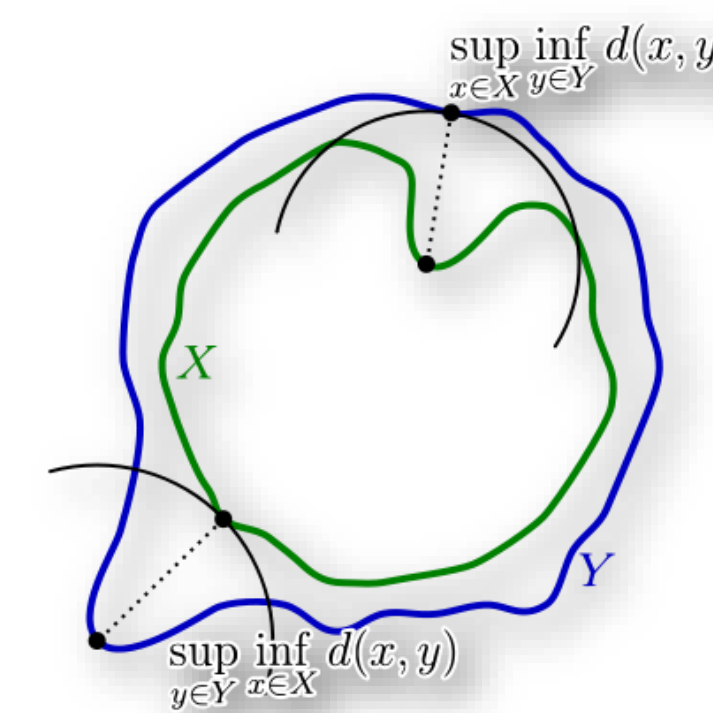


Evaluation

- Goal:** Evaluate the results using the Dice coefficient and a discretized version of the Hausdorff Distance.
- The Dice coefficient is a measure of similarity between two sets. Given two sets A and B , the associated Dice coefficient is:

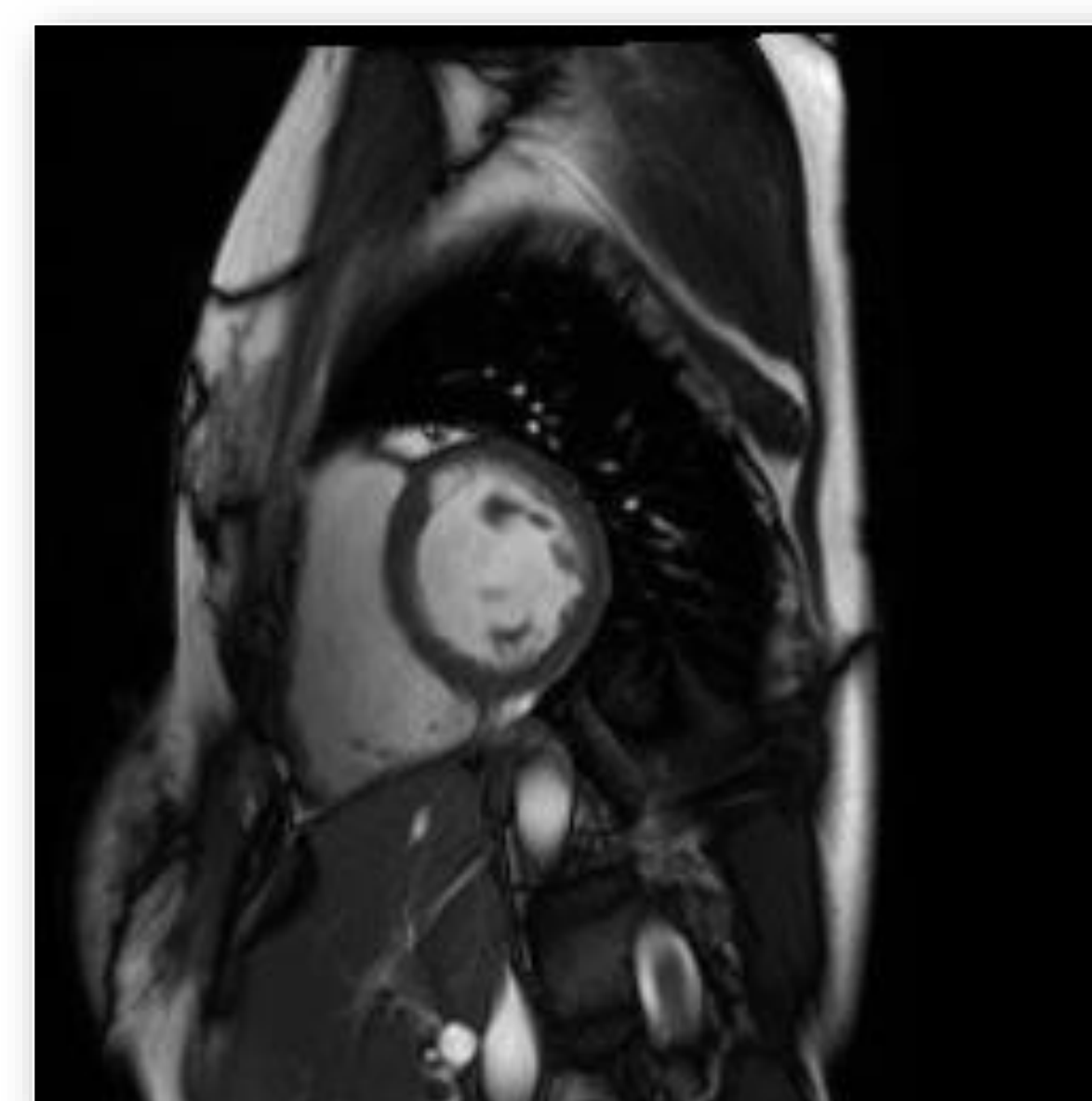
$$\text{Dice Coefficient} = \frac{2|A \cap B|}{|A| + |B|}$$

- The Hausdorff Distance measures how far two sets are from each other.

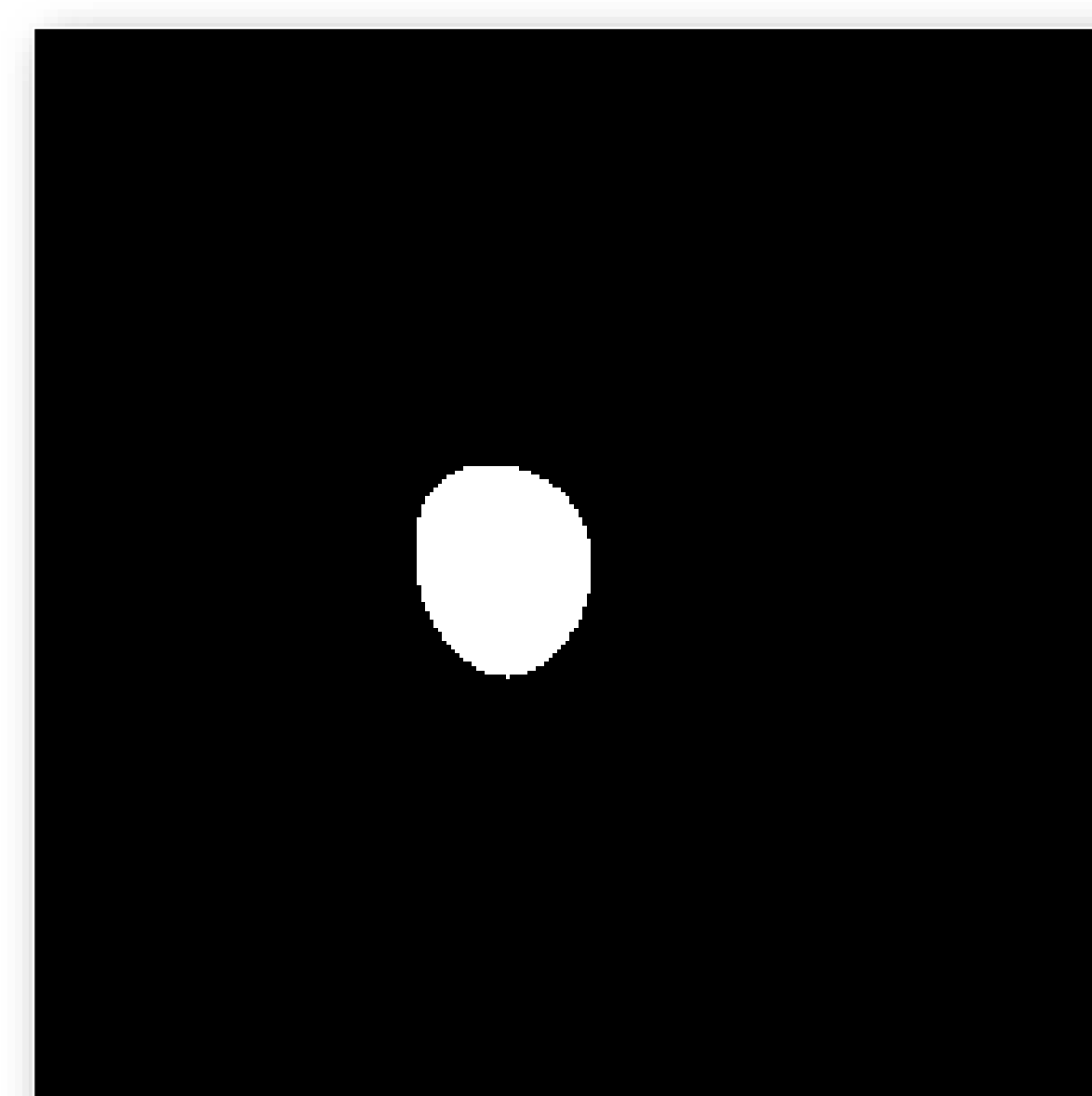


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Cardiac MRI

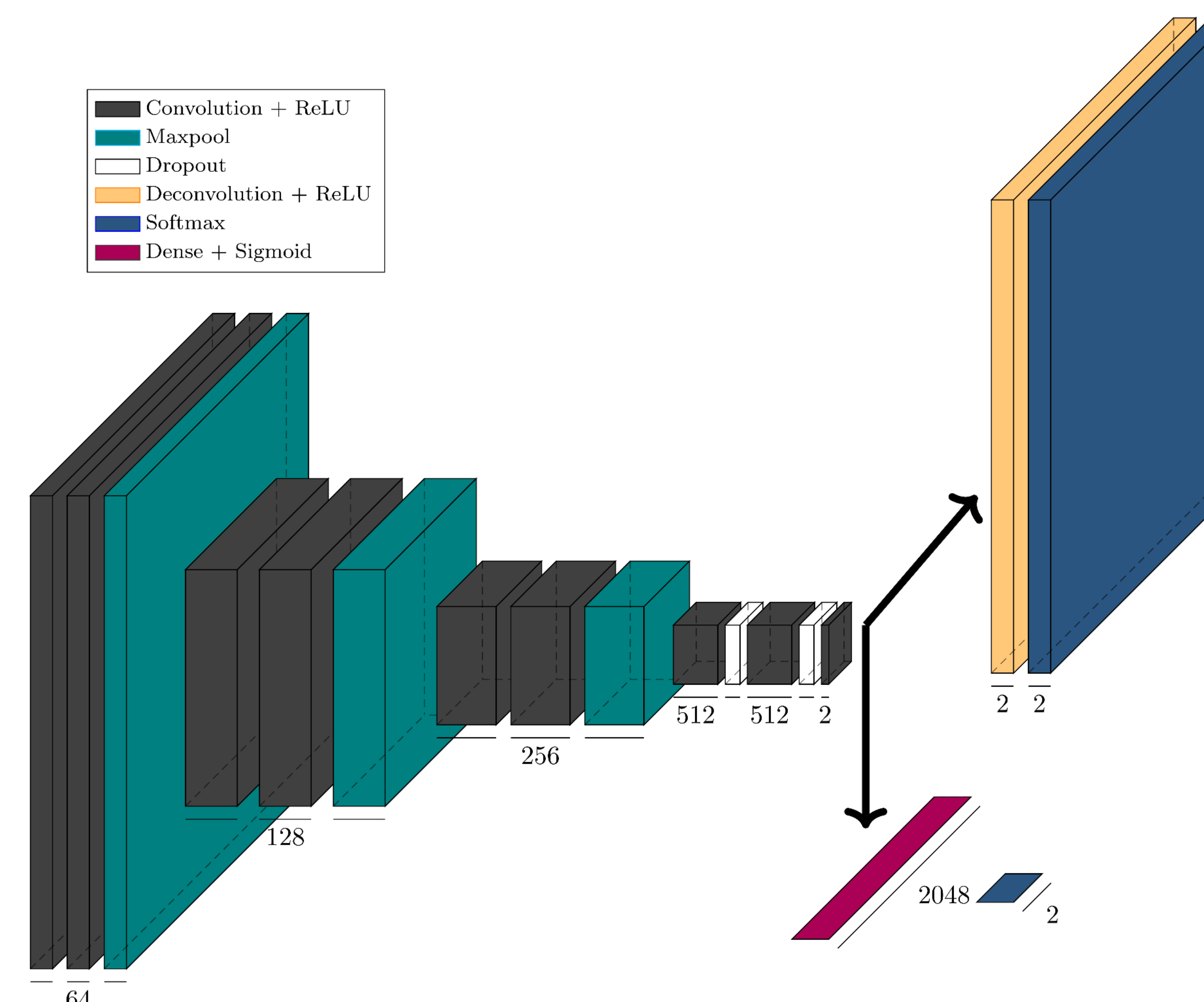


Left Ventricular Endocardium (LV) Manual Contour

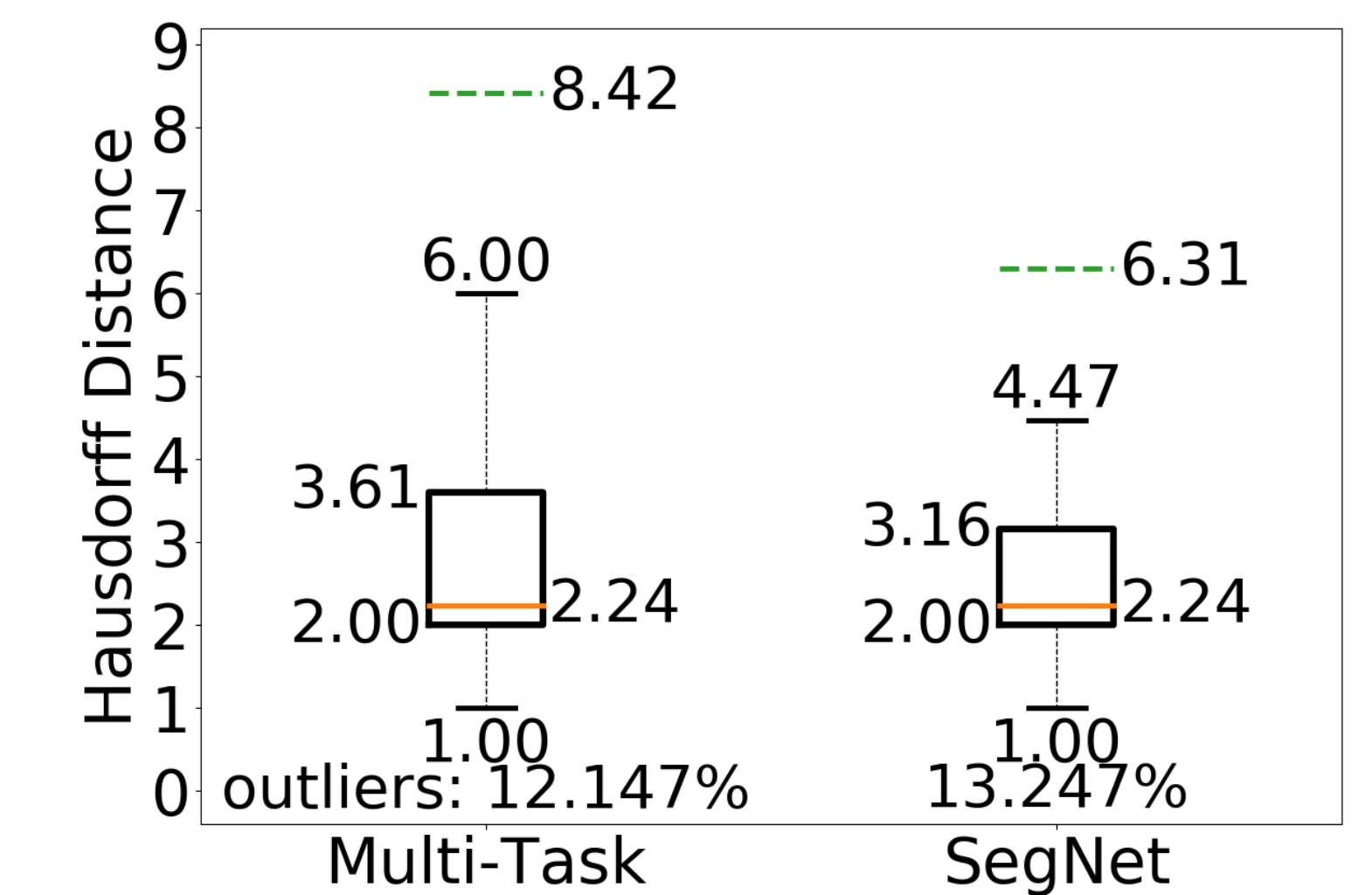
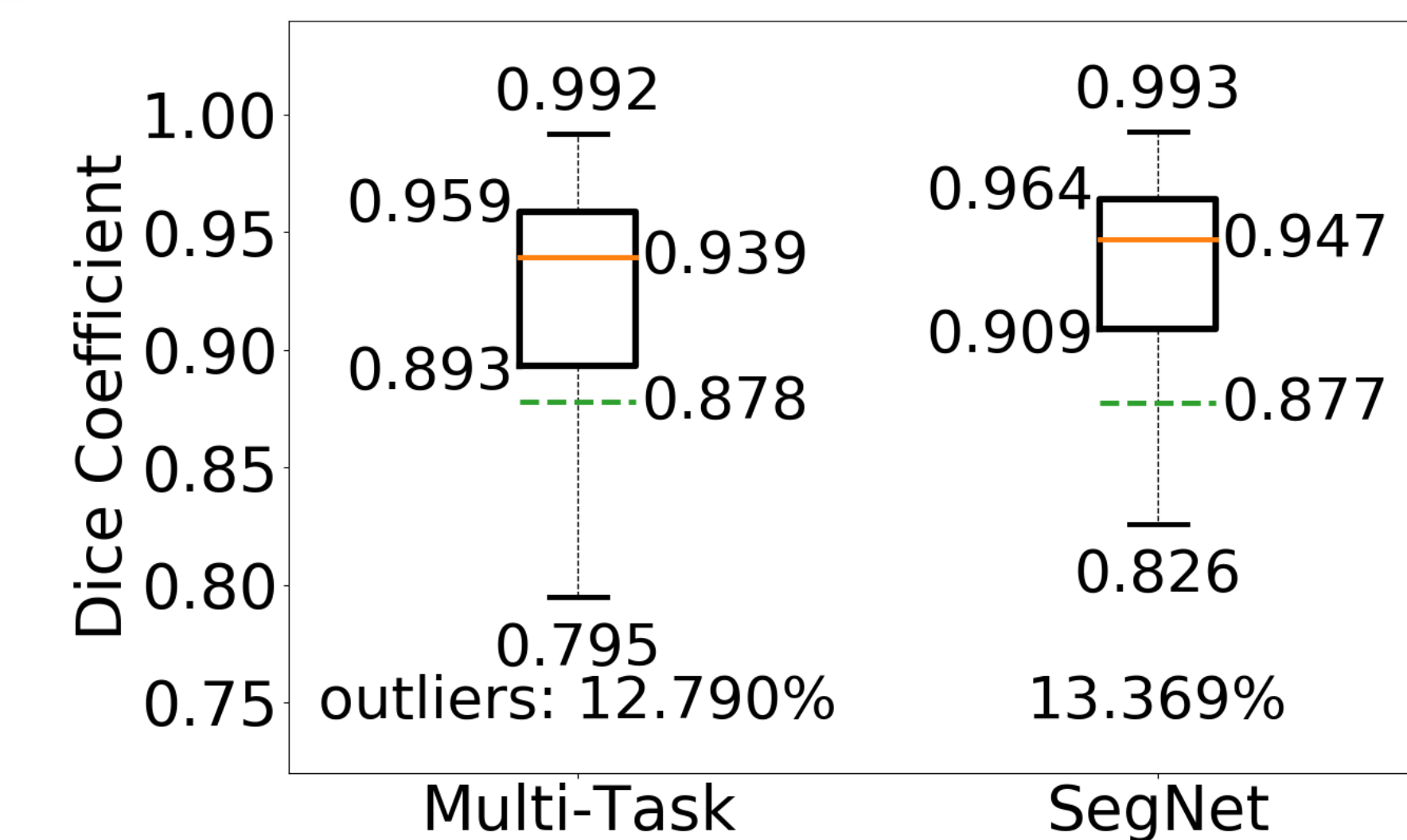


Multi-Task Learning

- Goal:** Simultaneously segment an image and classify whether it is empty or not.
- $$\text{Total Loss} = \frac{1}{\sigma_1^2} \cdot \text{Loss}(\text{Segmentation}) + \frac{1}{\sigma_2^2} \cdot \text{Loss}(\text{Classification}) + \log_{10} \sigma_1 + \log_{10} \sigma_2$$
- Learn σ_1 and σ_2 during training.



Results



	Manual	True	False
Automatic			
True		25299	2533
False		80	11850

	Manual	True	False
Automatic			
True		24942	7886
False		437	6497

Confusion matrices for Multi-Task (left) and SegNet (right).

Future Plans

- Classify images as empty or not prior to learning segmentation.
- Region of interest finding.
- Data augmentation.
- Cluster patients to train network to perform best on certain groups.

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- A. Kendall, Y. Gal, R. Cipolla. "Multi-Task Learning Using Uncertainty to Weigh Losses for Scene Geometry and Semantics."