# Data and Image Processing in Cardiac MRI Analysis


Joseph DiPalma

Advisors: Dr. Joshua Stough[1], Dr. Christopher Haggerty[2]

[1]*Department of Computer Science, Bucknell University, Lewisburg, Pa.*

[2]*Cardiac Imaging Technology Lab, Geisinger Health System*


## Motivation

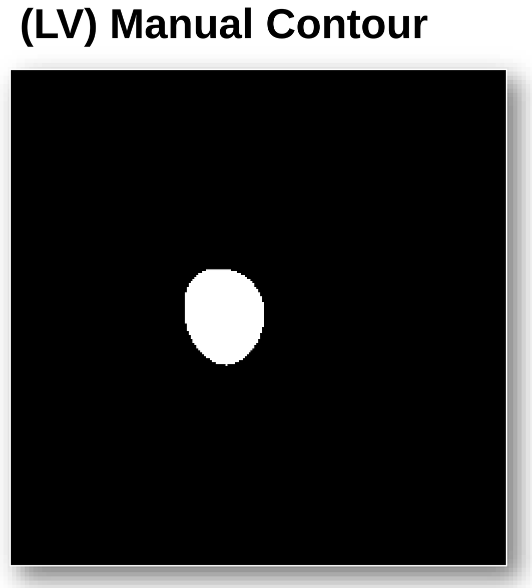
- Cardiovascular diseases are one of the leading causes of death worldwide.
- Doctors can quantitatively assess the effects of heart disease using cardiac MRI results.
- It is a time-consuming process to manually segment the Cardiac MR images. The process can be automated using machine learning with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

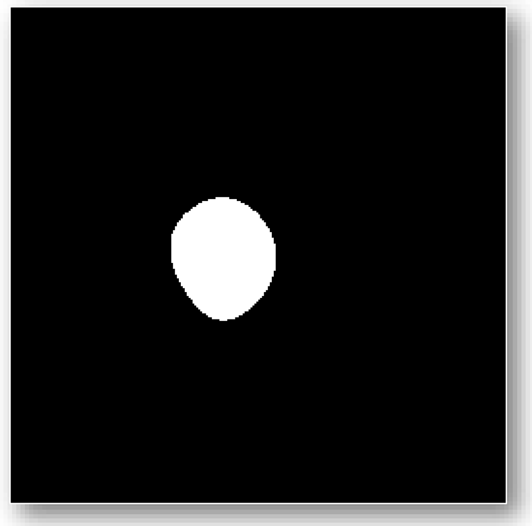
## Data Pipeline

- **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.

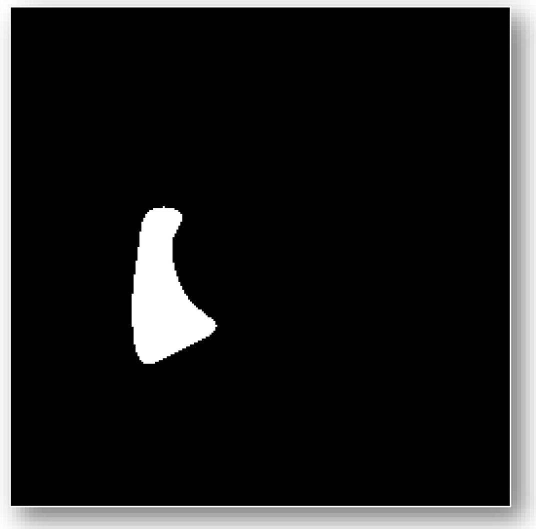
**Cardiac MRI**

**Left Ventricular Endocardium (LV) Manual Contour**





**Left Ventricular Epicardium (Epi) Manual Contour**



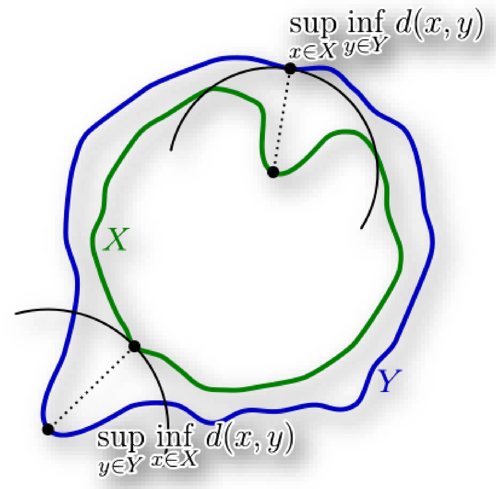
**Right Ventricular Endocardium (RV) Manual Contour**

## 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:

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

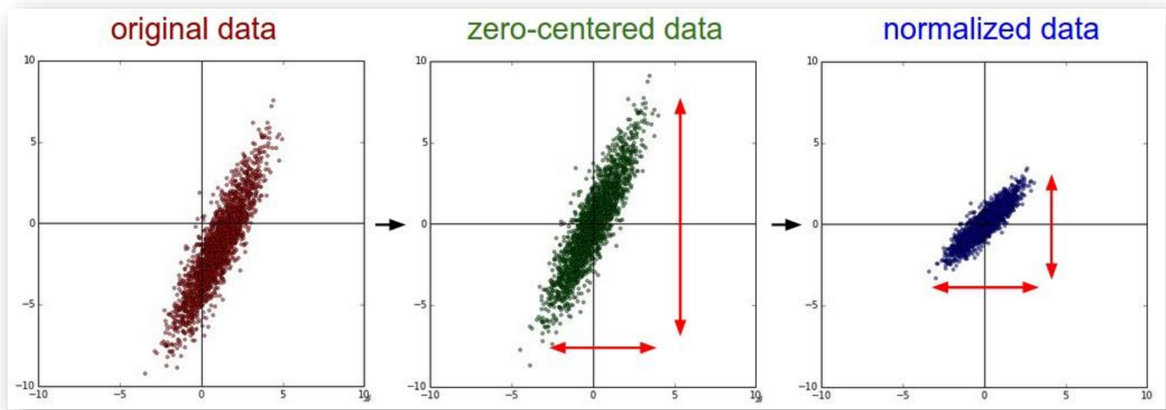
- The Hausdorff Distance measures how far two sets are from each other.




Source: *Rocchini - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=2918812*

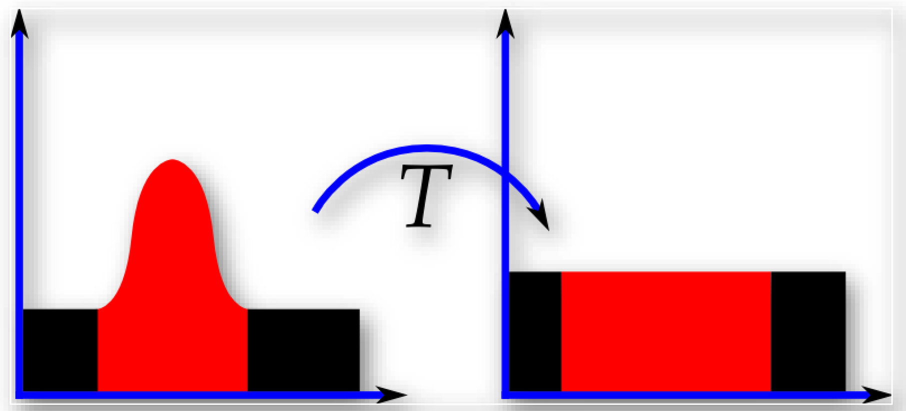
## Image Normalization

- **Goal:** Normalize the images to further improve our results.
- **Mean Variance Normalization:**
  - Normalize the image values to have a mean of zero and unit variance.



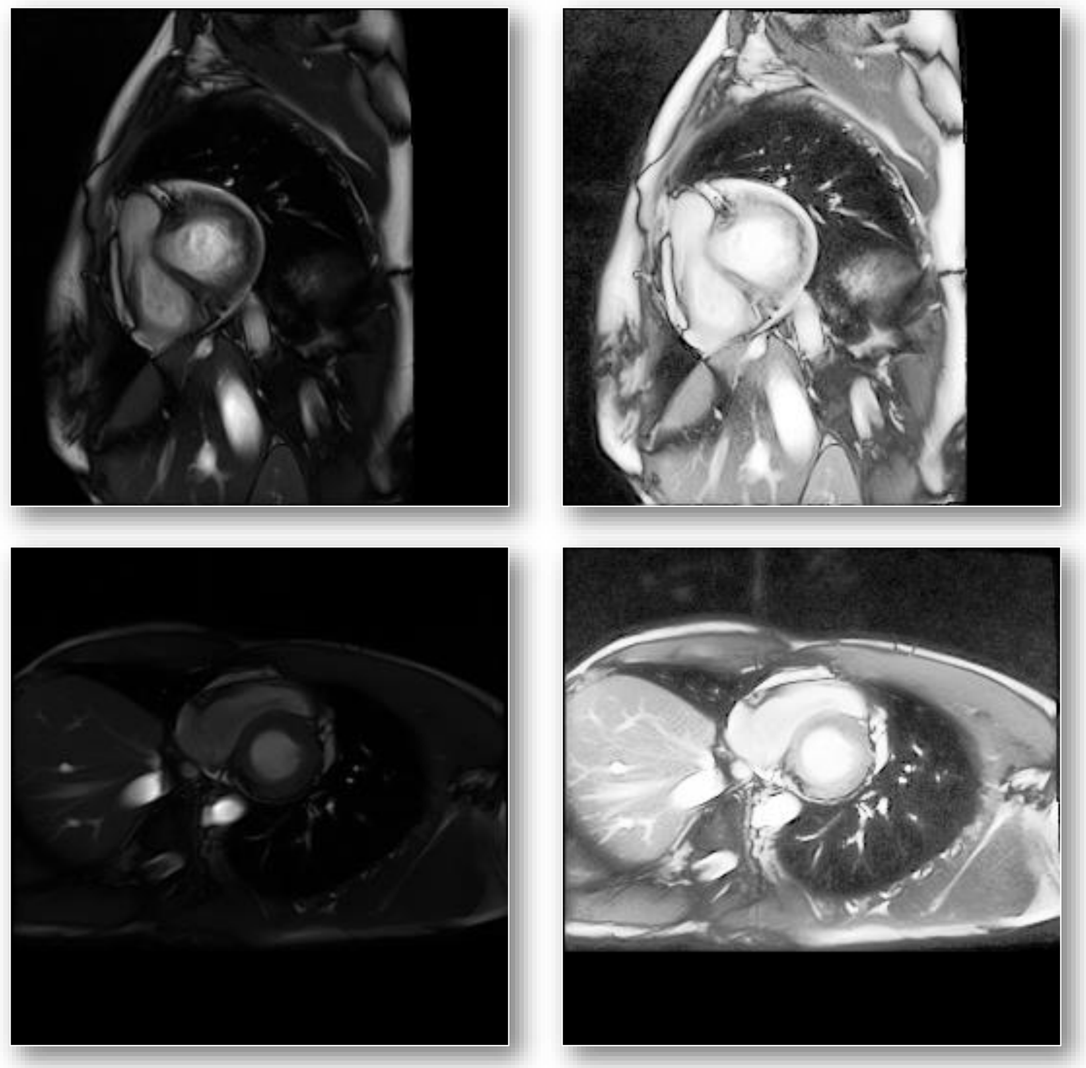

Source: *http://cs231n.github.io/neural-networks-2/*

- **Image Histogram Normalization:**



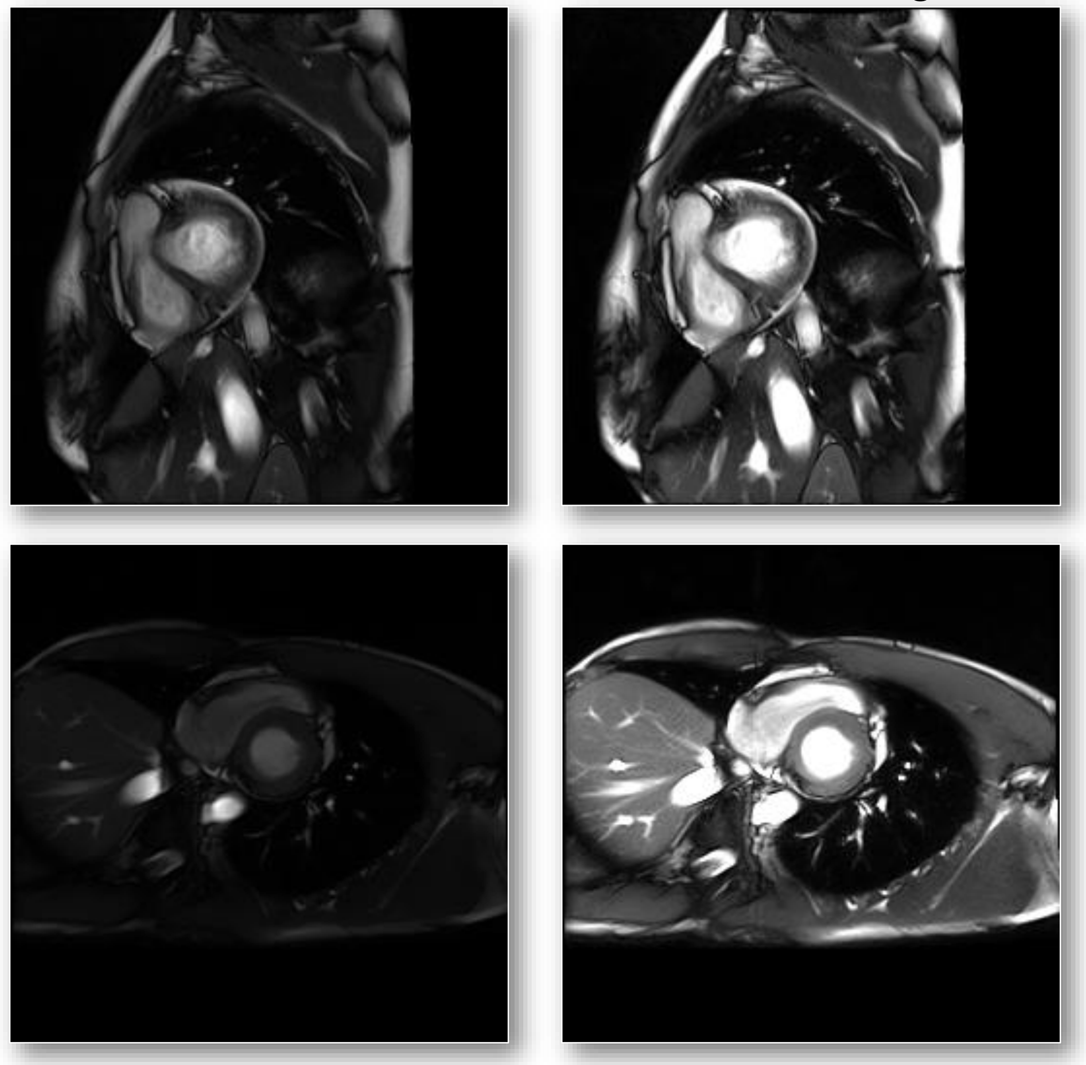

Source: *Zefram - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=668605*

**Unnormalized:** | **Normalized with Histogram Normalization:**



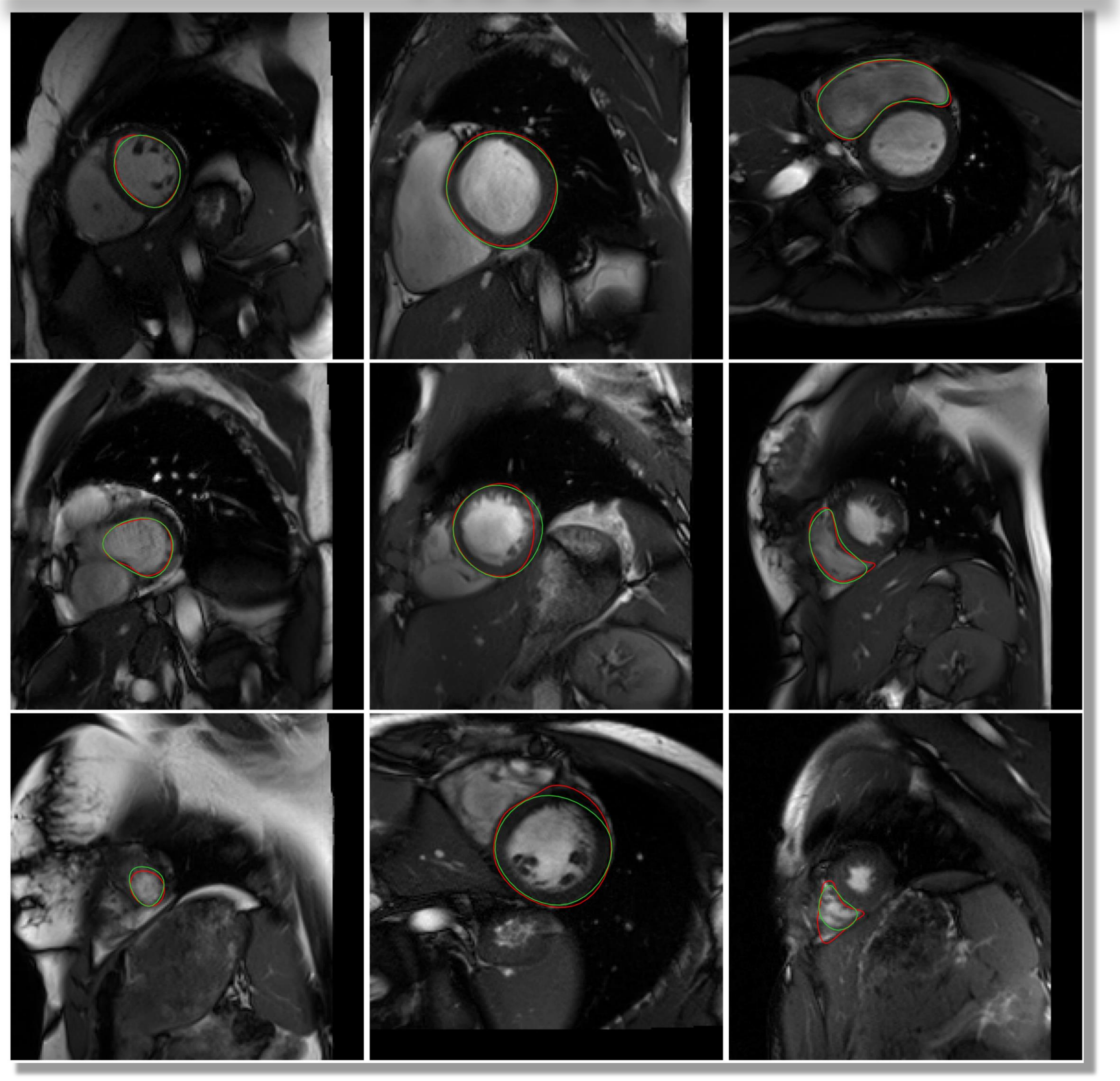
- **97th Percentile Scaling:**
  - Find the 97th percentile of the pixel values and set each pixel in the 97th percentile and above to 1.

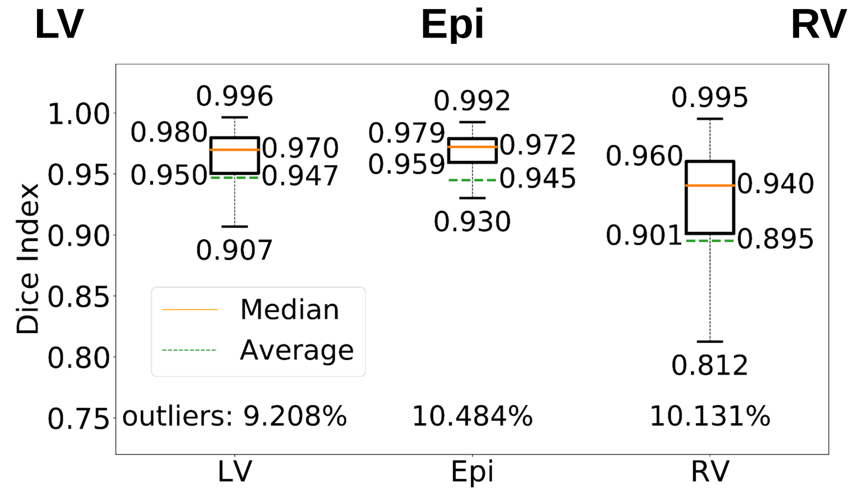
**Unscaled:** | **Scaled with 97th Percentile Scaling :**



- **Scaling:**
  - Multiply all of the image values by a scalar.
- Scaling works best. The network is being updated to learn the scalar that gives the best results.

## Results




## Discussion

- The resulting Dice coefficients are comparable to the results of other recent state-of-the-art work.
- There are outliers that result in an empty automatic segmentation when a manual segmentation exists. We will fix the problematic outliers using scaling.
- Next Steps:
  - Add different pathologies.
  - Spatial and temporal coherence.

## Acknowledgements


- Bucknell Geisinger Research Initiative
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- Library and IT staff, Jeremy Dreese and Mike Harvey



- J.V. Stough, J. DiPalma, Z. Ma, B.K. Fornwalt, C.M. Haggerty. "Ventricular segmentation and quantitative assessment in cardiac MR using convolutional neural networks." SPIE-Medical Imaging 2018 (forthcoming)