

# Mesh2SSM: From Surface Meshes to Statistical Shape Models of Anatomy

Krithika Iyer<sup>1,2</sup> and Shireen Elhabian<sup>1,2</sup>

<sup>1</sup> Scientific Computing and Imaging Institute, University of Utah, SLC, UT, US

<sup>2</sup> Kahlert School of Computing, University of Utah, Salt Lake City, UT, USA  
krithika.iyer@utah.edu shireen@sci.utah.edu

## 1 Supplementary

### 1.1 Architecture

1. FlowSSM: Used the official implementation provided by the authors at [github.com/davecaspl/flowssm](https://github.com/davecaspl/flowssm)

2. Mesh2SSM:

**Network:** See Figure 1 for network for (a) mesh autoencoder (MAE), (b) IM-NET, and (c) point VAE (P-VAE). All networks use leaky RELU.

**Hyper-parameters:**

- (a) Learning rate MAE 0.01 with step scheduler
- (b) Learning rate P-VAE 0.0009 with step scheduler
- (c) Batch size 10
- (d) Latent dim  $z_m$  and  $z_p = 32$  (box-bump), 64 (pancreas), 128 (left atrium)
- (e) Epochs: 1000
- (f) MAE:  $\alpha = 0.01$  increased gradually to 1,  $\gamma = 0.01$
- (g) GPU: NVIDIA GeForce RTX 2080 Ti
- (h) Adam optimizer

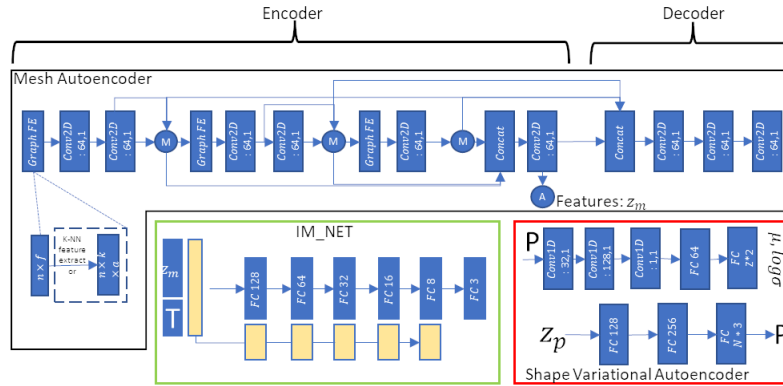
### 1.2 Results: Left Atrium

Left atrium dataset: 1102 anonymized segmented LGE MRI images from unique atrial fibrillation patients with spatial resolution  $0.65 \times 0.65 \times 2.5mm^3$ . Train, test, validation split: 900/66/136 samples.

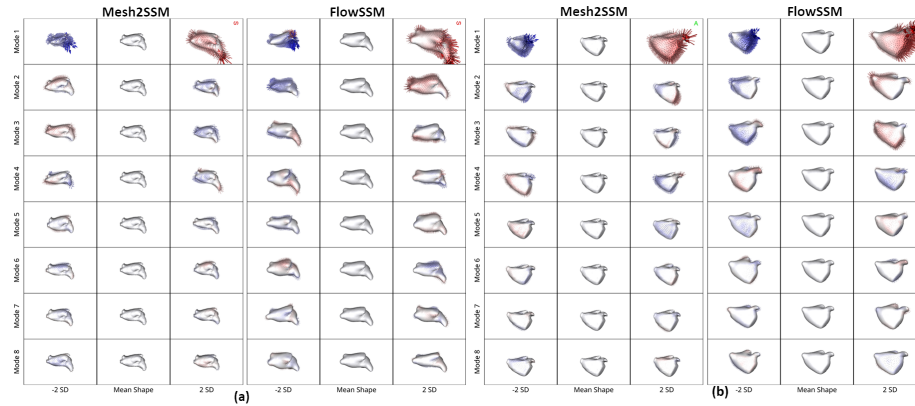
**Table 1.** Distance metrics (measured in mm) of the testing samples and their reconstructions for the left atrium dataset with medoid template

| Metrics            | Mesh2SSM            | FlowSSM             |
|--------------------|---------------------|---------------------|
| $L_1$ Chamfer      | $0.0383 \pm 0.0026$ | $0.2547 \pm 0.0532$ |
| Surface-to-Surface | $3.9439 \pm 0.6997$ | $0.2512 \pm 0.0505$ |

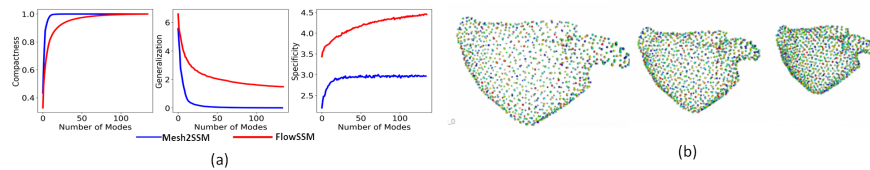
## References



**Fig. 1.** Architecture for (a) mesh autoencoder where each convolutional block is followed by non-linear activation and batch normalization, (b) IM-NET where each fully connected layer is followed by activation function, and (c) shape variational autoencoder. M: max-pool, A: average-pool, T: each point from the template point cloud.



**Fig. 2.** Top eight PCA modes of variations identified by Mesh2SSM and FlowSSM with medoid as template shown from the (a) top view and (b) anterior view. The color map and arrows show the signed distance and direction from the mean shape.



**Fig. 3.** (a) Shape statistics of left atrium dataset: compactness (higher is better), generalization (lower is better), and specificity (lower is better). (b) First dominant non-linear mode of variation identified by Mesh2SSM.