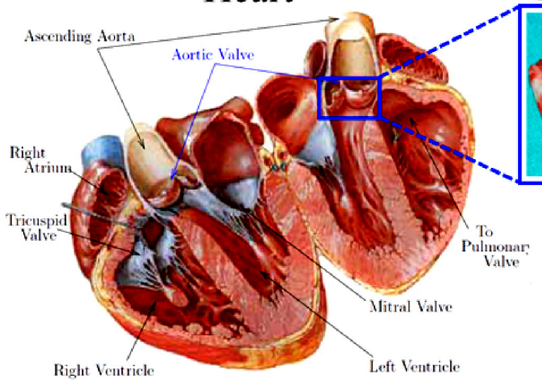
School of Civil Engineering

High Performance Computing Laboratory

"Aortic Heart Valve Simulation; A Multiscale Biomechanical Approach"

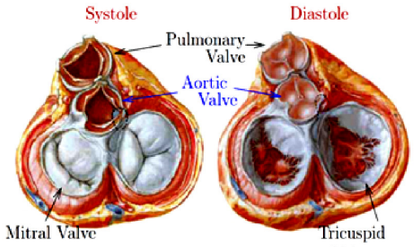
Shahrokh Shahi and Soheil Mohammadi

Heart



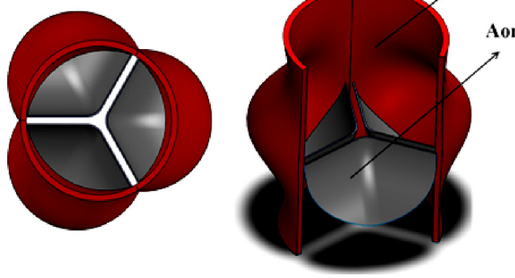
Aortic Heart Valves

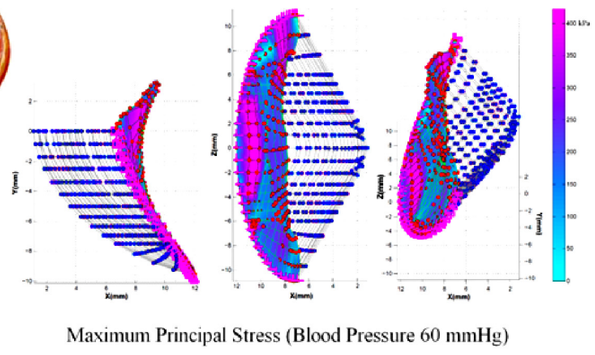
Heart Valves



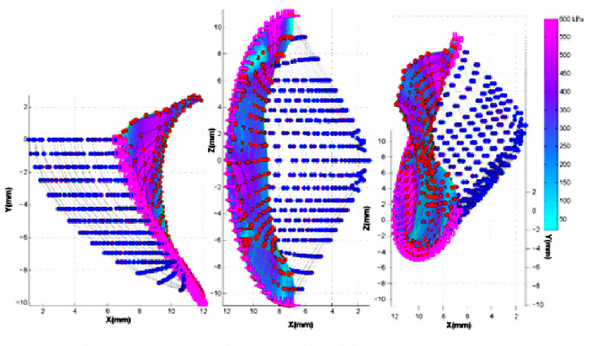
Blood Pressure (mmHg)	This Study	Photographs of Successive Frames	Other Models
1		a	
20			
40			
60			
90			

Organ Level Simulation





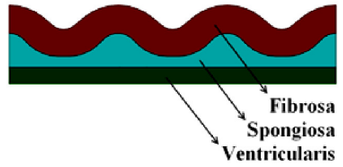
Maximum Principal Stress (Blood Pressure 60 mmHg)



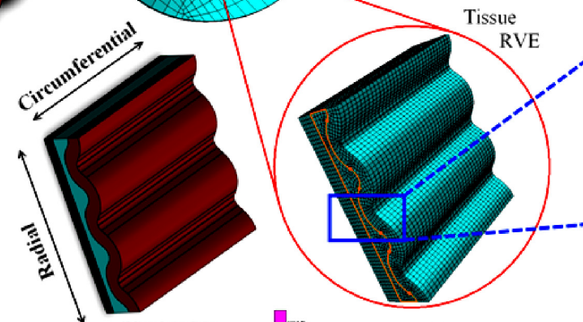
Maximum Principal Stress (Blood Pressure 90 mmHg)

Large Deformation Analysis
Incompressible Soft Tissue
Transversely Isotropic Behavior
Hyperelastic Constitutive Model
*Strain Energy Function:

$$\bar{\psi}_1(\bar{I}_1)=\frac{C_2}{2C_1}(e^{C_1(\bar{I}_1-3)}-1);\ \bar{\psi}_4(\bar{I}_4)=\begin{cases}0, & \bar{I}_4<0\\ \frac{C_4}{2C_3}(e^{C_3(\bar{I}_4-1)^2}-1), & \bar{I}_4\geq 0\end{cases}$$

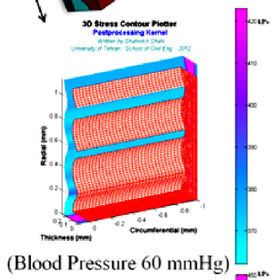


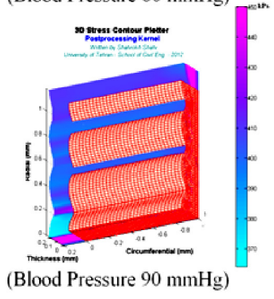
Tissue Level Simulation



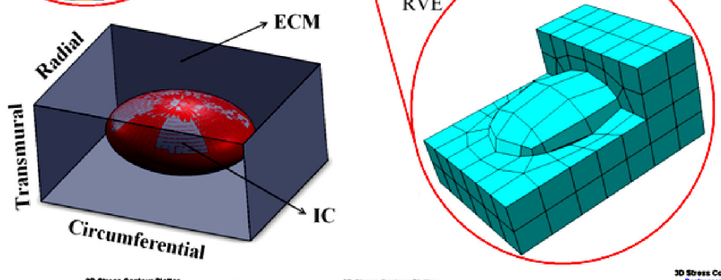
Multi-layer Model
*Fibous Layers:
Fibrosa
Ventricularis
*Gel-like Layer:
Spongiosa
**Strain Energy Function:

$$\bar{\psi}(\bar{I}_1,\bar{I}_4)=C_1\times\left(e^{C_2(\bar{I}_1-3)}-1\right)+\frac{C_3}{2C_4}\left(e^{\left[C_4(\bar{I}_4-1)^2\right]}-1\right)+C_5(\bar{I}_1-3)$$





Cell Level Simulation



Interstitial Cell (IC)
*Strain Energy Function:

$$\bar{\psi}=C(\bar{I}_1-3)$$

Extra Cellular Matrix (ECM)