A Non-Invasive Diagnostic Tool for Cardiac Pressure Gradients

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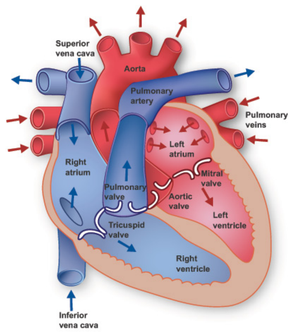
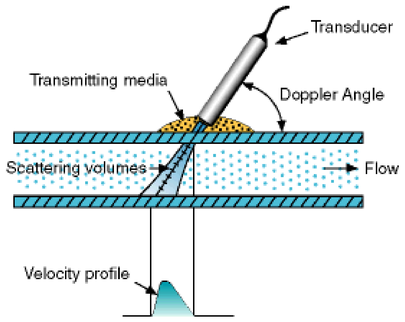
Cardiac Pressure

- Cardiac pressure gradients are an important metric of overall cardiovascular health
- Obtaining cardiac pressure gradients requires invasive placement of a catheter inside the heart
- Goal: develop software to get cardiac pressure gradients non-invasively from the velocity profile of M-Mode Doppler echocardiograms

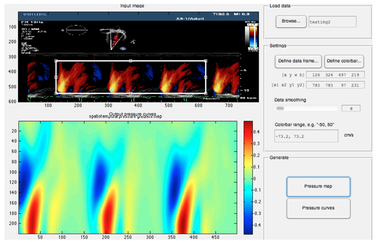


Heart's Anatomy



Motion-Mode Doppler

Previous Work



GUI developed by last year's team

- Used the 1D Euler Momentum Equation
- Result was not verified by the experimental data
- User Interface for clinical use by technicians

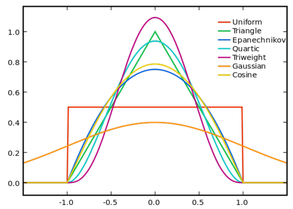
Data Acquisition

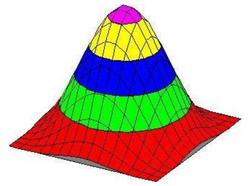
- From Texas Children's Hospital's animal lab
- Acquired simultaneous velocity and pressure data
- Performed on baby pig

Image of the operation

Kernel Smoothing

- Kernel functions are non-negative normalized density functions



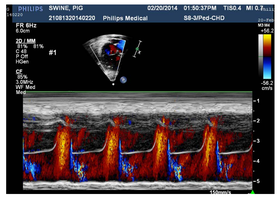


Examples of kernel functions

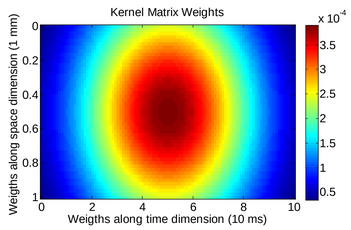
- Formulate optimization problem by varying the kernel function to produce the best matched pressure

Procedure

Echocardiogram



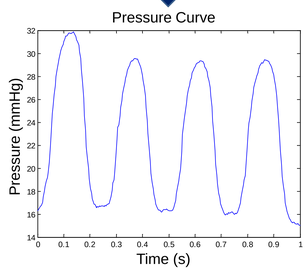
Kernel matrix



Preprocessing

$$\rho\left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v}\cdot\nabla\mathbf{v}\right) = -\nabla p + \eta\nabla^2\mathbf{v}$$

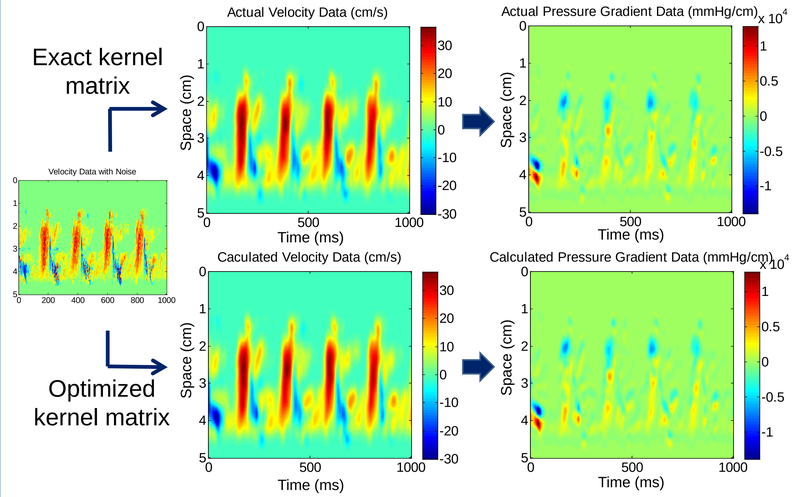
Navier-Stokes equation:
ρ = density of blood
v = velocity
p = pressure
η = viscosity



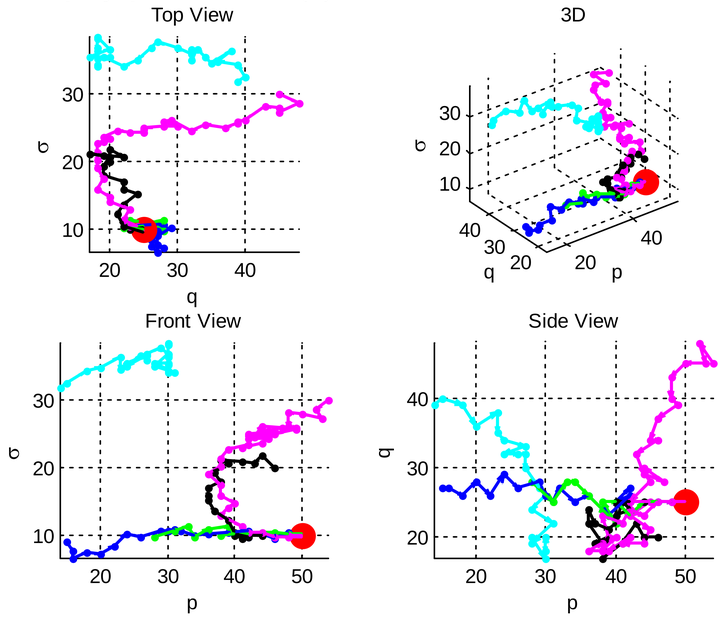
Desired pressure curve from velocity profile

Optimization of the Kernel

- PSWARM Optimization performed on synthetic data



- Convergence path of Gaussian kernel parameters with size p by q and with SD (σ)



Future Work

- Obtain optimal convergence of the kernel function optimization approach
- Successfully confirm the model

References

- J. C. Antoranz et al. Noninvasive assessment of ejection intraventricular pressure gradients. *Journal of the American College of Cardiology*, 43, 2004