An Approach to Aortic Outflow Velocity Image Analysis

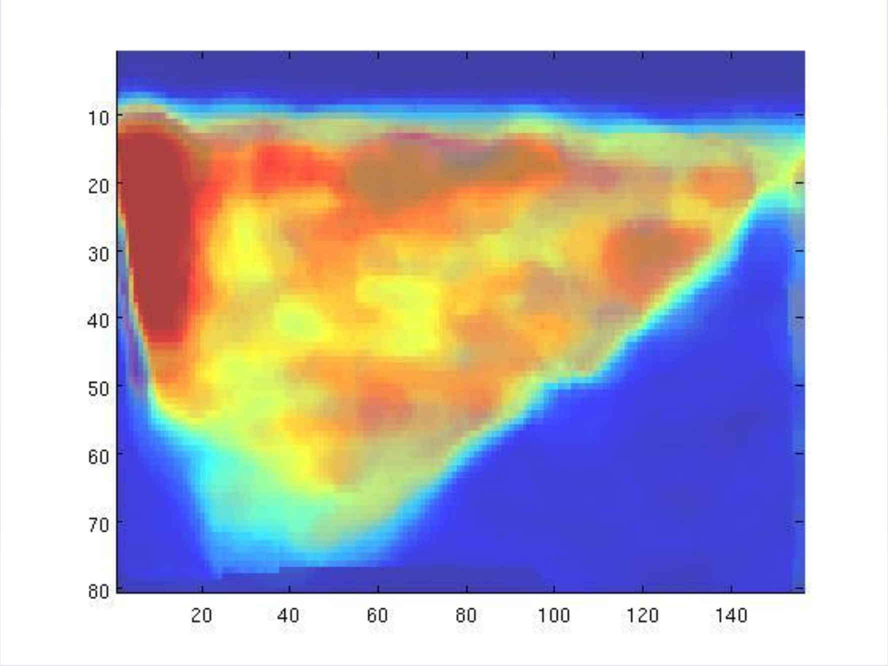
H. Kalinić, S. Lončarić, M. Čikeš, A. Baltabaeva*,
C. Parsai*, J. Šeparović, I. Čikeš, G.R. Sutherland*,
B. Bijnens[#]

University of Zagreb, Croatia
*St. George's Hospital, London, UK
#Pompeu Fabra University, Barcelona, Spain

Background

- Detection of changes in cardiac function is important for diagnosis of coronary artery disease (CAD)
- DSE - Dobutamine stress echocardiography is a non-invasive method used for quantification of ischaemia (E. Meri, G. R. Sutherland 2004, EHJ)
- Blood velocity and cardiac deformation are related (ed. Sutherland et al., 2006)

Aortic Outflow Profile Images

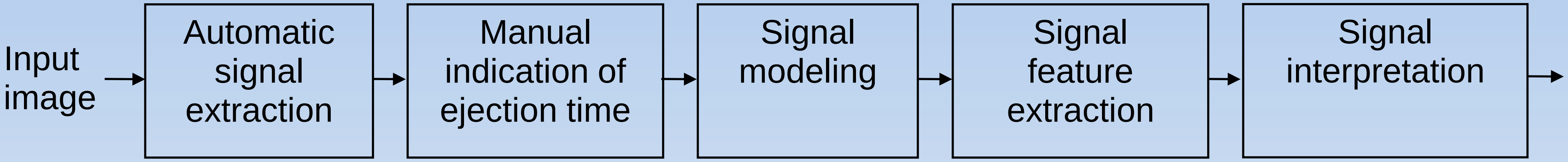


- Aortic outflow profile images show blood velocity
- Profile of the aortic outflow velocity provides information on global myocardial function

Hypothesis

- There is a correlation between the morphology and duration of aortic outflow velocity profile and myocardial function.

Proposed Method



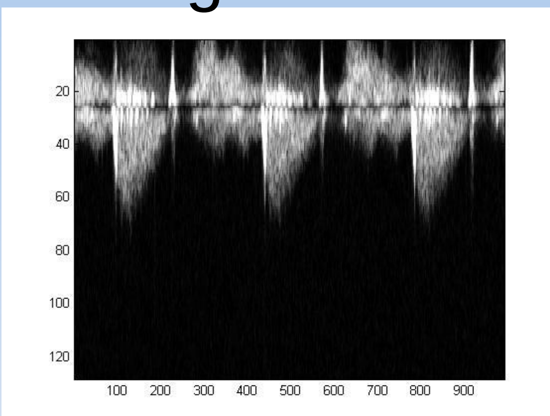
A method for aortic outflow velocity profile image analysis

Data Acquisition

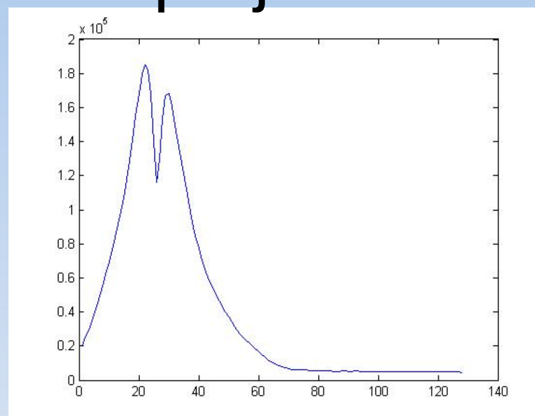
- Cardiographic scanner (Vivid 7, GE Healthcare)
  - Apical 5-chamber view
- Echopac workstation (GE Healthcare)
  - Images exported in Hierarchical Data Format (HDF)

Automatic Signal Extraction

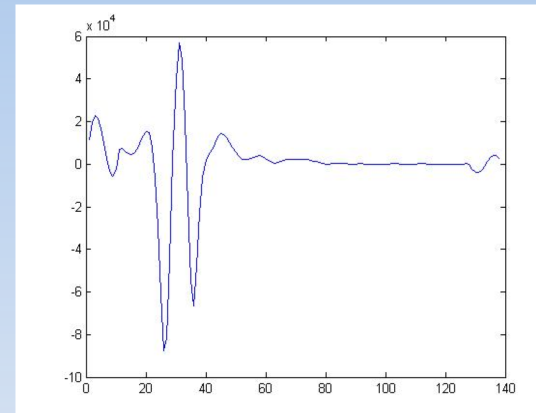
Image



Hor. projection



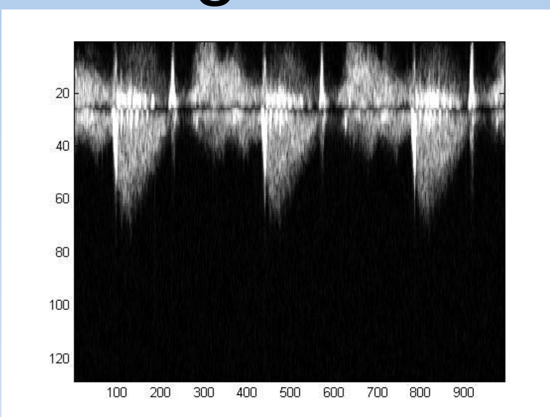
Cross-correlation



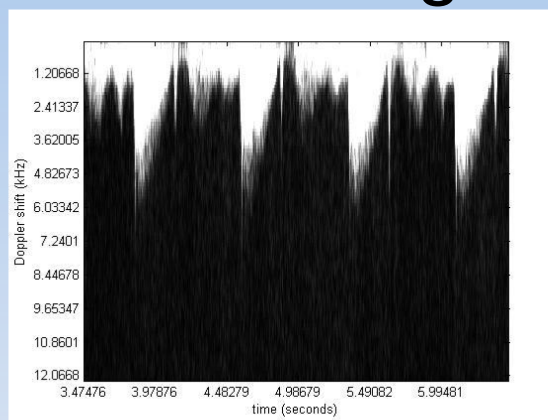
- Step one
  - Projecting the image onto the y-axis
- Step two
  - Cross-correlation with negative sine

Automatic Signal Extraction

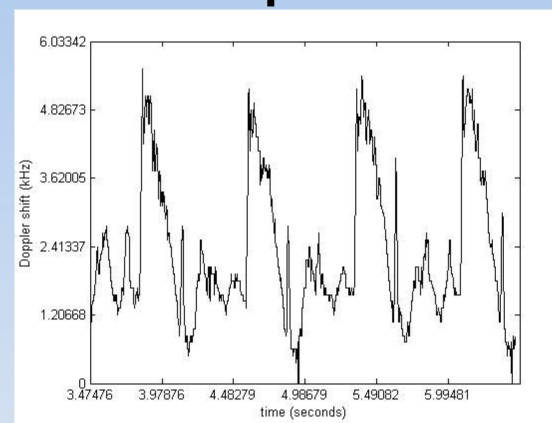
Image



No-zero image



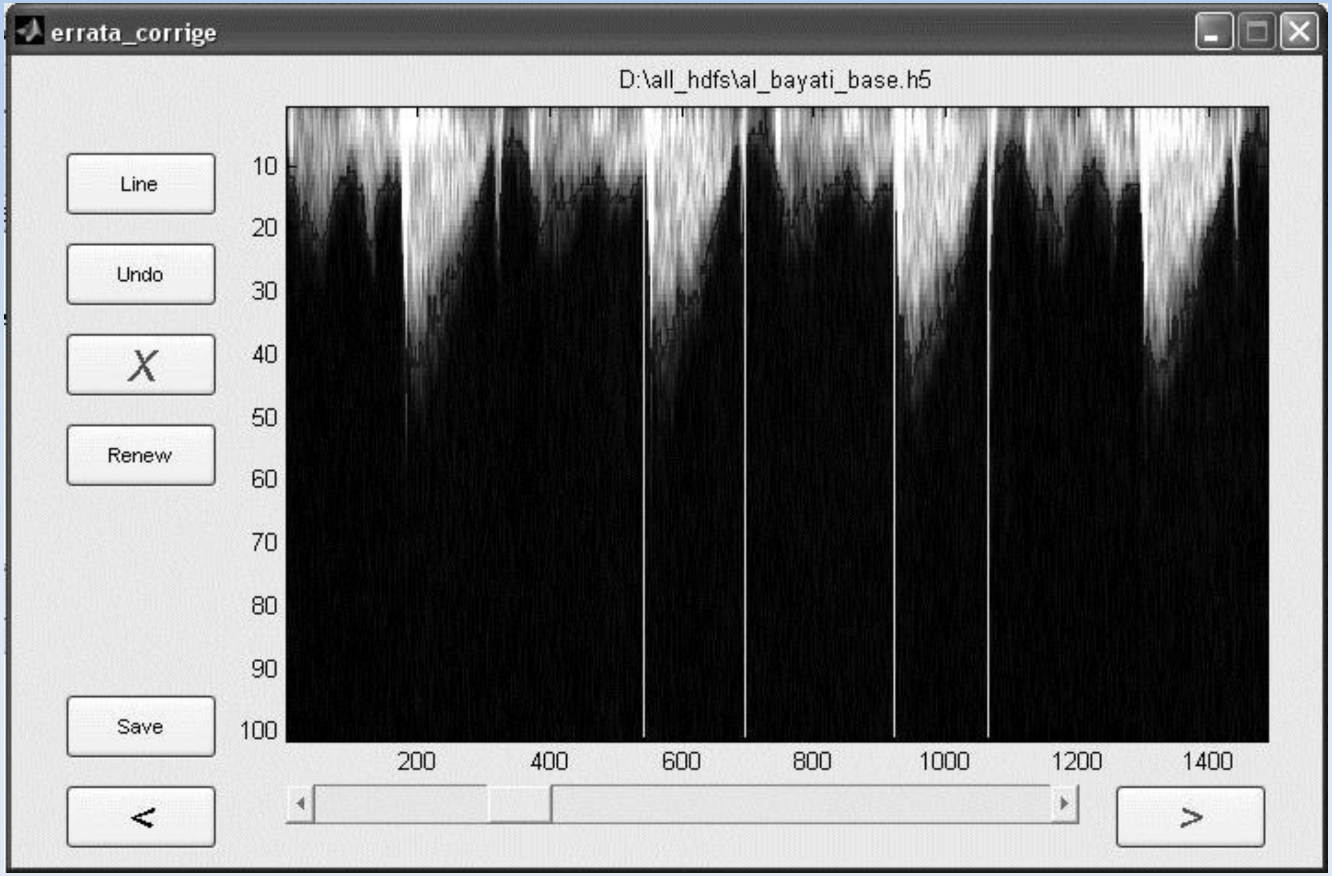
Envelope

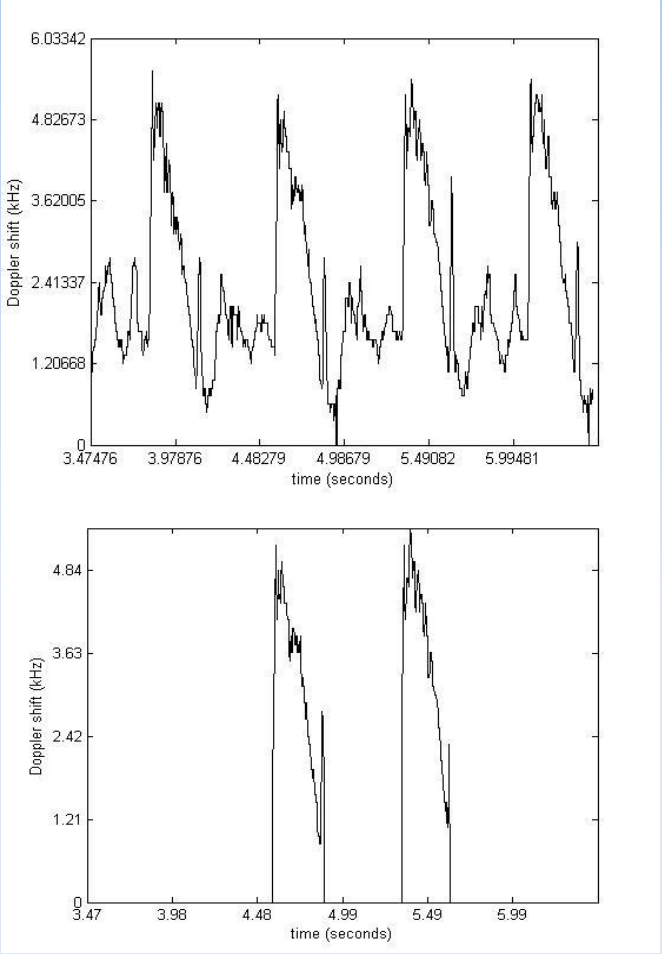


- Step three
  - Discarding the negative part of the signal
- Step four
  - Envelope detection by thresholding

Manual Signal Segmentation

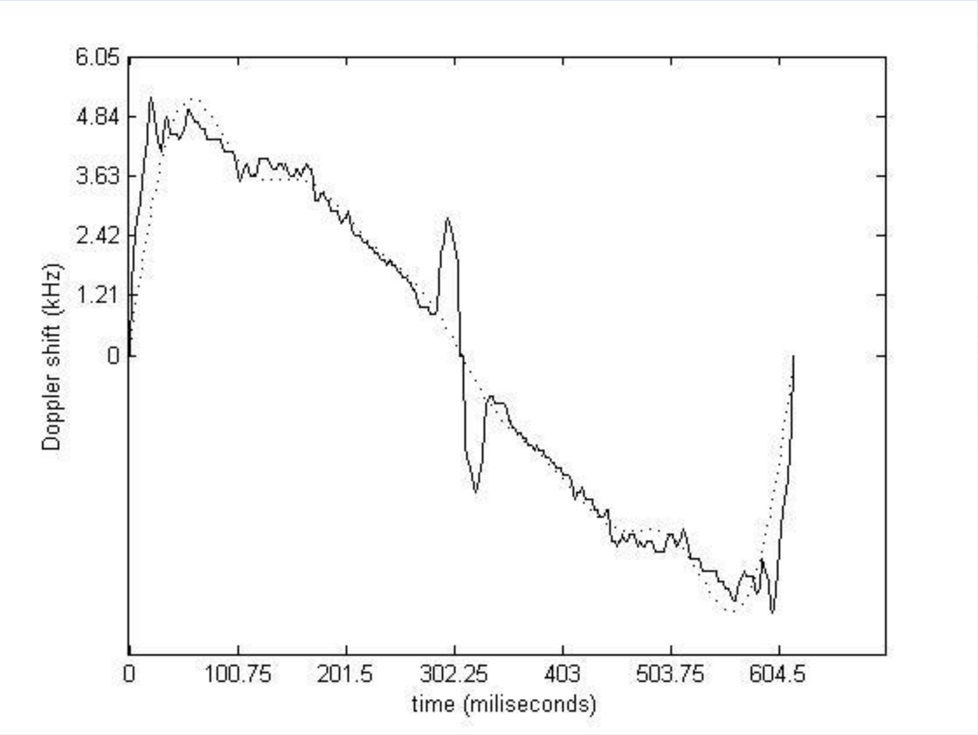
- Manual control and timing of the cycle

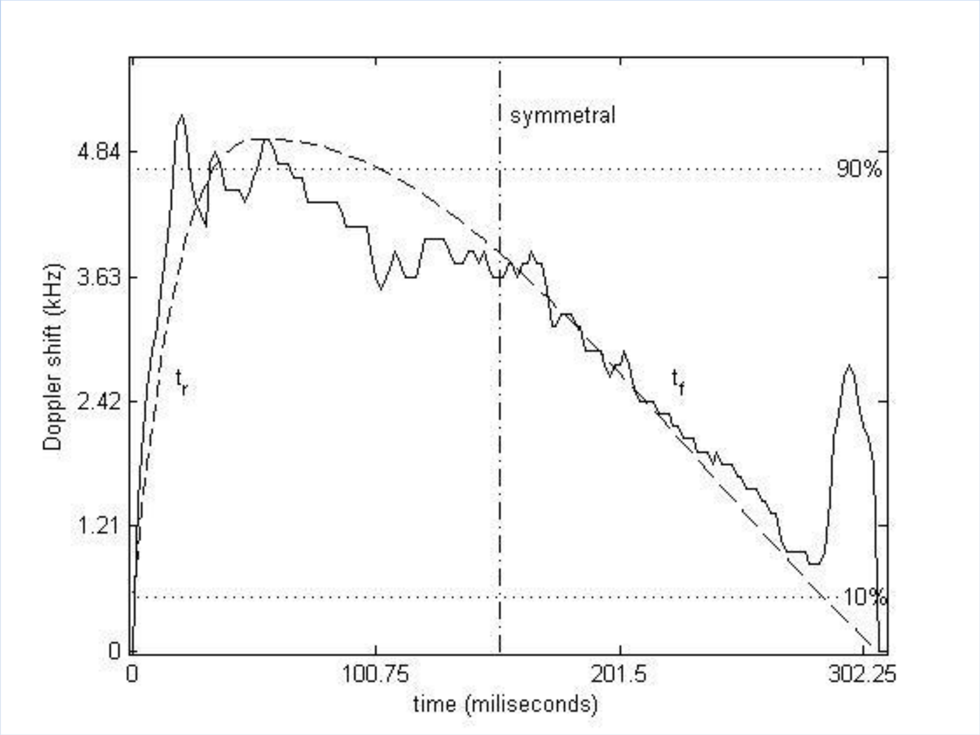




Signal Modeling

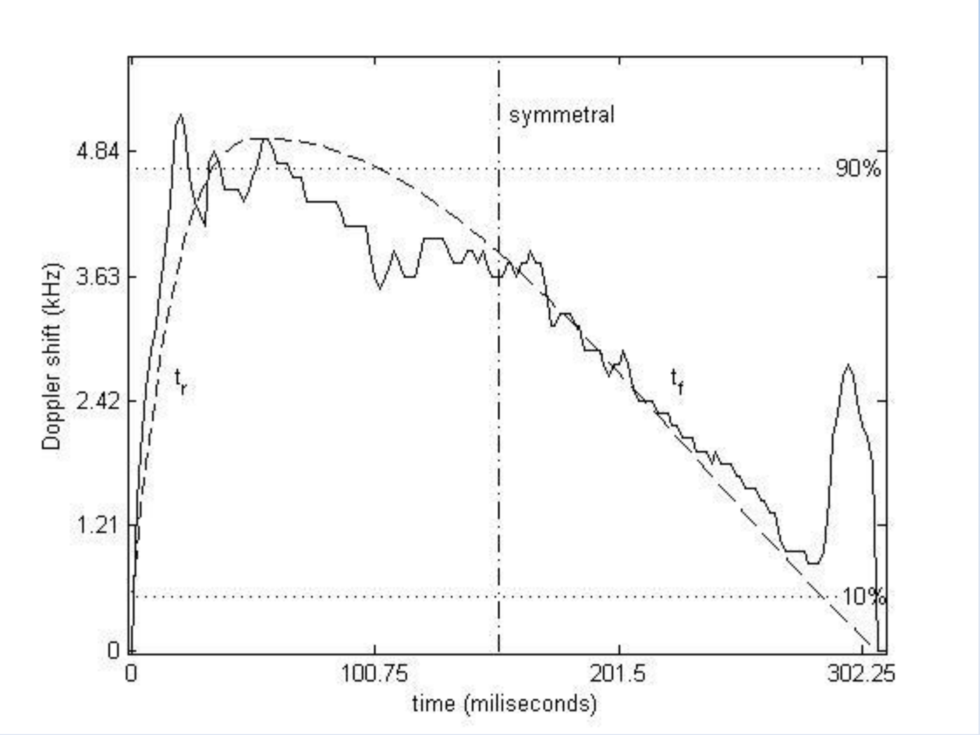
- Filtering in Fourier domain
- Piecewise cubic approximation





Signal Feature Extraction

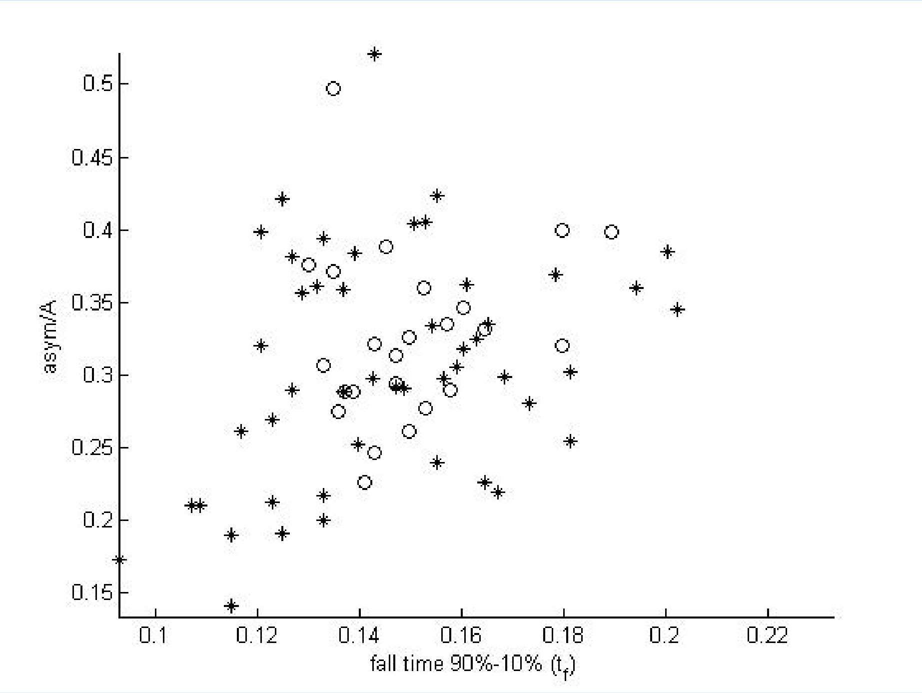
- 14 features
  - Rise time
  - Fall time
  - Harmonics
  - Area
  - Asymmetry measure
  - ...



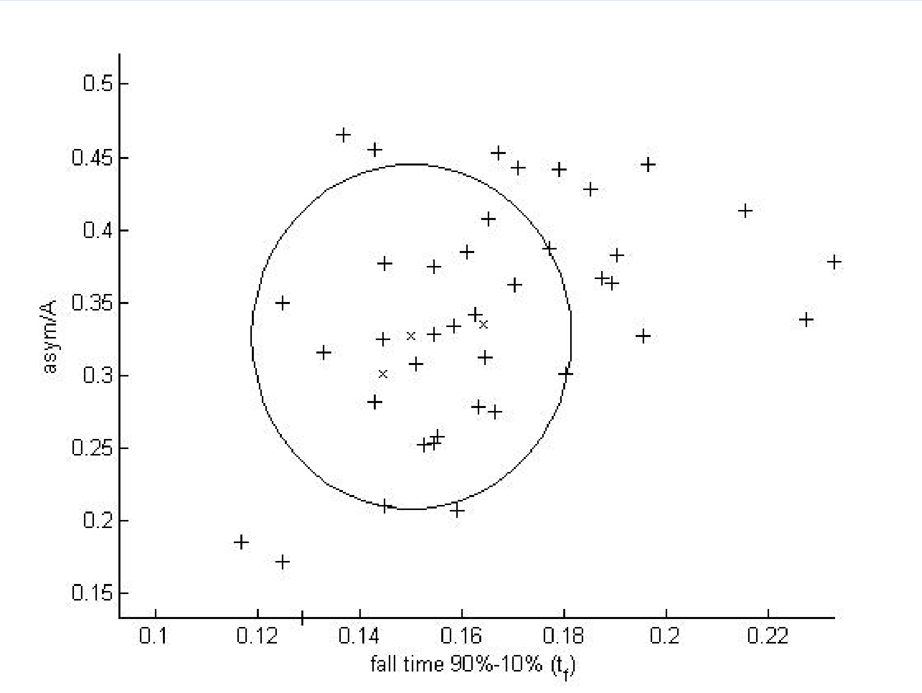
Results: Signal Interpretation

- Two signal features (fall time and symmetry factor)

Ongoing CAD



Scheduled patients



Statistical Aortic Profile Atlas

- Step 1: Construction of statistical atlas of aortic outflow profiles for normal cases
- Step 2: Comparison of a new patient case with the atlas in order to:
  - Perform atlas-based segmentation
  - Measure similarity of a patient to normal cases

Construction of Atlas

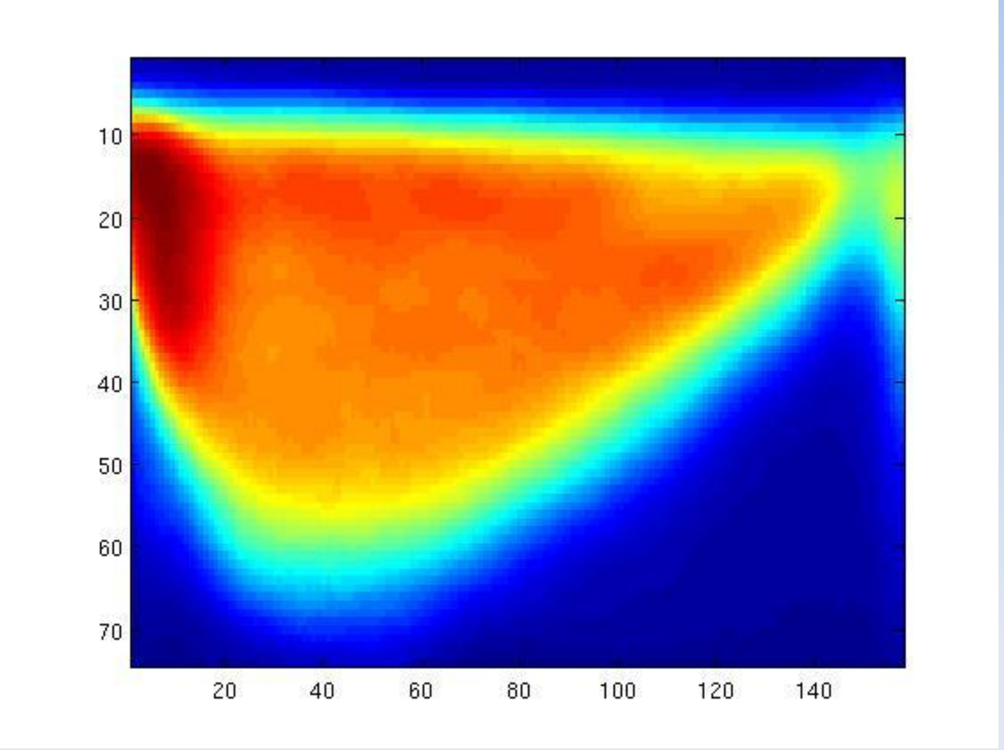
- Step 1: Select a population of normal cases
- Step 2: Choose a case which is “most average” in the sense of maximizing a criterion of geometrical similarity to all other normal cases
  - Geometrical similarity is measured by the amount of scaling required to match one aortic profile image to another
- Step 3: Register all images to the reference image
- Step 4: Calculate average of all registered images

Aortic Profile Image Registration

- Mutual information used as image similarity measure
- Genetic algorithm used for maximization of mutual information
- Scaling image transformation
  - Image divided into 10 vertical bands, which are scaled vertically
  - Transformation defined by 10 scaling factors, one for each vertical band

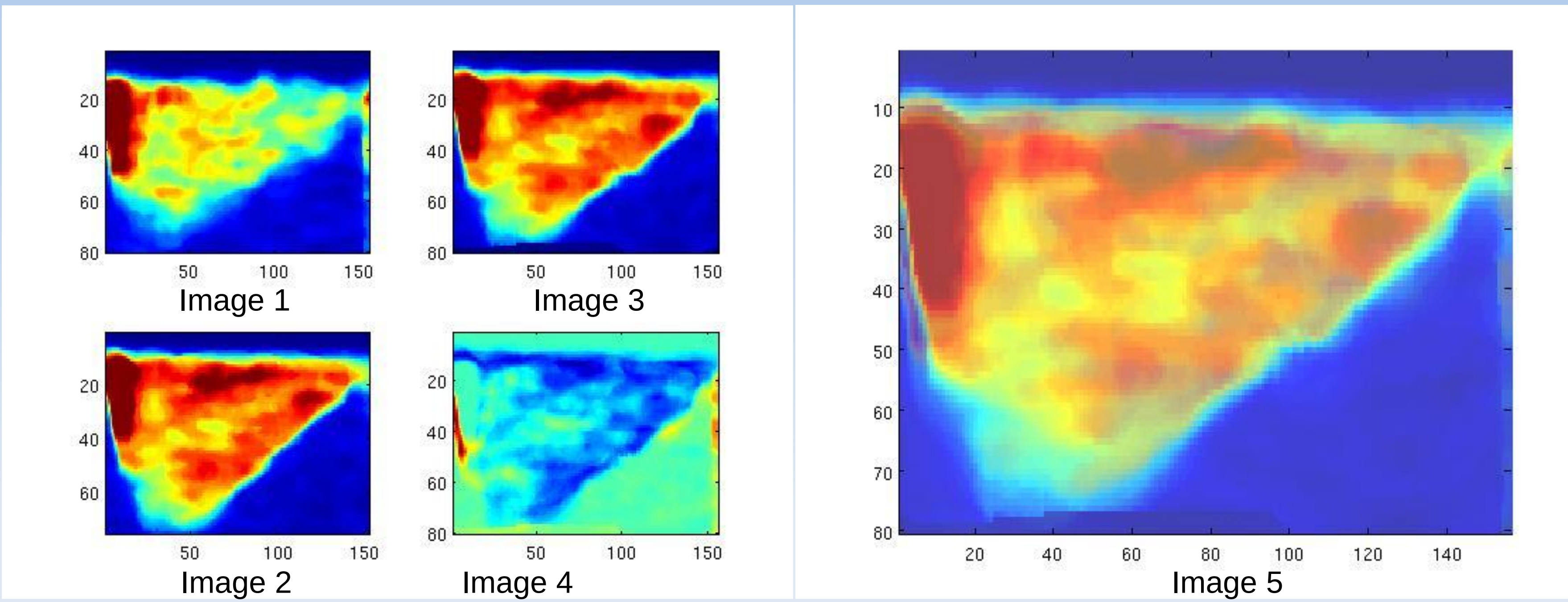
Statistical Aortic Profile Model

Grayscale



Pseudocolored

Results



Results

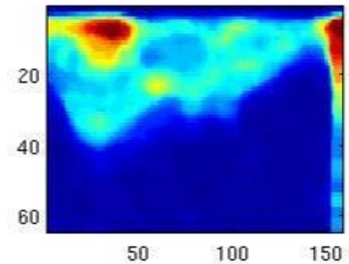


Image 1

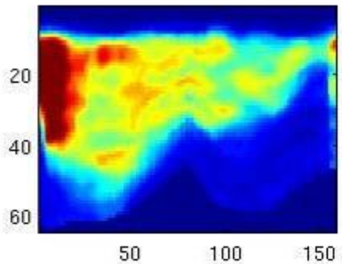


Image 3

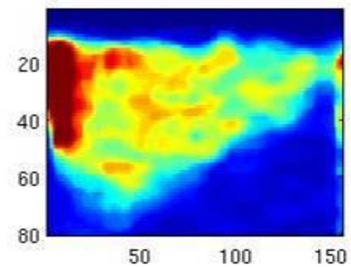


Image 2

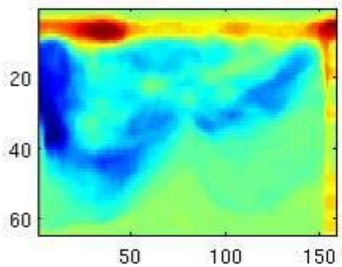


Image 4

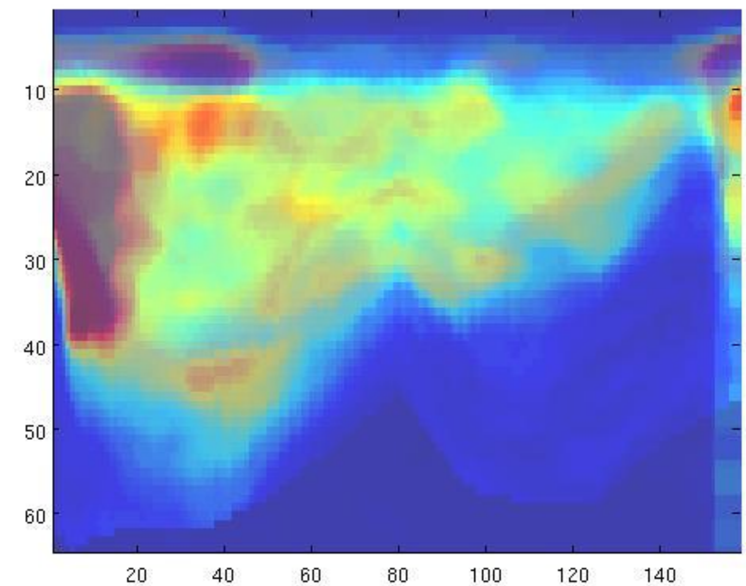


Image 5

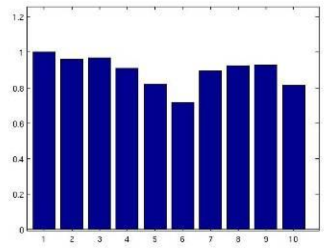


Image 6

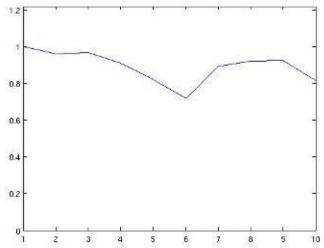


Image 7

Conclusion

- A method for quantification of Doppler traces has been developed
- Statistical analysis of results has identified a different profile in a subgroup of patients
- A method for construction of statistical atlas of aortic outflow images has been proposed