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BODY SURFACE MAPPING OF THE CARDIAC ACTIVITY

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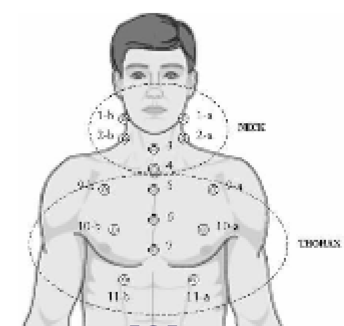
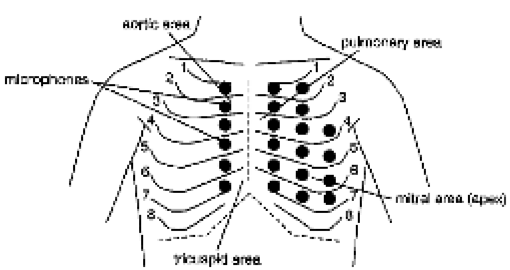
Background

- Chest surface Measurement shows potentials in diagnosing heart failure [1]
  - Heart valve sounds
  - Murmurs
  - SeismoCardioGraphy (SCG)

- Body Surface Mapping (BSM) of heart sound
  - Indicator for diagnosis of sleep aphnoea [2]
  - Origin of heart sounds and murmurs [3]



[2]



[3]

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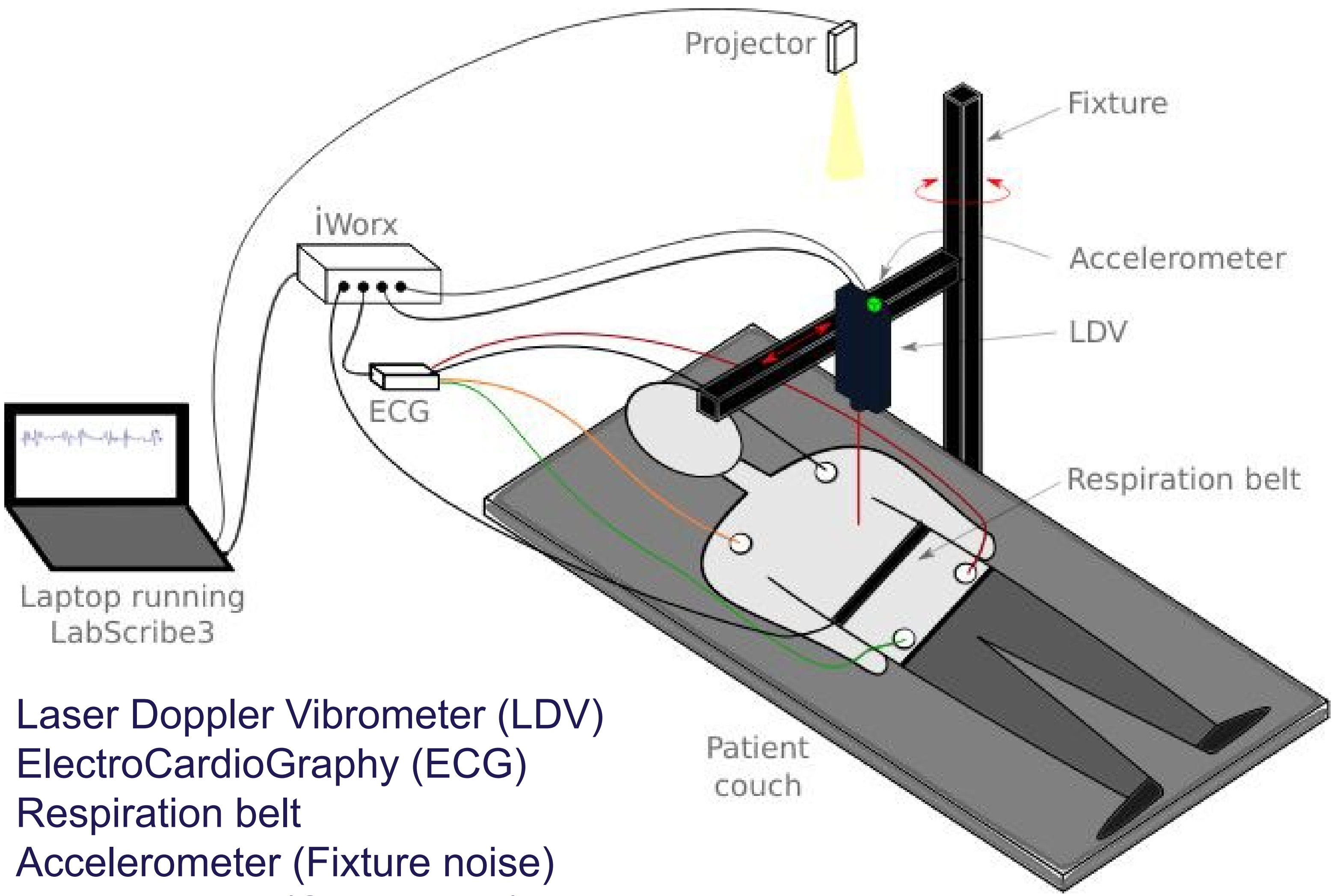
1. Hu Y, Kim EG, Cao G, Liu S, Wu Y. *"Physiological acoustic sensing based on accelerometers: A survey for mobile healthcare"*, Annals of Biomedical Engineering 2014
2. Rendón DB, Ojeda JLR, Foix LFC, Morillo DS, Fernández MA. *"Mapping the human body for vibration using an accelerometer",* IEEE EMBS 2007;23–26
3. Durand MCLG, Guardo R. *"Development of a cardiac acoustic mapping system"*, Med Biol Eng Comput 1998

Aim

- BSM of the mechanical cardiac activity
  - Low frequency (<0.25 Hz)
  - Mapping the displacement of the chest area
  - Finding identifiers between the cardiac events and the map

- Aim:
  - Evaluate BSM for exploration of the mechanical cardiac activities

Method – Experimental setup



- Laser Doppler Vibrometer (LDV)
- ElectroCardioGraphy (ECG)
- Respiration belt
- Accelerometer (Fixture noise)
- Projected grid (Considency)

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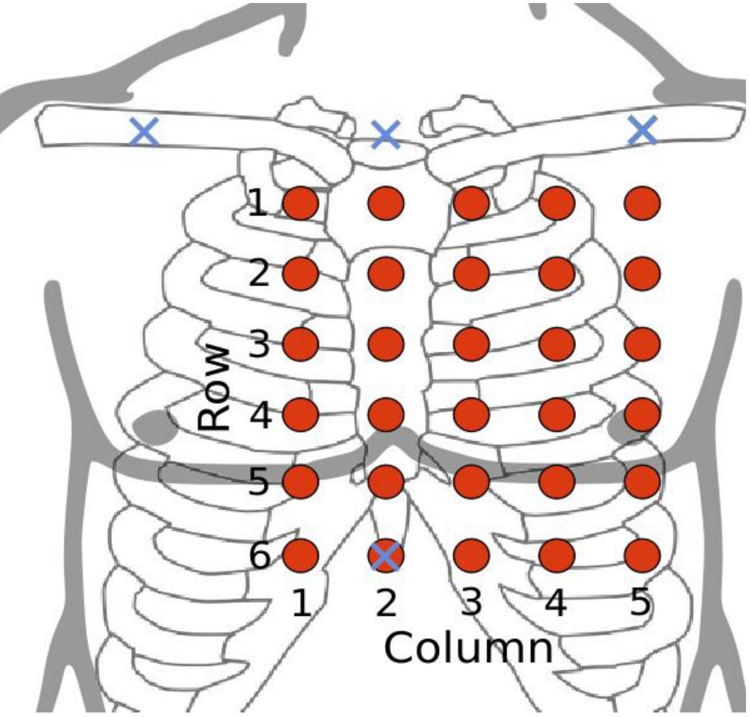
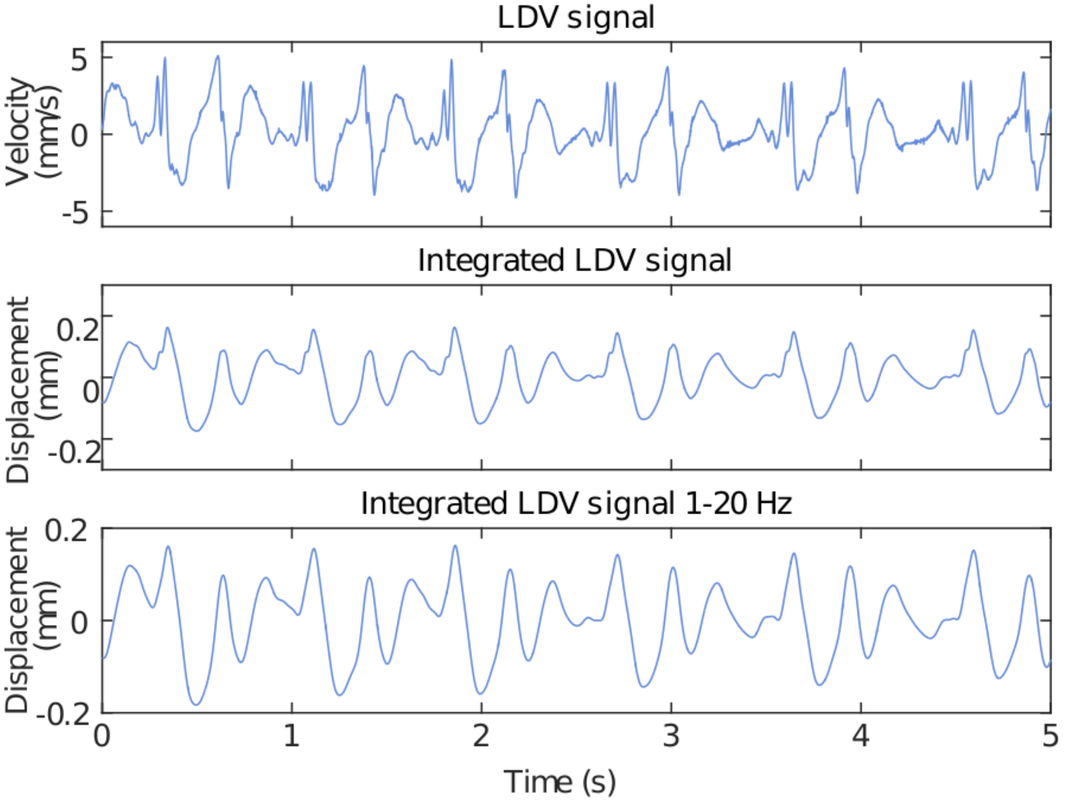
Signal sampling, filtering and transformation

- 5x6 spatial resolution
- 1-20 Hz filtering (low frequency)
- Velocity to displacement





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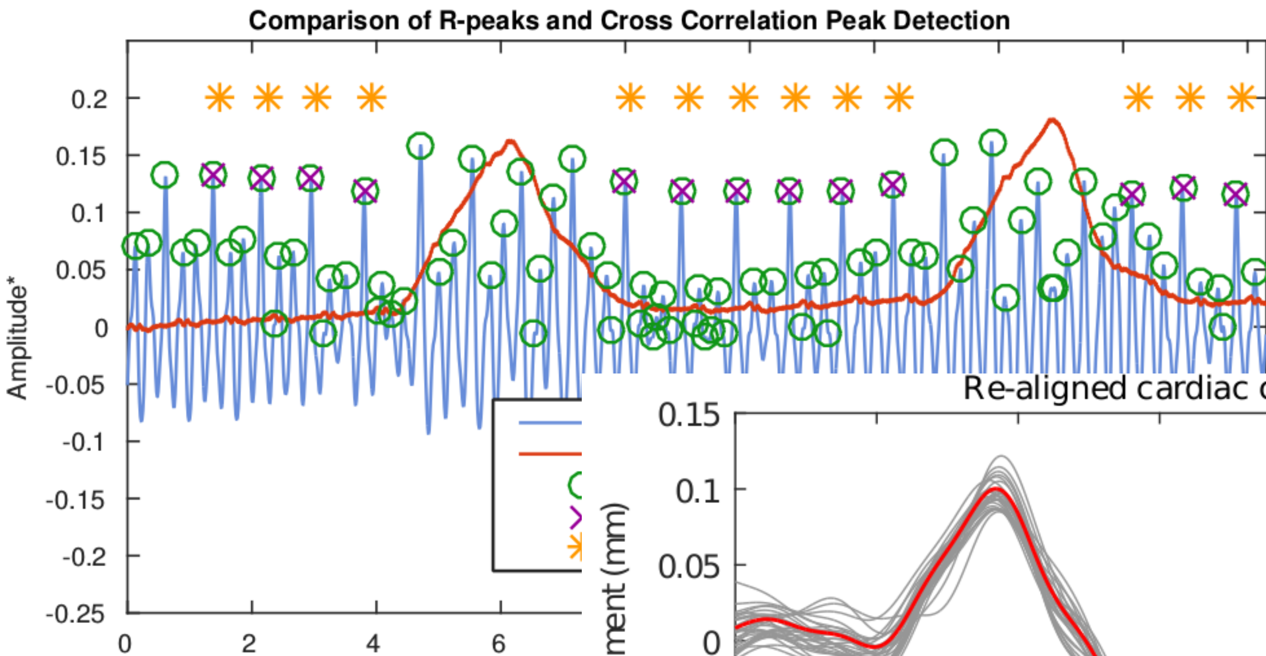
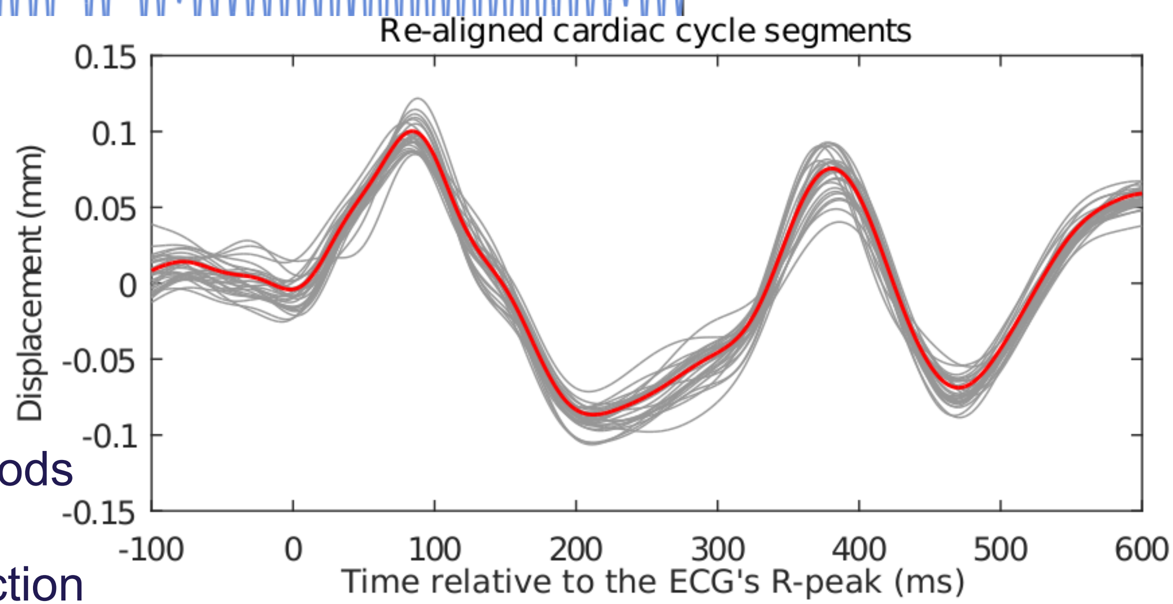
Segmentation and re-alignment by cross-correlation

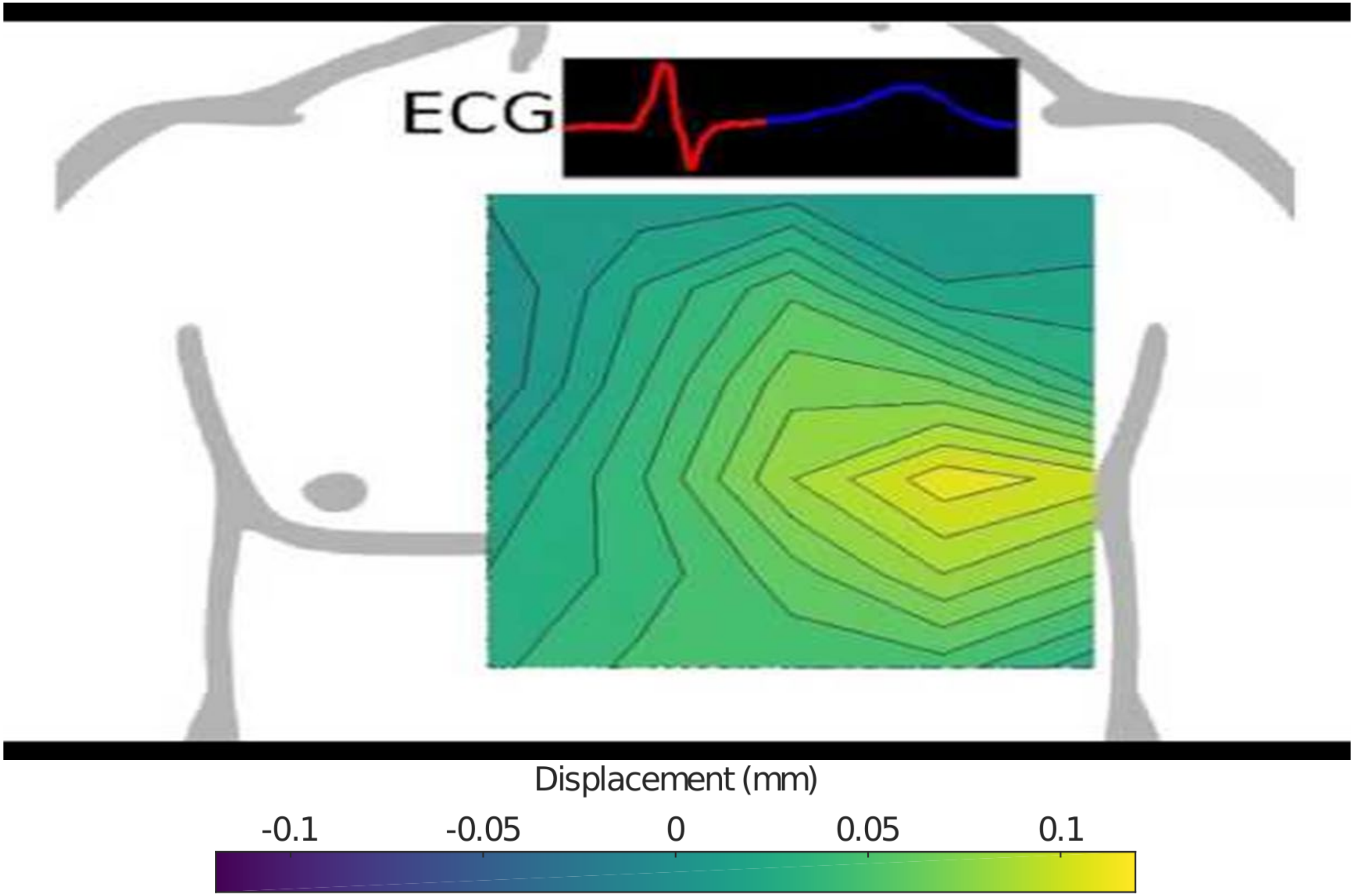




- R-peak detection
- Exclude respiration periods
- Mean segment
- Cross-correlation correction
- Re-aligned mean segment

https://www.youtube.com/watch?v=QAzsT6JHY9M

Results



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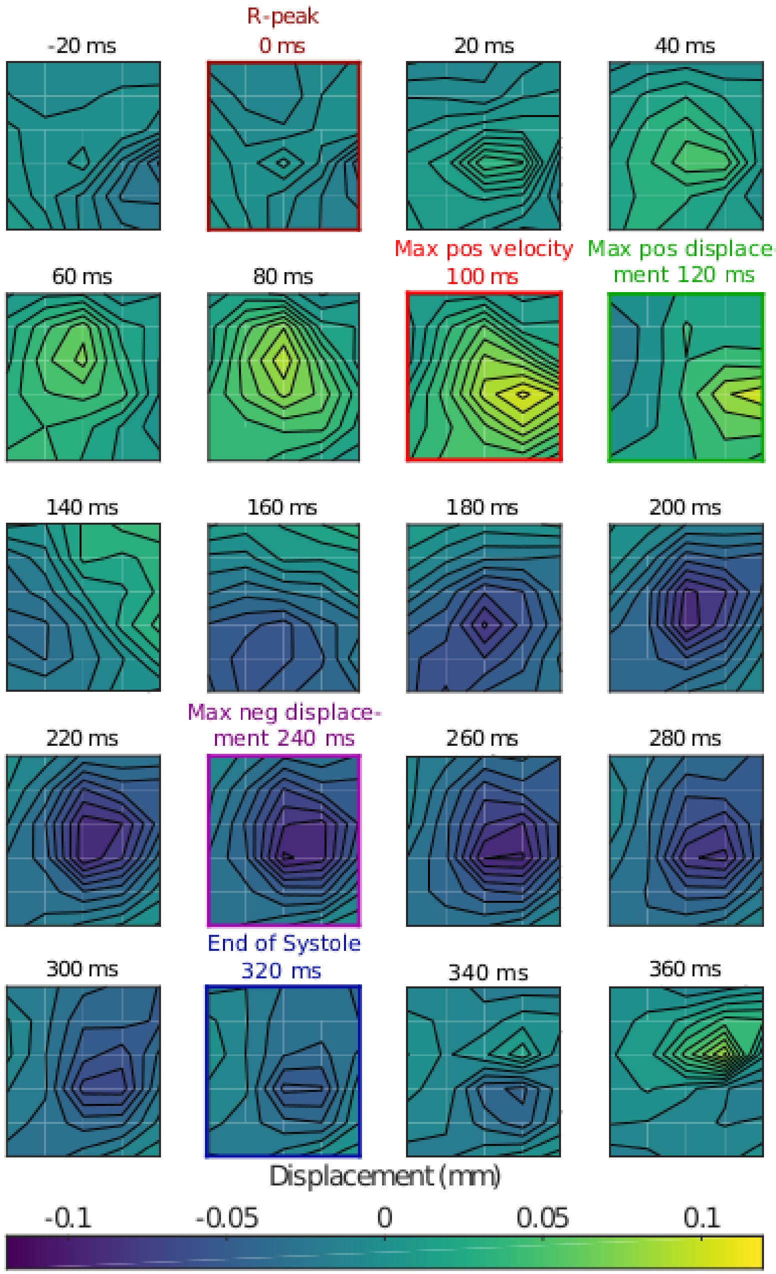
Results - quantifiable

- Identifiers across subjects
- Identifiers features
  - Latency (S1 heart sound)
  - Spatial position (X,Y)
  - Amplitude (Z)

Table 1: Feature values of identifiers as mean±std, where time is relative to the S1 heart sound and position is relative to the sternum and the lowest point of the grid.

Event	Time (ms)	Position (mm) Transverse	Position (mm) Longitudinal
Maximum positive velocity	50±40	-2.9±30	98±95
Maximum positive displacement	68±46	50±17	180±68
Maximum negative displacement	160±61	64±32	135±56



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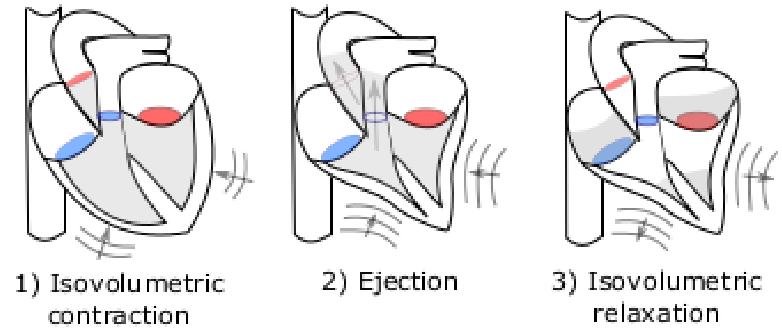
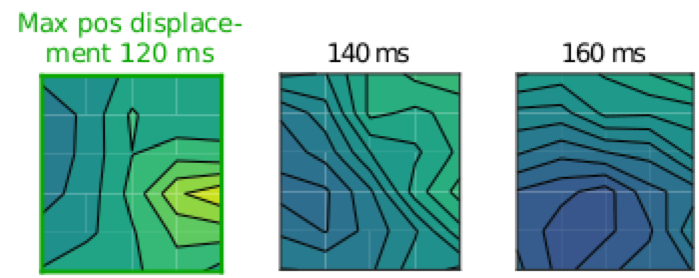
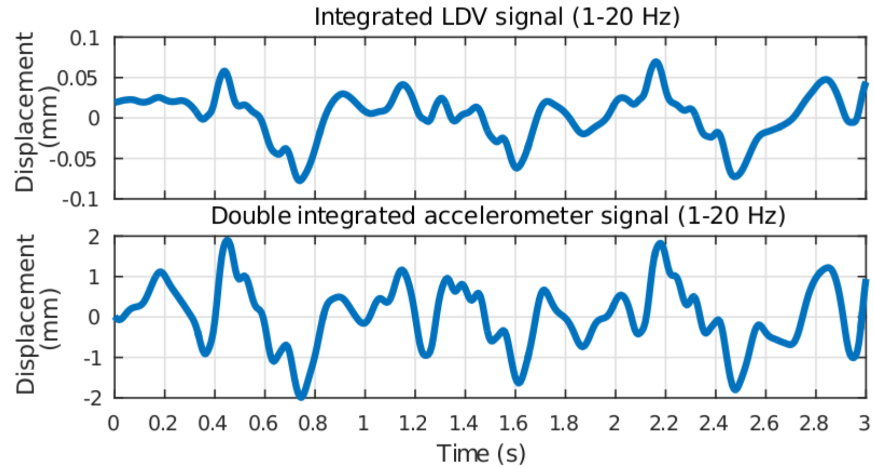
Discussion

- Relate identifiers to cardiac events
  - Maximum Positive Velocity
    - End of isovolumetric contraction [4]
    - Agrees with O'Rourke et al. [5]
  - Maximum Positive Displacement
    - End of rapid ejection [5]
  - Maximum Negative Displacement
    - Left ventricular retraction [5]
      - Well before S2 heart sound
  - Opposite displacements
    - Rotation [4,5]

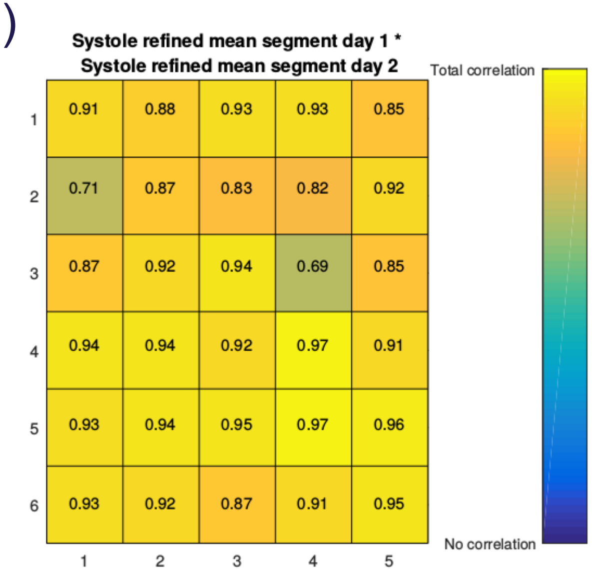




Further studies and conclusion



- Further studies
  - Better understanding of the LDV vs Accelerometer
    - Doppler Monte Carlo Model
  - Measuring grid points simultaneous
  - Substituting the LDV
  - Larger population
    - Diagnosed subjects
  - Cardiac event reference (ECHO, arterial pressure)
- Conclusion
  - Results was reproducible
  - Concordance with existing evidence
  - Further studies are needed



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References

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4. Luo X, Cao T, Li Z, Duan YA *"Preliminary study on the evaluation of relationship between left ventricular torsion and cardiac cycle phase by two-dimentional ultrasound speckle tracking imaging"* Int J Cadiovase Imaging, May 2009, 25(6): 559-568
5. O'Rourke R A, Shaver J A , Silverman M. E, *"Hurst's The Heart"*, The McGraw-Hill Companies, 2008: 215-293

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