Body surface mapping of the mechanical cardiac activity

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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 aphnnea [2]
  - Origin of heart sounds and murmurs [3]

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
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 (Consistency)
Signal sampling, filtering and transformation

- 5x6 spatial resolution
- 1-20 Hz filtering (low frequency)
- Velocity to displacement
Segmentation and re-alignment by cross-correlation

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

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

<table>
<thead>
<tr>
<th>Event</th>
<th>Time (ms)</th>
<th>Position (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum positive velocity</td>
<td>50±40</td>
<td>-2.9±30</td>
</tr>
<tr>
<td>Maximum positive displacement</td>
<td>68±46</td>
<td>50±17</td>
</tr>
<tr>
<td>Maximum negative displacement</td>
<td>160±61</td>
<td>64±32</td>
</tr>
</tbody>
</table>
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
References


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

