Multichannel Seismocardiography

A Novel Method for Investigating the Seismocardiogram

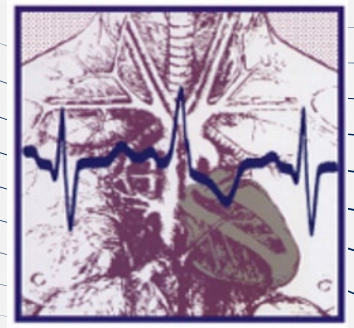
Munck, Kim; Schmidt, Samuel Emil; Sørensen, Kasper; Struijk, Johannes Jan

Publication date:
2018

Multichannel Seismocardiography: A Novel Method for Investigating the Seismocardiogram

by Kim Munck*, Samuel Emil Schmidt, Kasper Sørensen, Johannes Struijk

at Computing in Cardiology 2018



SIEMENS | Fonden

AALBORG UNIVERSITY
DENMARK

Seismocardiography

Measuring of vibrations

- Single site measurement
- Different equipment for measuring vibrations

SCG is a composition of

- Heart sounds
- Flow of blood
- Movement of heart

Evidence

- Cardiac event and SCG annotations
- Cardiac factors and SCG features

What happens in between

Cardiac → SCG

- Wave propagation
- Reflection, distortion, artefacts
- Seismology

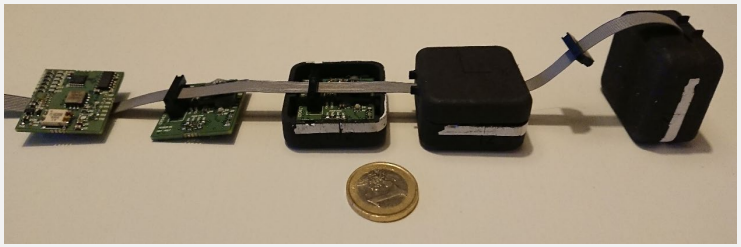
Multichannel seismocardiography

- Wave characteristics
  - Frequency
  - Wavelength
  - Group / Phase velocity
  - Epicenter
  - Direction
  - Magnitude
  - 3 axis pattern

Wave acquisition

16 channel 3-axis SCG

- ADXL355, from Analog Devices
  - 25 µg/√Hz noise
  - Sampling frequency (ODR) up to 1 kHz
  - Synchronized precision ±1.5% of ODR
  - Precision 3.9 µg/LSB
  - Medium cost (35 USD)

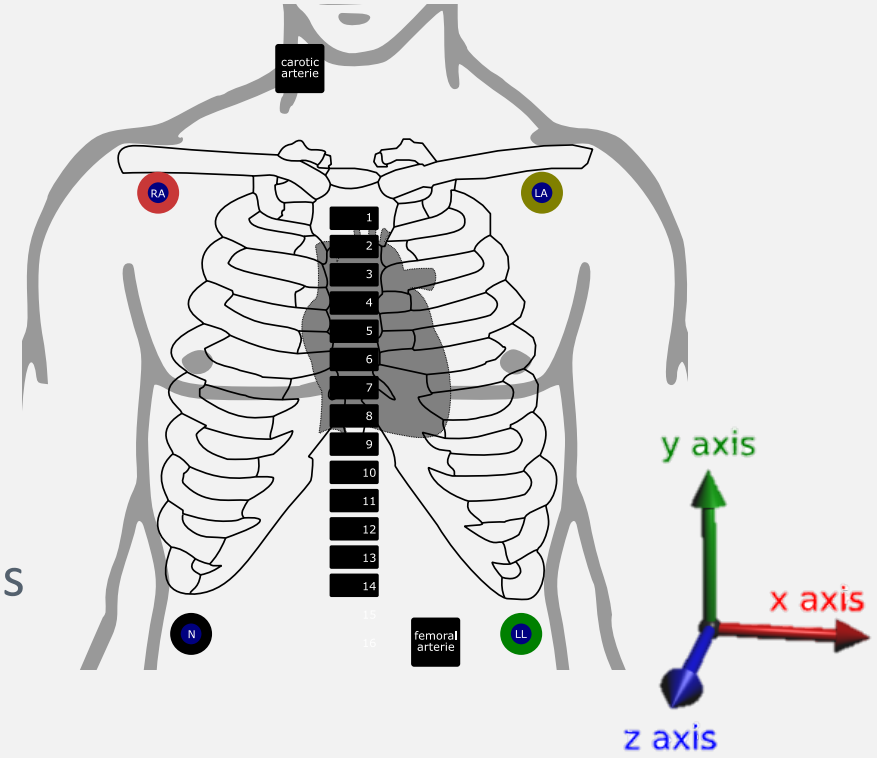


Sensor dimensions

- Spatial filtering at
  - Y axis = 62 mm
  - X axis = 36 mm
  - Z axis directionality dependent

Wavelength

- Sensor formation and modalities
- Spatial sampling at 30 mm
  - Some wavelength aliasing



The experiment

4 Subjects pilot study

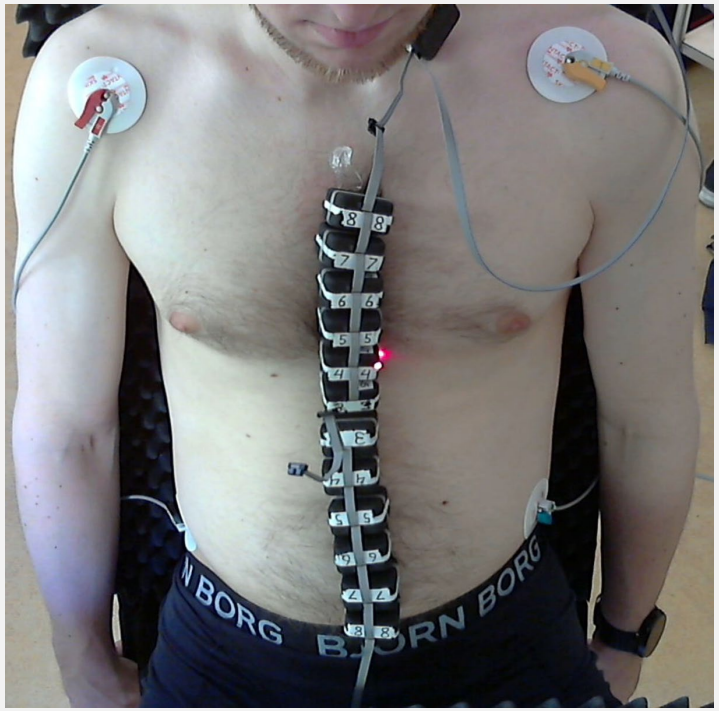
- Age 29-42 (males)
- Transversal wave
- Pavel Shirkovkiy (CinC 2017)
- Moving downwards

Modalities

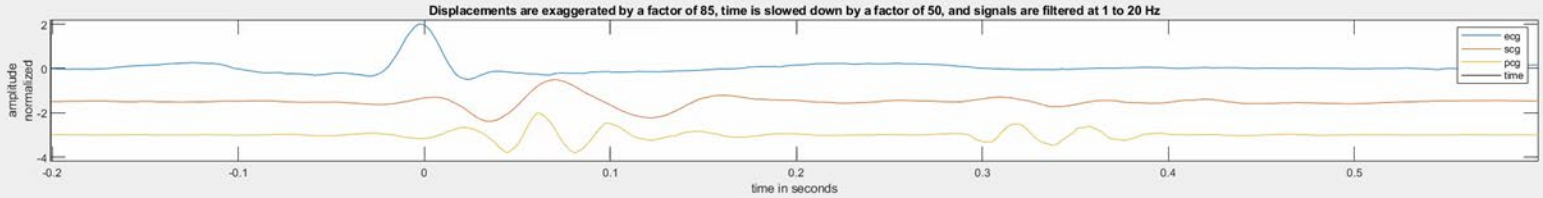
- Include ECG for segmentation
- Breath held for 26 seconds

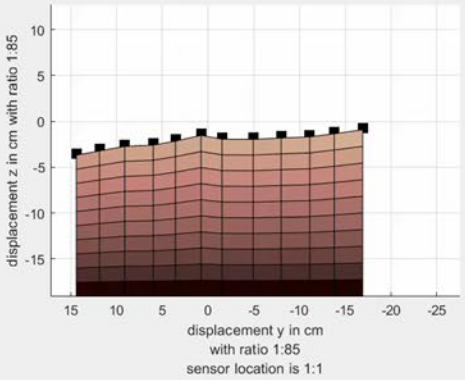
Signal processing

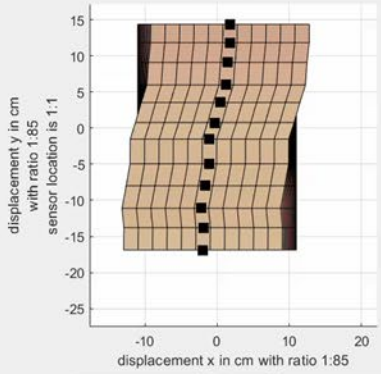
- Segmented mean beats
- Acceleration to displacement

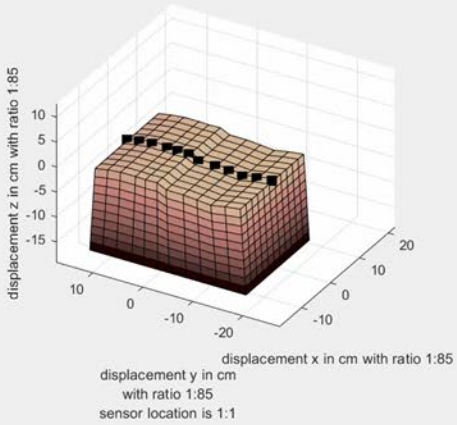


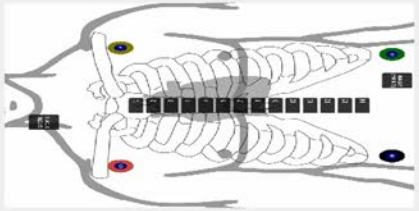
Case result

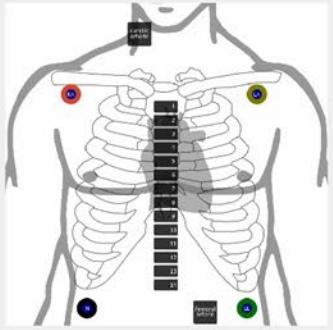

Displacements are exaggerated by a factor of 85, time is slowed down by a factor of 50, and signals are filtered at 1 to 20 Hz
amplitude normalized
time in seconds
ecg
scg
pcg
time

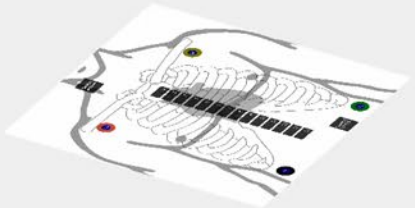

displacement z in cm with ratio 1:85
displacement y in cm
with ratio 1:85
sensor location is 1:1


displacement y in cm
with ratio 1:85
sensor location is 1:1
displacement x in cm with ratio 1:85


displacement z in cm with ratio 1:85
displacement x in cm with ratio 1:85
displacement y in cm
with ratio 1:85
sensor location is 1:1







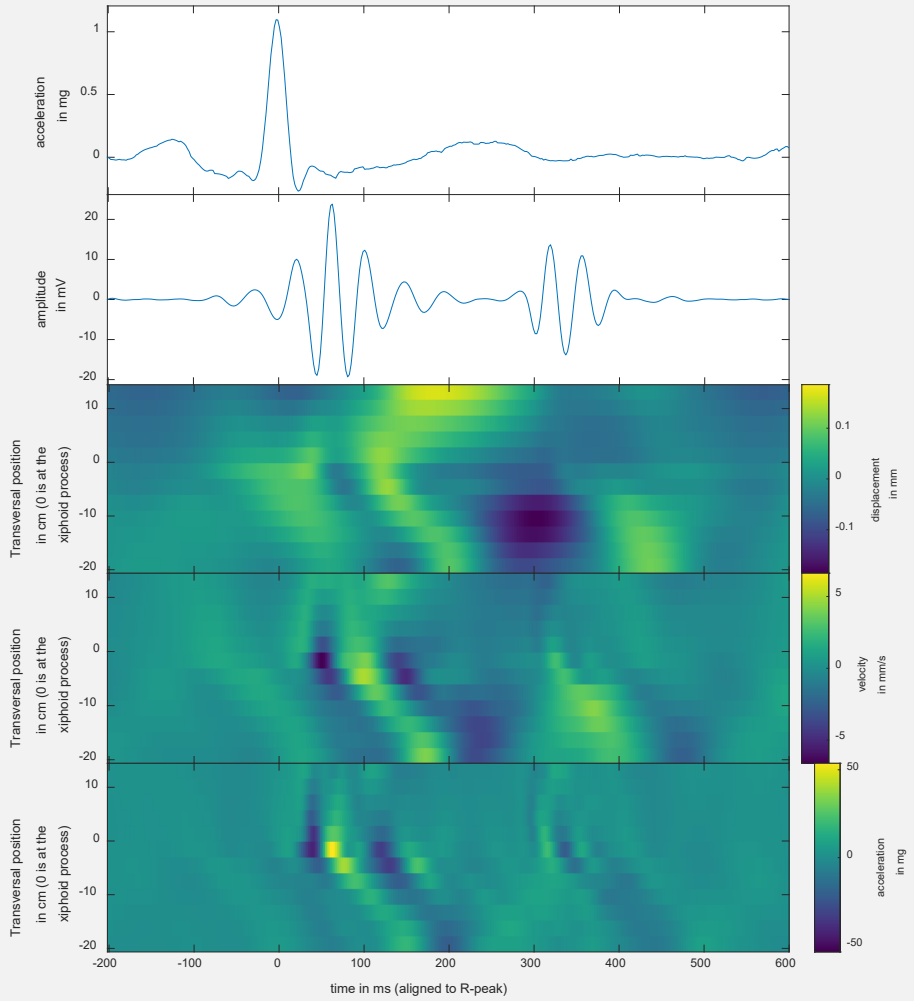
Backup if video fails

Signals

- ECG
- SCG sound (20-120 Hz)
- Displacement
- Velocity
- Acceleration

The wave of interrest

- Downwards wave



Wave hypothesis

Wave characteristics (n=4)

- Frequency: 1 to 20 Hz
- Wavelength: 20 to 30 cm
- Phase velocity: 1 to 2.4 m/s
- Timing: Aorta open
- Epicenter: xiphoid process
- Direction of wave: up and down
- Wave pattern

Blood flow

- Aorta
  - Direction
  - Pulse wave velocity: 10 to 16 m/s

Table 2: Carotid-femoral PWV for each age group in the examined population.

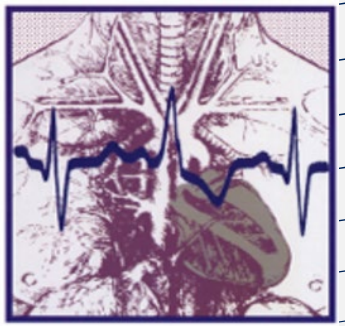
Age group (years)	n	Mean PWV (m/s)	SD	95% CI Lower-upper limit	Range
10–19	156	5.04	0.72	4.92–5.15	3.12–7.33
20–29	110	5.86	0.92	5.68–6.03	3.92–8.14
30–39	109	6.32	0.82	6.16–6.47	4.08–8.26
40–49	108	6.85	0.91	6.68–7.03	5.0–9.84
50–59	164	8.15	1.17	7.97–8.33	5.46–12.5
60–69	103	8.47	1.09	8.25–8.68	6.46–11.2
>70	30	9.01	2.00	8.27–9.76	5.52–13.4
Total	780	6.84	1.65	6.73–6.96	3.12–13.4

PWV: pulse wave velocity, CI: confidence intervals.

Alejandro Díaz, Cintia Galli, Matías Tringler, Agustín Ramírez, and Edmundo Ignacio Cabrera Fischer, 2014, *"Reference Values of Pulse Wave Velocity in Healthy People from an Urban and Rural Argentinean Population",* International Journal of Hypertension

Concluding remarks

- Quantified chest and abdominal surface movement related to cardiac activity
- Identified downwards moving pulse wave
- Characterized wave parameters in spatial domain
- Indication of a lower velocity of the surface wave compared to pulse wave velocity



SIEMENS Fonden

Thank you for your attention

Kim Munck*, Samuel Emil Schmidt,
Kasper Sørensen, Johannes Struijk

kkj@hst.aau.dk

Department of Health, Science and Technology
at Aalborg University, Denmark

AALBORG UNIVERSITY
DENMARK