MEASURING CAROTID-FEMORAL PULSE-WAVE VELOCITY WITH REAL-TIME LASER-DOPPLER VIBROMETRY

Simeon Beeckman [1], Yanlu Li [2], Soren Aasmul [3], Nilesh Madhu [4], Smriti Badhwar [5], Rosa Maria Bruno [5], Pierre Boutouyrie [5], Patrick Segers [1]

BioMMeda / IBiTech – UGent [1], Photonics Research Group, UGent-imec [2], Medtronic Bakken Research Center [3], IDlab, Ghent University - imec [4], INSERM U970, Université de Paris [5]

Project rationale

- Screening for cardiovascular disease crucial in modern society
- Current state-of-the-art (e.g. ultrasound, arterial tonometry):
  - Expensive
  - Requires expertise
  - Located at dedicated medical facilities
- CARDIS device: cheaper and user-friendly alternative for quick measurements at the GP level
- Assess carotid-femoral pulse-wave velocity (cf-PWV), among others

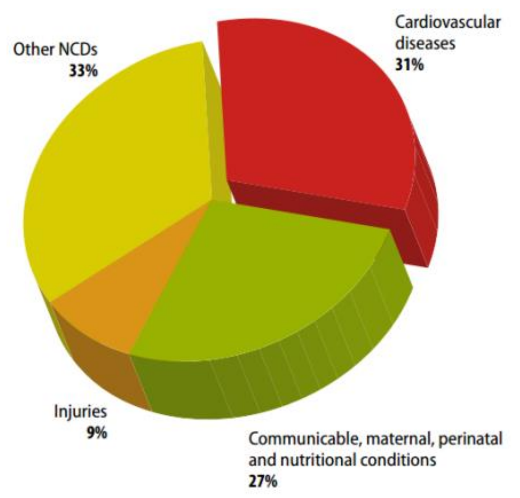
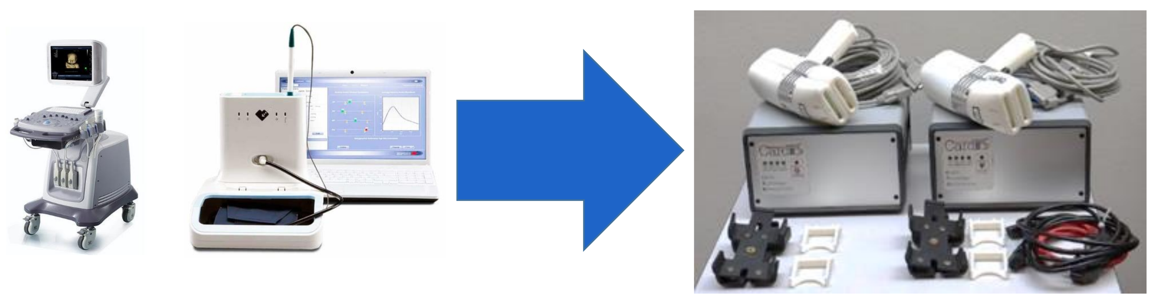
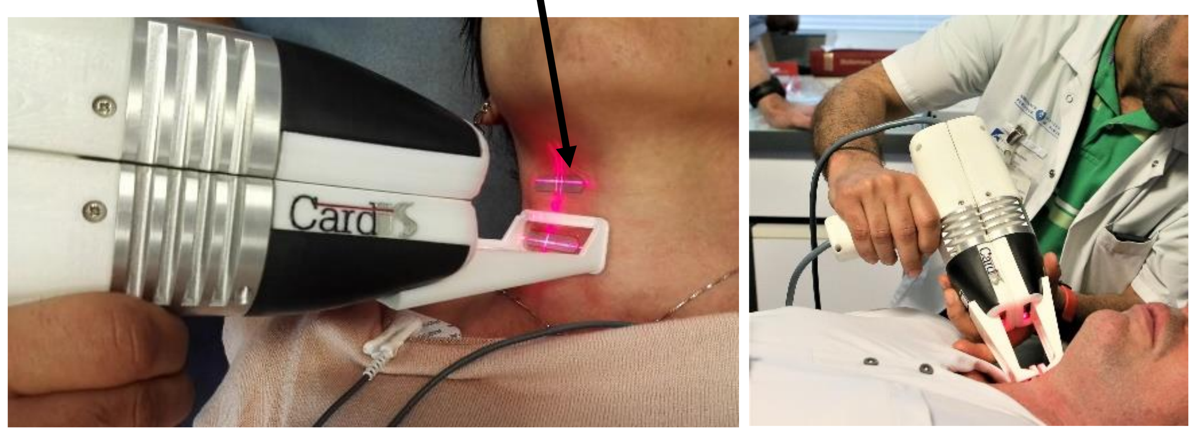


Figure 1: Cardiovascular disease: The biggest killer in the world, responsible for 30% of deaths (WHO, 2011)



Prototype specifications

- Device uses laser-doppler vibrometry
  - Measure skin vibrations above large arteries e.g. carotid & femoral arteries
- 2 Separate handpieces
- Array of 6 laserbeams on each handpiece
- Retroreflective patch applied to skin to aid laser reflection
  - Need for patch to be eliminated soon!



- Measure carotid & femoral skin displacement simultaneously
- Differentiate twice for acceleration
  - Remove signal drift
  - Point of max. acceleration as timepoint of arrival pulse wave
- Real-time signal-quality feedback implemented along with new GUI, algorithms[1]

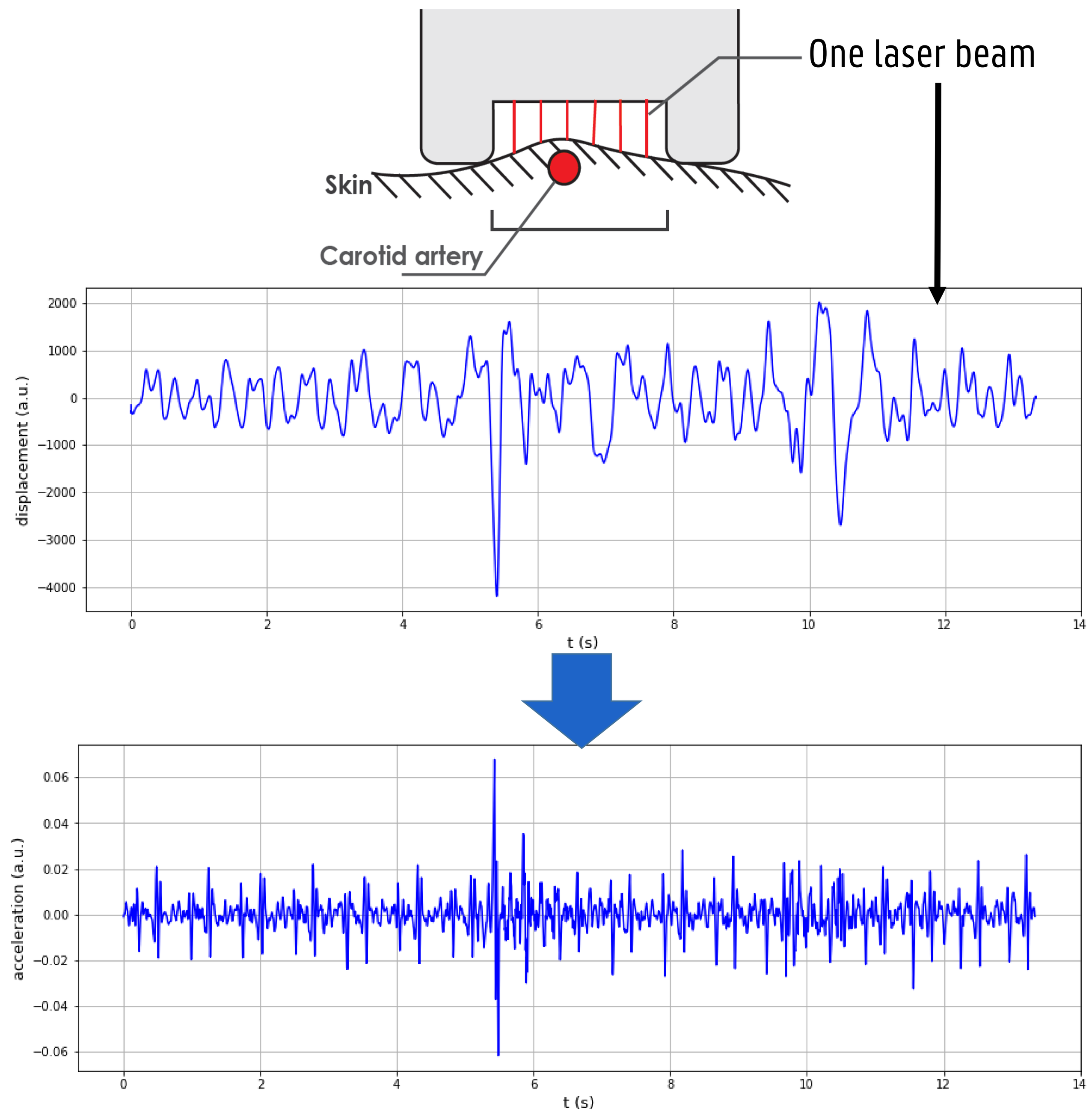


Figure 2: Example of one laser beam resulting in one skin-displacement time series. Differentiating twice yields acceleration.

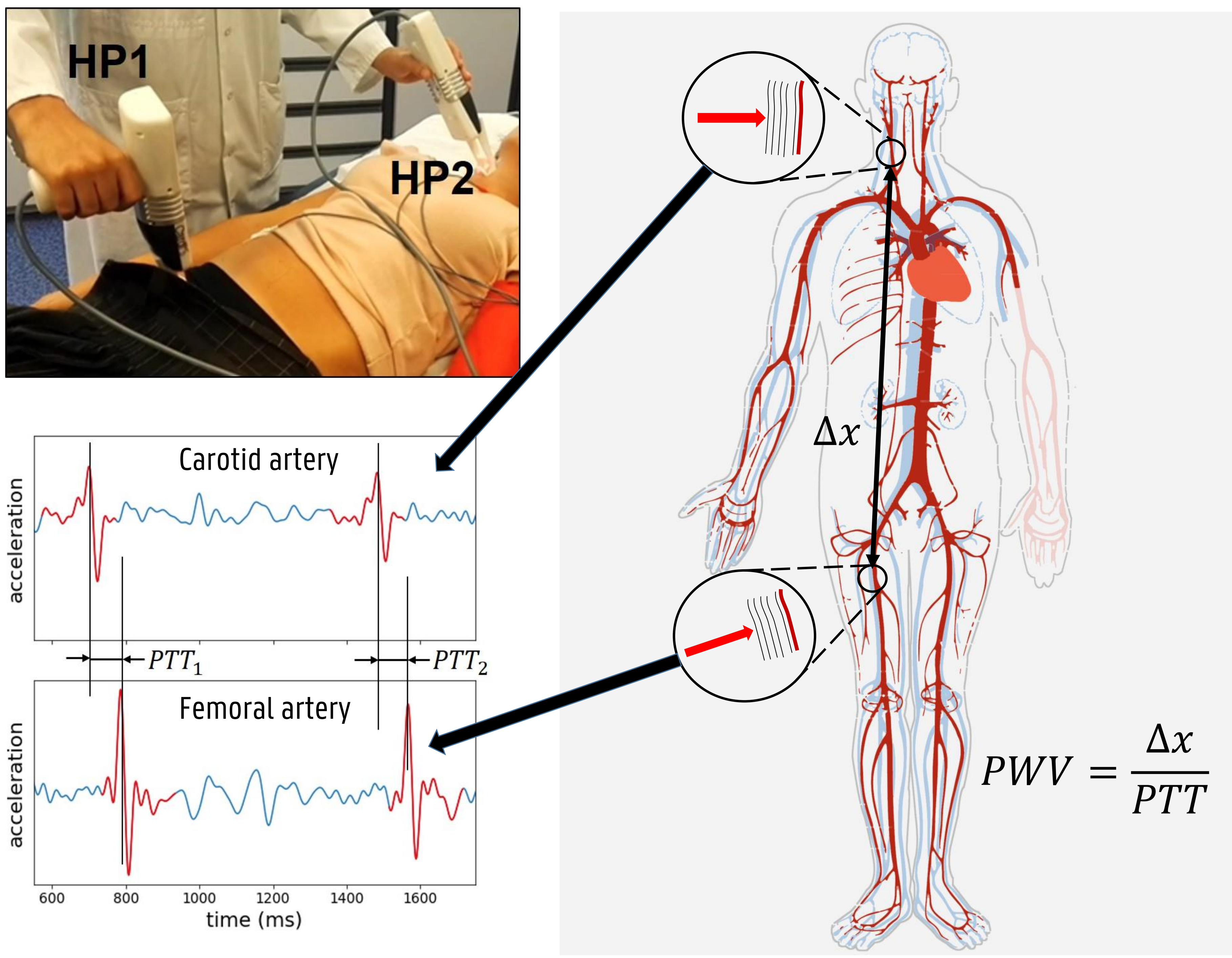


Figure 3: cf-PWV estimation principle. Foot-of-the wave timepoint identified as point of max. acceleration in the LDV time series. Time delay between carotid & femoral waveforms as PTT estimate.

Methods

- Ongoing clinical feasibility study by INSERM at HEGP in Paris
- 22 Of planned 100 subjects analyzed in this work
- Three carotid-femoral measurements each
- Visually score channels per measurement (1 – 5)
- Identify measurements with good quality signals (score 4 & 5)
- Get pulse-transit times (PTT)
- Compare with gold standard = Sphygmocor system

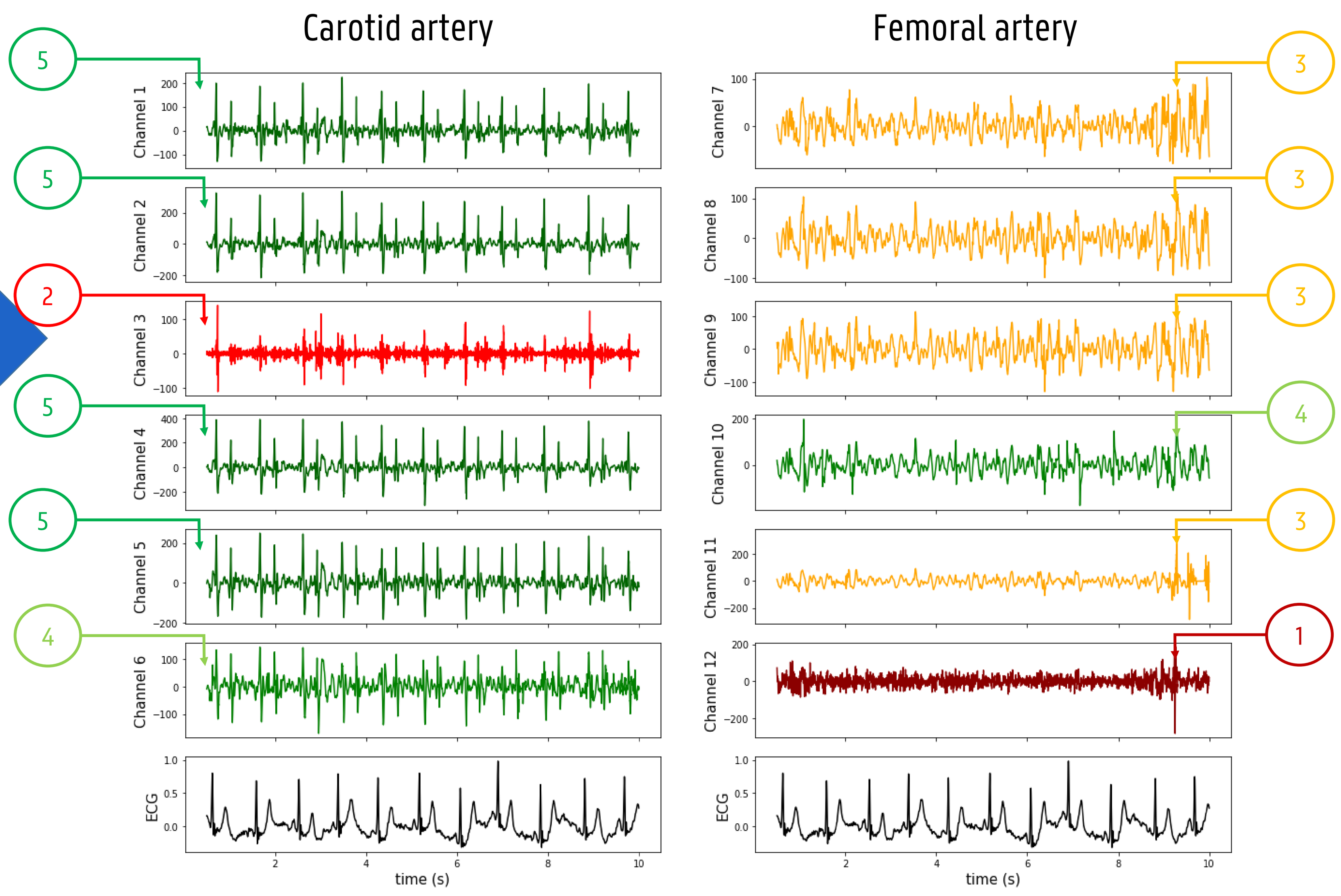


Figure 4: Example dataset generated by 1 carotid-femoral measurement. Each time series is visually scored on a 5-pointer scale. ECG is displayed for reference.

Results

14 out of 22 subjects: good quality signals at both carotid & femoral sites (4 & 5)

Figure 5A:
- correlation coefficient of 0.91 (P<0.05)
- High agreeance for good quality signals

Figure 5B:
- The mean difference in transit times between LDV and Sphygmocor was -1.14 (± 6.83) ms
- Confidence interval broad because of outliers

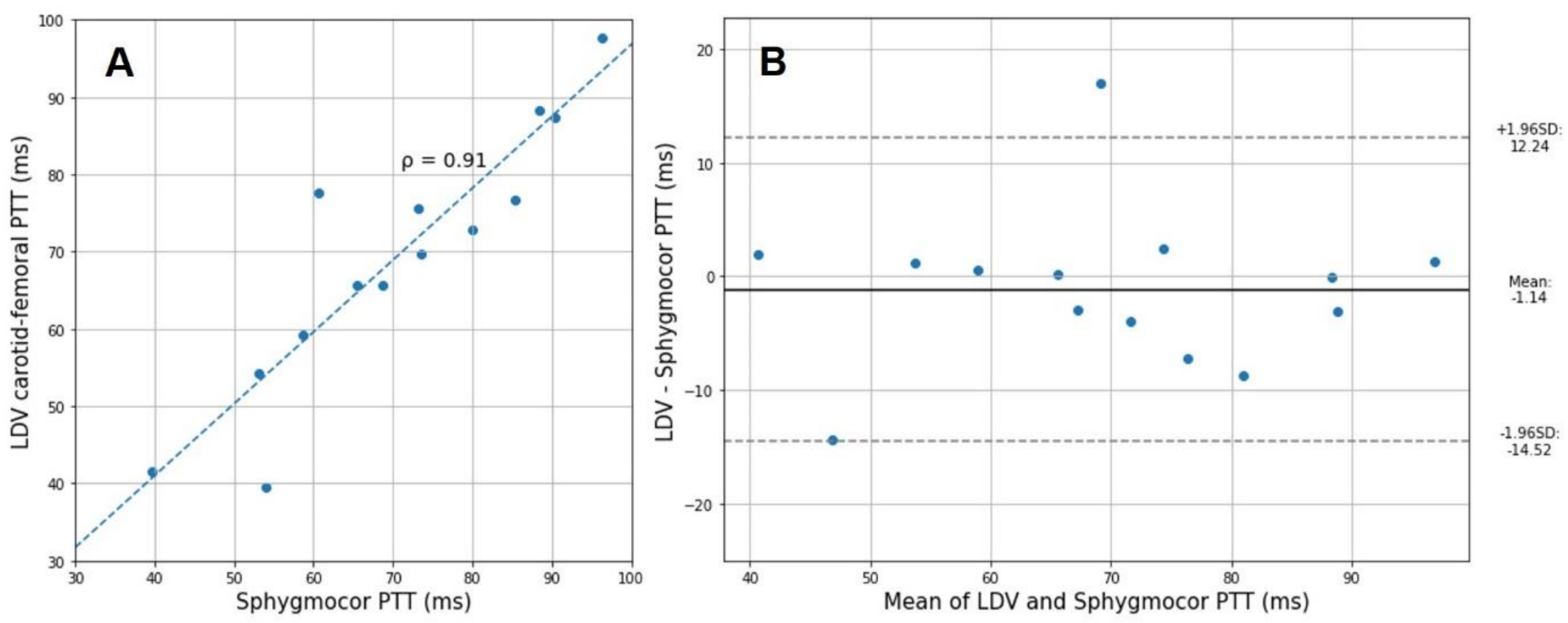
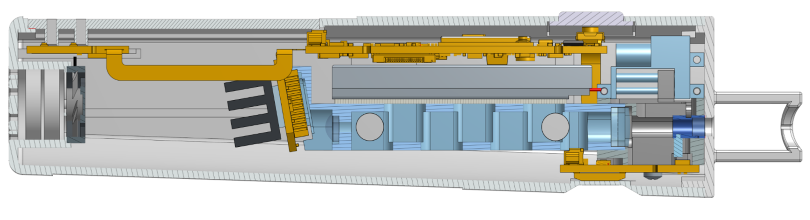


Figure 5: A) scatter plot showing correlation between LDV & Sphygmocor PTT estimates. B) Bland-Altman plot of LDV - Sphygmocor PTT values vs the means between the two methods.

Conclusions & future work

- LDV measurements feasible for cf-PTT
- Need to ensure good quality measurements!
- Little to no bias in LDV cf-PTT estimates

- New InSiDe-prototype underway → no more retroreflective patches
- Signal quality indicators onboard
- Light & wearable pieces



[1]Seoni et al. Front. Physiol., 11 January 2022

GHENT UNIVERSITY
BioMMedA INSTITUTE OF BIOMEDICAL ENGINEERING & TECHNOLOGY
InSiDe
Horizon 2020 Programme under Grant Agreement No. 871547

Contact
- Simeon.beeckman@ugent.be
- www.ugent.be/ea/ibitech/en/research/biommeda
- www.inside-h2020.eu

IEEE EMBC 2023