

Hemodynamics by Interferometric Photonics

M. Nemati ^a, N. Bhattacharya ^a, P. Urbach ^a, R. Wijshoff ^b, M. Mischi ^b, R. Aarts ^{b,c}, M. Stijnen ^d, L. Paroni ^d
^a Delft University of Technology, ^b Eindhoven University of Technology, ^c Philips Research, ^d LifeTec Group

{m.nemati, n.bhattacharya, h.p.urbach}@tudelft.nl, {r.w.c.g.r.wijshoff, r.m.aarts}@tue.nl, {m.stijnen}@lifetecgroup.com

Laser Speckle imaging in noisy scenarios

Experimental setup in-vitro and in-vivo

In case of systematic and random motion induced artifact

Illumination:

VCSEL at 850nm with optical output power of 0.5mW

Sample:

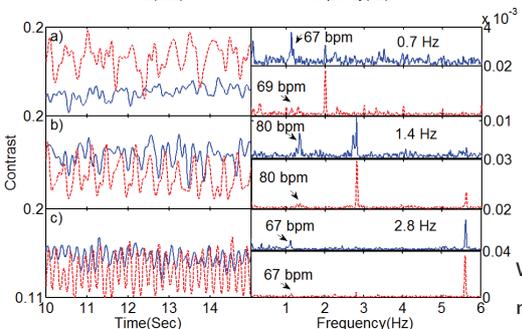
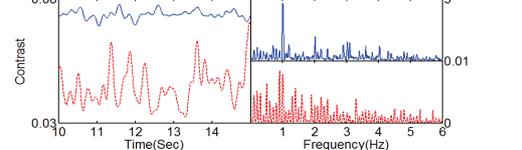
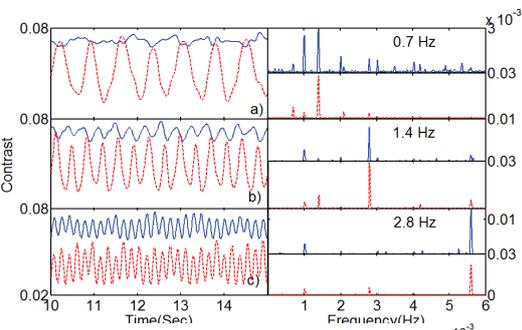
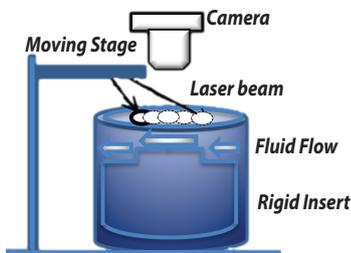
Flow cell with Delrin as top membrane

Detection:

Photron Fastcam SA3

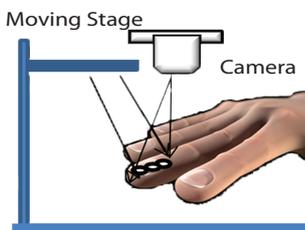
A heart rate has been simulated using a roller pump.

The motion induced artifacts have been generated using the shaker to move the illuminating laser at three different frequencies (0.7, 1.4 and 2.8 Hz) with two amplitudes (0.5 and 2mm). Also a more general case has been studied using a band limited white noise signal (0.1 and 10Hz)



In-vitro: A generated pulse of 1Hz with amplitude/stroke of 6.7ml and base flow of 40ml/min.

In-vivo: A volunteer wore a commercial pulse oximeter on thumb to verify the measurements.



With full camera resolution (1024px) measurement time of 45 sec exposure time of 20ms

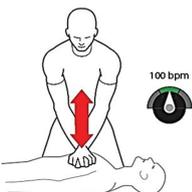
We observe that the pulsation signal is clearly detectable for a range of motion amplitudes and oscillation frequencies but for higher amplitudes and oscillation frequencies of motion the signal due to pulsation becomes more difficult to detect.

Photoplethysmography during cardiopulmonary resuscitation

±1,000,000 cardiac arrests per year world wide, survival is low (10% - 40%)

Interruptions to chest compressions adversely affect CPR outcome

Cardiopulmonary Resuscitation (CPR)



Pulse check by palpation can be unreliable and time-consuming

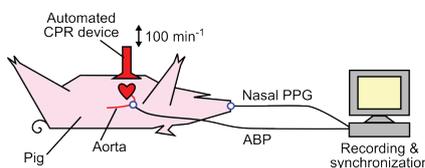


Investigated potential of photoplethysmography (PPG) to detect pulse

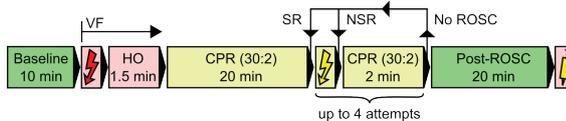


Methods

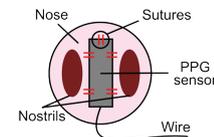
Setup



Protocol



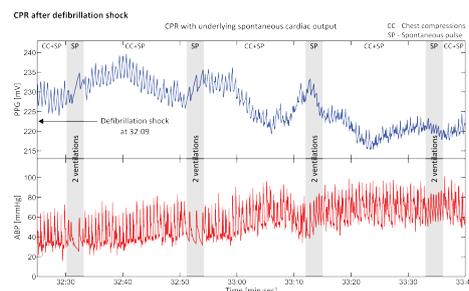
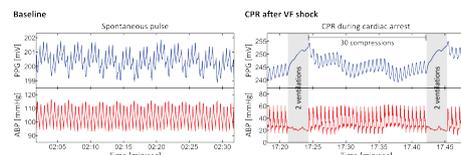
Sensor attachment



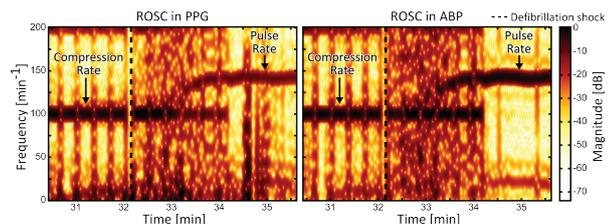
- ⚡ VF shock
- ⚡ Defibrillation shock
- ABP: arterial blood pressure
- CPR: cardiopulmonary resuscitation
- HO: hands-off
- PPG: photoplethysmography
- ROSC: return of spontaneous circulation
- (NSR): (non-)shockable rhythm
- VF: ventricular fibrillation

Results

Observation of spontaneous pulse during ventilation pauses



Observation of spontaneous pulse during chest compressions



PPG can potentially detect spontaneous pulse during CPR
 Detecting absence of pulse can potentially prevent unnecessary interruptions

Detecting presence of pulse can guide administration of vasopressors