Control Method for Continuous Non-Invasive Arterial Pressure Monitoring using the Non-Pulsatile Component of the PPG Signal

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Introduction: Photoplethysmograph (PPG) contact pressure has a noticeable effect on blood pressure (BP) tracking, pulse wave analysis and pulse propagation measurements. BP changes alter the difference between intra-arterial and contact pressure, called transmural pressure. We propose a new technique enabling continuous control of transmural pressure using the non-pulsatile (DC) component in the PPG signal as feedback.

Methods: An instrument with combined pressure and PPG sensors is used to apply pressure and measure blood flow from the fingertip. An initial BP calibration is performed using an arm cuff device. An increasing pressure ramp is induced to obtain a bell shaped oscillometric waveform envelope from the pressure sensor signal. External pressure is lowered until it reaches a level corresponding to mean arterial pressure (MAP). At this point, transmural pressure equals zero. The DC component of the PPG signal at a beat-to-beat level is marked as a setpoint for the feedback loop. The DC level varies inversely to intra-arterial pressure, which along with adjusting the contact pressure is used to compensate for variations in BP. As the DC level shifts from the setpoint, the applied pressure is adjusted in order to maintain zero transmural pressure. The pressure reading from the sensor then equals intra-arterial pressure.

Results: The technology was verified by comparing: (i) measured pressure variation induced by hydrostatic changes with theoretical values, (ii) pulse morphology with and without feedback control during hydrostatic changes, and (iii) continuous MAP readings measured with the reference device (CNSystems CNAP 500) and our device.

Discussion: The proposed technology performed well compared to traditional volume clamp technique while requiring significantly less complex control logic and no fast-switching pneumatics. The technology could be used for continuous BP monitoring or improving the accuracy of PPG based pulse wave analysis (PWA) and pulse transit time (PTT) devices.

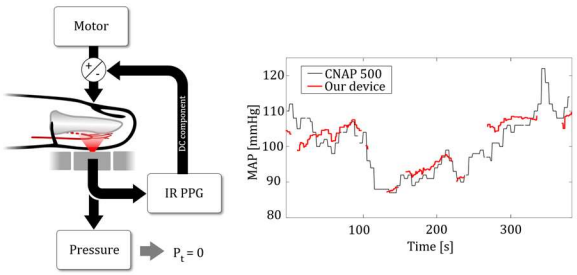

Figure 1. The proposed control principle.