Multi-Channel Blood Oxygenation Measurements for Newborn Care


Within infant and newborn care, blood oxygenation is a fundamental parameter to be monitored. The limitations of currently available blood oxygenation measuring devices motivated the development of an innovative approach based on multiple channel measurements.

Measuring the level of oxygen in the blood is of foremost importance especially in the care of infants and newborns. Indeed, blood oxygenation enables the detection of improper functioning of the respiratory system and of congenital heart malformations.

Infant and newborn blood oxygenation probes are commonly based on transmittance photoplethysmography at the wrist or at the foot. Light is transmitted from one extremity to the other of the wrist or the foot and its absorption is measured. Nevertheless, the obtained measurements lack reliability. This is mainly due to the peripheral vasoconstriction typical of infants and newborns and to the fact that the wrist and the foot are severely affected by artifacts caused by movements. In addition, movement artifacts cause repetitive false alarm in intensive care units.

When choosing a different site for the measurement of blood oxygenation, one has to cope with heterogeneous and low perfusion as well as with tissue configurations that do not allow measurements by light transmittance. Consequently, standard measuring probes and estimation algorithms cannot be applied.

Within the European Space Agency (ESA) project “PIPOx” a blood oxygenation measurement technique based on multi-channel reflectance photoplethysmography has been investigated, developed, and tested. Figure 1 depicts a prototype sensor based on reflectance photoplethysmography.

Multi-channel measurements of reflected light absorption have several key advantages. First of all, a measurement technique based on the absorption of the light that has been reflected by the tissue theoretically enables the positioning of the probe anywhere on the body. Secondly, the use of multiple light receivers gathers spatial measurements by collecting measurements on a whole surface rather than in a spot, thus overcoming problems related to heterogeneous perfusion.

In order to process the multi channel measurements and provide reliable blood oxygenation estimation, an innovative algorithmic concept has been developed\(^1\). Such an algorithm provides high noise robustness as the result of the inclusion of the most promising state of the art methods of pulse oximetry together with techniques of advanced multichannel signal processing. More precisely, the algorithm a) intelligently takes advantage of multiple photoplethysmographic signals recorded at the sternum by selecting the most reliable ones and b) provides a noise robust blood oxygenation estimation using a frequency based approach. In addition, the probe integrates an accelerometer and the related signals are used by the algorithm to remove movement artefacts.

A first research prototype of the multi-channel probe has been tested on adult volunteers undergoing induced hypoxia. Targeted measuring locations have been the sternum, the head, the lower abdomen, the biceps, and the quadriceps. Best results have been obtained at the head and the sternum. Figure 2 presents a typical blood oxygenation measurement (in red, the result of the multi-channel sensor at the sternum, in blue, the result of the reference sensor at the fingertip).

Interviewed paediatricians and newborn care specialists outlined the great clinical interest of a multi-channel probe based on reflectance photoplethysmography for blood oxygenation measurements on infants and newborns. Industrial collaborations are currently being explored for the development of a final miniaturized prototype that is better fit for measurements on an infant or newborn body. A validation campaign on infant and newborn in a paediatric intensive care unit is also foreseen.

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