

Contactless Neonatal ECG & Respiration

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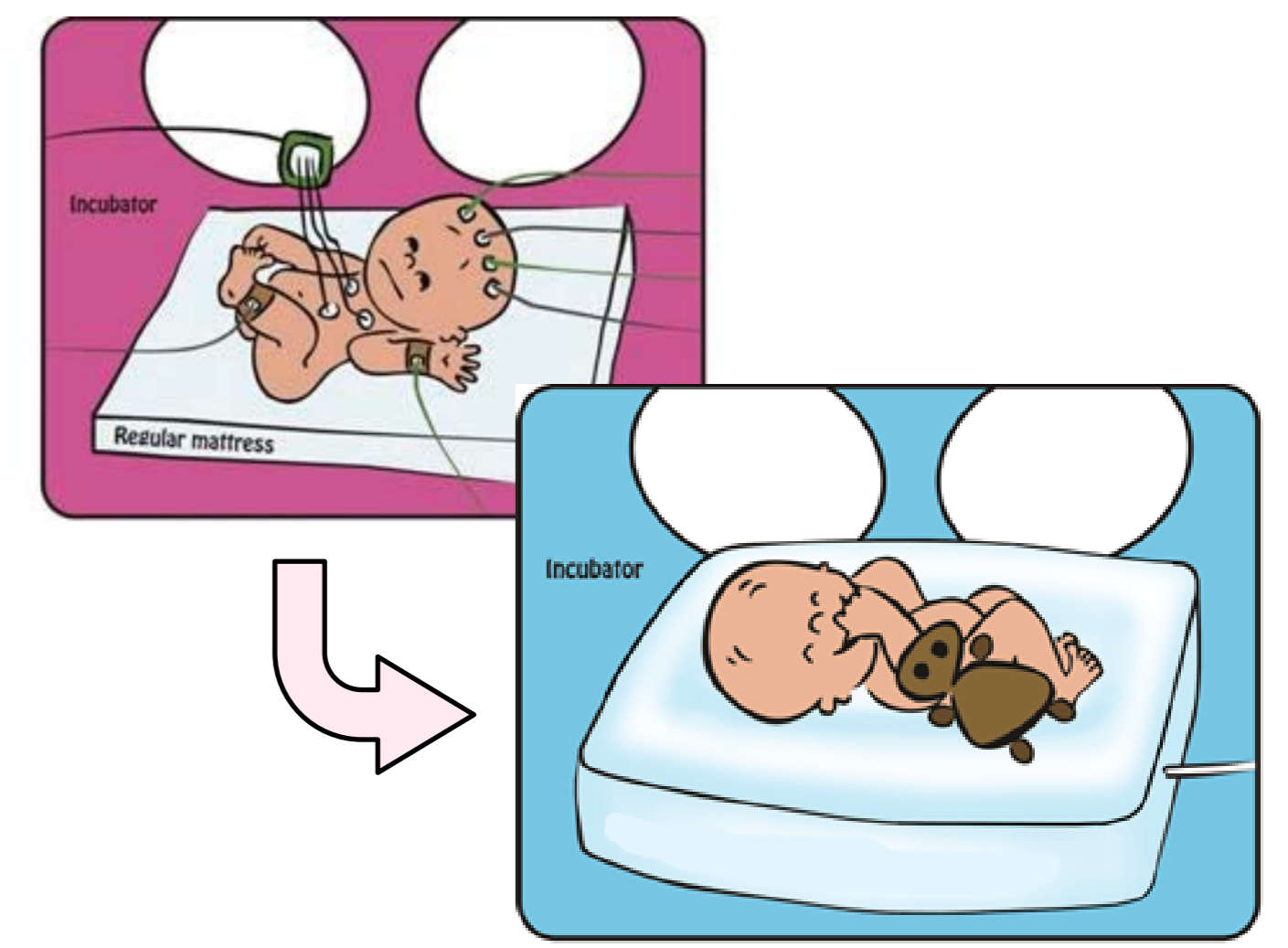
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Contactless Neonatal ECG & Respiration

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Motivation

Capacitive sensors can record an ECG and respiratory signal through clothing, which is a more comfortable alternative to the adhesive electrodes for the fragile neonates in the ICU and their parents.

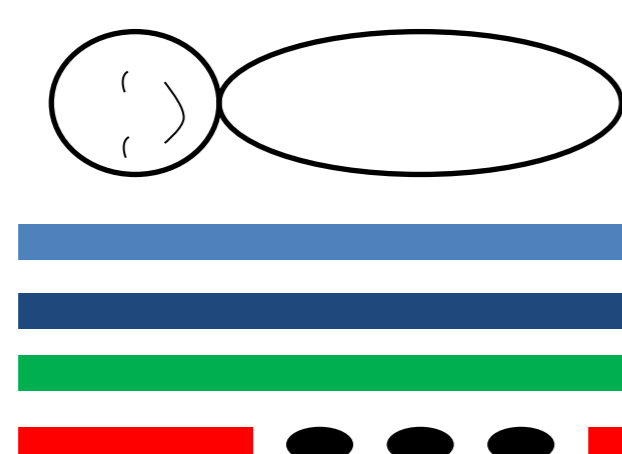


Technology

A textile ground electrode and an array of 8 capacitive sensors are integrated in the incubator mattress to measure the electrocardiogram (ECG). An imperceptible current ($1\mu\text{V}$, 1kHz) is injected through the body and used to observe the coupling strength of the sensors over time.



Layers between the skin and sensor array:



Clothing
Bed sheet(s)
Waterproof mat cover
Sensors

Signal processing

ECG: The best channels are selected based on the injection current and weighted according to their position on the mattress surface and added to obtain the vectorcardiogram (VCG). Specific projections of the VCG can provide the 3 Einthoven leads or be used for improved R-peak detection and heart rate (HR) computation.

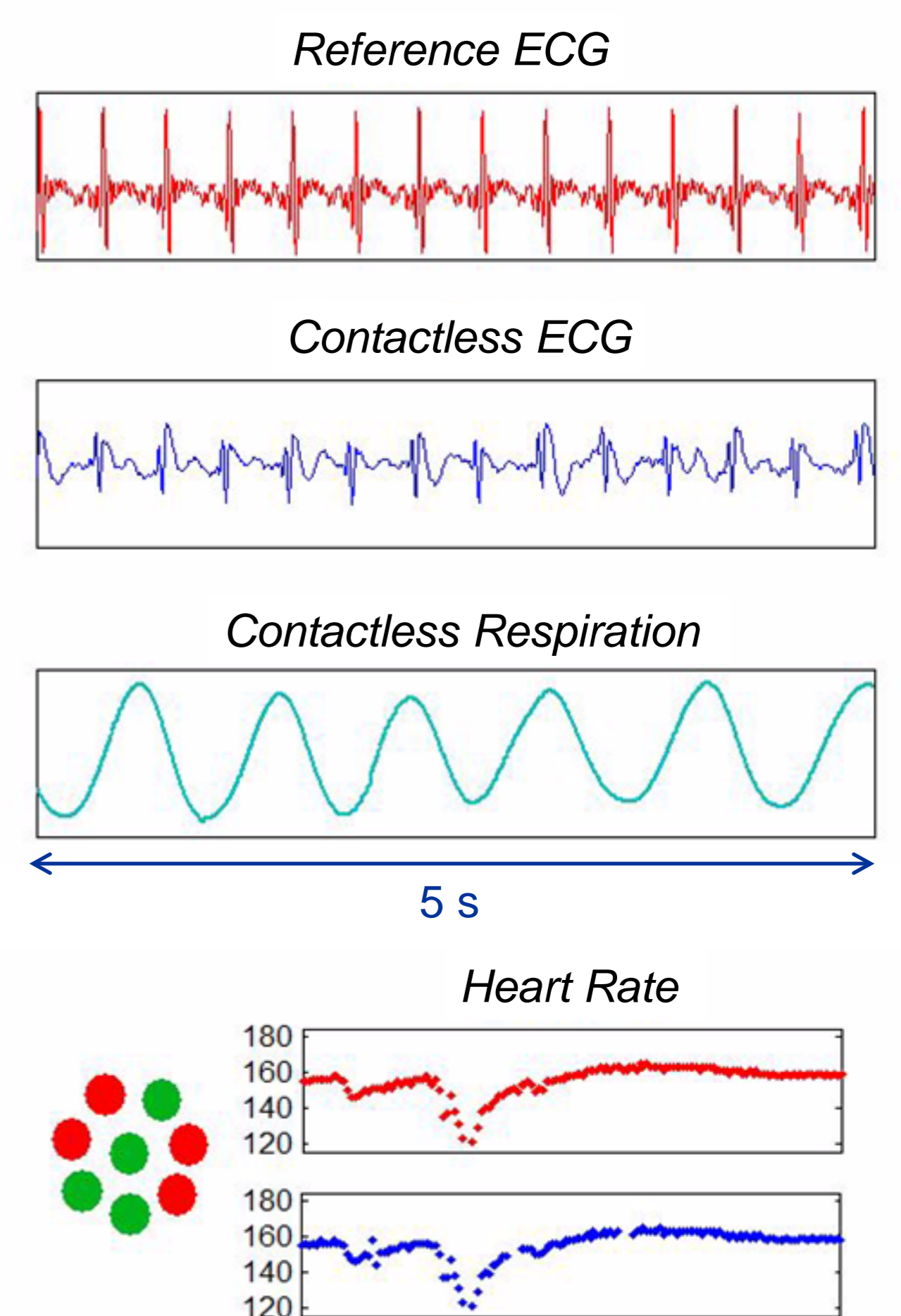
Respiration: The amplitude variations of the measured injection current correspond to the distance changes between the body and sensor surface, i.e. it correlates with the respiratory movements.

Data collection

15 neonates from the intensive and medium care units of the Máxima Medical Center; 68 hours of recordings.

Results

When the baby is lying prone or supine, the 3 Einthoven leads can be obtained. A HR exactly matching the reference HR was obtained for 7% (worst case) to 86% (best case) of the total time of each baby recording. Bad results occur when the baby is not covering at least two sensors of the array (e.g. lying on his side) or when there are too many bed sheets [1].



Discussion

Results are highly dependent on the measurement condition: body position on the mattress, number and type of layers between the skin and sensor array, motion severity, external interferences (e.g. people passing by) and length of the interventions (e.g. changing diapers). Taking these parameters into account when designing a capacitive sensing system can greatly improve the system performance.

Conclusion

Although further work is needed in terms of motion artifact reduction and system design, the proposed system shows promising results for long-term non-skin-damaging neonatal ECG and respiration monitoring. The technology could be used for other applications, e.g. home monitoring, sleep studies,...

[1] L. Atallah et al., *Physiol. Meas.*, 35, pp. 895–913, 2014;