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Remote Vital Signs Monitoring in Neonatal Intensive Care Unit Using a Digital Camera

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Abstract : Conventional contact-based vital signs monitoring sensors such as pulse oximeters or electrocardiogram (ECG) may cause discomfort, skin damage, and infections, particularly in neonates with fragile, sensitive skin. Therefore, remote monitoring of the vital sign is desired in both clinical and non-clinical settings to overcome these issues. Camera-based vital signs monitoring is a recent technology for these applications with many positive attributes. However, there are still limited camera-based studies on neonates in a clinical setting. In this study, the heart rate (HR) and respiratory rate (RR) of eight infants at the Neonatal Intensive Care Unit (NICU) in Flinders Medical Centre were remotely monitored using a digital camera applying color and motion-based computational methods. The region-of-interest (ROI) was efficiently selected by incorporating an image decomposition method. Furthermore, spatial averaging, spectral analysis, band-pass filtering, and peak detection were also used to extract both HR and RR. The experimental results were validated with the ground truth data obtained from an ECG monitor and showed a strong correlation using the Pearson correlation coefficient (PCC) 0.9794 and 0.9412 for HR and RR, respectively. The RMSE between camera-based data and ECG data for HR and RR were 2.84 beats/min and 2.91 breaths/min, respectively. A Bland Altman analysis of the data also showed a close correlation between both data sets with a mean bias of 0.60 beats/min and 1 breath/min, and the lower and upper limit of agreement -4.9 to + 6.1 beats/min and -4.4 to +6.4 breaths/min for both HR and RR, respectively. Therefore, video camera imaging may replace conventional contact-based monitoring in NICU and has potential applications in other contexts such as home health monitoring.

Keywords : neonates, NICU, digital camera, heart rate, respiratory rate, image decomposition
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