ROBUST RESPIRATORY RATE MONITORED ‘TOUCHLESSLY’ USING A DEPTH CAMERA

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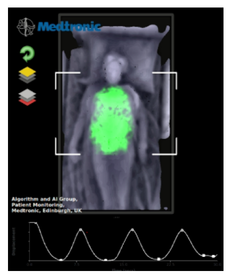
Introduction: One of the most common vital signs measured in the clinical setting is respiratory rate (RR). A significant change in RR is often an early indication of a major complication such as respiratory tract infections, respiratory depression associated with opioid consumption, anesthesia and/or sedation, as well as respiratory failure [1–3]. Here, we report on the performance of a depth-sensing camera system [4] for the continuous non-contact ‘touchless’ monitoring of Respiratory Rate (RR), extending our previous results reported previously at STA [5] from 266 separate rates within a cohort of six volunteers to 908 rates and thirteen volunteers.

Method: Thirteen healthy subjects undertook a range of breathing rates from 4 to 40 BrPM. These were set rates of 4, 5, 6, 8, 10, 15, 20, 25, 30, 35 and 40 BrPM. In total, 908 separate tasks were captured across a range of conditions including posture (prone, supine, lateral), position (center and edge of bed) and coverings (no sheets, sheets, duvet). Depth information was acquired from the scene using an Intel D415 camera. This data was processed to extract depth-changes within the subject’s torso region corresponding to respiratory activity (as shown in the figure). A respiratory rate RR_{depth} was calculated using our latest algorithm and output once-per-second from the device. This was compared to a capnograph reference, RR_{capno}.



Results:
The table contains the results for RR_{depth} versus RR_{capno} for all subjects and tests. An overall RMSD of 0.73 BrPM (mean bias of -0.06 BrPM) was achieved across the target RR range of 4-40 BrPM. The table also contains the results across four separate subranges 4-10, 10-20, 20-30 and 30-40 BrPM: all demonstrating adequate performance for the clinical setting. Note also the high uptime of the algorithm (where uptime is defined as the time that a respiratory rate is posted by the algorithm during the study). A high uptime is essential for the development of a clinically viable algorithm for use in a medical device.

Range (BrPM)	RMSD	Bias	uptime	N_tasks	samples
>1 to 10	0.43	-0.06	99.70	288	8602
>10 to 20	0.81	-0.17	100.00	207	6204
>20 to 30	0.93	-0.10	100.00	207	6148
>30 to 40	0.73	0.09	100.00	206	6171
>4 to 40	**0.73**	**-0.06**	**99.90**	**908**	**27125**

Conclusions:
We believe that non-contact monitoring has great potential for the robust monitoring of a range of physiological and contextual parameters. The results reported here indicate the viability of touchless monitoring for the determination of one of these parameters - respiratory rate - over a pertinent clinical range of 4 to 40 BrPM. We are currently exploring other potential uses of the technology including the detection of malignant respiratory patterns and the identification of apnea episodes.

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