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Detection of Patient Roll-Over Using High-Sensitivity Pressure Sensors

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Abstract : Recent advances in medical technology have served to enhance average life expectancy. However, the total time for which the patients are prescribed complete bedrest has also increased. With patients being required to maintain a constant lying posture- also called bedsore- development of a system to detect patient roll-over becomes imperative. For this purpose, extant studies have proposed the use of cameras, and favorable results have been reported. Continuous on-camera monitoring, however, tends to violate patient privacy. We have proposed unconstrained bio-signal measurement system that could detect body-motion during sleep and does not violate patient's privacy. Therefore, in this study, we propose a roll-over detection method by the date obtained from the bi-signal measurement system. Signals recorded by the sensor were assumed to comprise respiration, pulse, body motion, and noise components. Compared the body-motion and respiration, pulse component, the body-motion, during roll-over, generate large vibration. Thus, analysis of the body-motion component facilitates detection of the roll-over tendency. The large vibration associated with the roll-over motion has a great effect on the Root Mean Square (RMS) value of time series of the body motion component calculated during short 10 s segments. After calculation, the RMS value during each segment was compared to a threshold value set in advance. If RMS value in any segment exceeded the threshold, corresponding data were considered to indicate occurrence of a roll-over. In order to validate the proposed method, we conducted experiment. A bi-directional microphone was adopted as a high-sensitivity pressure sensor and was placed between the mattress and bedframe. Recorded signals passed through an analog Band-pass Filter (BPF) operating over the 0.16-16 Hz bandwidth. BPF allowed the respiration, pulse, and body-motion to pass whilst removing the noise component. Output from BPF was A/D converted with the sampling frequency 100Hz, and the measurement time was 480 seconds. The number of subjects and data corresponded to 5 and 10, respectively. Subjects laid on a mattress in the supine position. During data measurement, subjects—upon the investigator's instruction—were asked to roll over into four different positions—supine to left lateral, left lateral to prone, prone to right lateral, and right lateral to supine. Recorded data was divided into 48 segments with 10 s intervals, and the corresponding RMS value for each segment was calculated. The system was evaluated by the accuracy between the investigator's instruction and the detected segment. As the result, an accuracy of 100% was achieved. While reviewing the time series of recorded data, segments indicating roll-over tendencies were observed to demonstrate a large amplitude. However, clear differences between decubitus and the roll-over motion could not be confirmed. Extant researches possessed a disadvantage in terms of patient privacy. The proposed study, however, demonstrates more precise detection of patient roll-over tendencies without violating their privacy. As a future prospect, decubitus estimation before and after roll-over could be attempted. Since in this paper, we could not confirm the clear differences between decubitus and the roll-over motion, future studies could be based on utilization of the respiration and pulse components.

Keywords : bedsore, high-sensitivity pressure sensor, roll-over, unconstrained bio-signal measurement
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