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A Study on Respiratory Rate Measurement Using Wearable CO_2 Sensors

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It is necessary to obtain respiratory rate with simple devices in order to detect a sudden change in a patient's condition in case of emergency situations [1]. Although the respiratory rate is usually measured based on combination of impedance change of electrodes and ECG, the impedance measurement should be largely affected by body movement. In contrast, a capnometer used with a ventilator can measure respiratory rate accurately, avoiding the body movement influence. However, the capnometer requires a large scale of the device and the connection to the ventilator circuit. Therefore, this study developed a simple respiratory rate measurement system using a wearable CO_2 sensor. We then experimentally evaluated the estimation accuracy of the respiratory rate based on the wearable CO_2 sensor.

Figure. 1 shows an example of the time waveform of the CO_2 concentration at rest obtained from this experiment. A sharp peak according to the subject's respiration was clearly observed, which suggests the possibility to estimate the respiration rate based on the CO_2 concentration. In addition, Figure 2 shows the time waveform of the normalized filter output by band-pass filtering the measurement data. It can be seen from this figure that the respiration rate of the subject can be estimated with an appropriate threshold indicated by the red bolded line in Figure 2. The data measurement during the body movement were then carried out. The average and standard deviation of the estimation results under rest and motion situations were evaluated, where the mean estimation value of 22.03 bpm was achieved in the experiment. A good estimation accuracy was obtained with an absolute value error of 0.47 bpm, as compared with the reference respiration of 22.50 bpm. In addition, a standard deviation of 1.555 bpm was also achieved. It is confirmed that the standard deviation of changes due to individual differences was relatively small, less than 2 bpm. The experimental results demonstrated that the respiratory rate can be precisely measured avoiding the body movement influence.

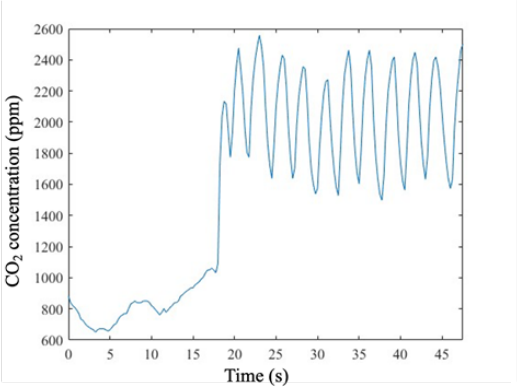

Figure 1. Measurement data

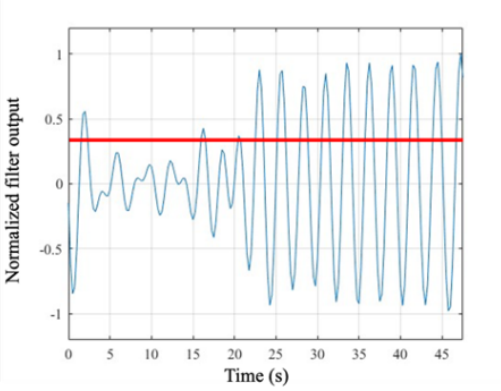

Figure 2. Normalized filter output

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References

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