Development and Evaluation of Portable Self-respiratory Training System Using Patch Type Magnetic Sensor

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Introduction

- An anatomic motion of organs and tumors due to breathing increases the internal margin in radiation therapy, which increases uncertainty of treatment.
- To improve this uncertainty, many reconstruction method and tracking system have been developed, but such techniques do not directly manage the problem of irregular breathing motion.
- A number of studies have been conducted for motion mitigation, and respiratory training is important to apply them well.
- However, equipment used in hospital for respiratory training require additional space, time and professional human resources.

Aim

- In this study, we developed the portable self-respiratory training system using patch type magnetic sensor, and evaluate the performance of this system.

Methods

- The system consists of hardware and software including MEMS based magnetic sensor, magnet and phone for display the signal.

Figure 1. Overview of the self-respiratory system

- The sensor size is 35 x 18 x 3 mm^3, and it transmits magnetic field signal to phone through Bluetooth. The signal output is obtained by a time-magnetic field strength along each 3-axis, and the RMS signal is displayed.
- When breathing, the distance between the magnet and the sensor attached to the chest changes depending on the movement of the chest surface, which is shown as a signal.
- QUASAR™ Programmable Respiratory Motion Phantom (Modus Medical Devices Inc.) was used to evaluat

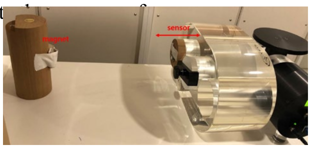

Figure 2. *Experimental setup for measuring the sensor signals with QUASAR™ Programmable Respiratory Motion Phantom*

- The performance of the sensor was evaluated by comparing the output signal obtained from the sensor with the waveform showing the actual movement of the phantom.
- In addition, we analyzed how the signal changes as the distance between the magnet and the sensor changes, and evaluated the sensor by comparing the signals generated in the presence and absence of the material (RW3 slab phantom 15cm) in-between the magnet and sensor.

Results

- The signals were measured by moving the phantom in the form of a sine wave with a period of 1 to 5 seconds and an amplitude of 0.5 to 1.5 cm. The period and amplitude error of the signal was 0.02 to 0.12 seconds and 19.80 to 172.45μm, respectively.

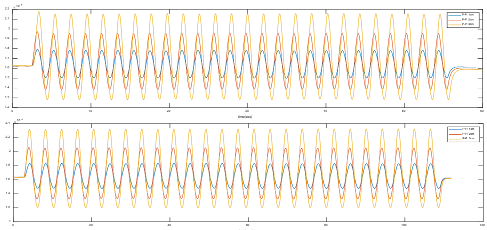

Figure 3. *The signals according to the amplitude measured by moving the phantom with period 2 and 4 seconds*

- The signals were measured by changing the distance between the magnet and the sensor, and when the distance between the magnet and the sensor was 15 cm, the period and amplitude errors were the least measured.

Distance[cm]	10	15	20
Amplitude error[μm]	74.59	21.65	32.09
Period error[sec]	2.046	2.045	2.048

Figure 4. *The amplitude and period errors by distance between sensor and magnet*

- The signals were measured with the material in-between the magnet and the sensor, moving the phantom in the same way and there was little difference with signal measured without the materials.

Conclusion

- We evaluated the sensor to function well according to the movement of the phantom, and the cycle and amplitude errors of sensor were reasonable.
- For the future works, we will check the signal changes depending on remaining battery capacity, and reproducibility test will be carried out.
- This system can be used by the patient themselves without limitations of time, space and monitoring support.

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