Development and evaluation of portable self-respiratory training system using patch type magnetic sensor

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Purpose:

An anatomic motion of organs and tumors due to breathing increases the internal margin in radiation therapy, which increases the uncertainty of treatment. Many studies have been conducted for motion mitigation, but respiratory training is important to apply them well. However, equipment currently used for respiratory training requires professional human resources, space and time. In this study, we evaluate the performance of developed portable self-respiratory training system.

Materials and Methods:

The system consists of magnet, sensor, and phone for display the signal. The size of the sensor 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 of 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 evaluate the sensor performance. A sinusoidal waveform with different cycles and amplitude was created to move the phantom, and 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 1 to 3 cm. The period and amplitude error of the signal was 0.02 to 0.12 seconds and 19.80 to 172.45µm, respectively.

The signals were measured by changing the distance between the magnet and the sensor, moving the phantom in the form of a sine wave with a period of 3 seconds and an amplitude of 1cm. When the distance between the magnet and the sensor was 15 cm, the period and amplitude errors were measured at 0.072 seconds and 21.65µm, respectively. 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.

Conclusions:

In this study, we evaluated the sensors to function well according to the movement of the phantom, and the cycle and amplitude errors of sensor were reasonable. As the distance between the sensor and the magnet changed, the accuracy of the sensor changed, and the error was the smallest when the distance was 15cm. The presence or absence of material between the magnet and the sensor did not affect the signal, so respiratory training is possible with the magnet behind the back or in front of the chest.

Keywords:

Respiratory training system, respiratory monitoring, motion management, radiation therapy