1.Comparison of the swallowing mensuration using MI sensor with swallowing sound using the pharynx microphone

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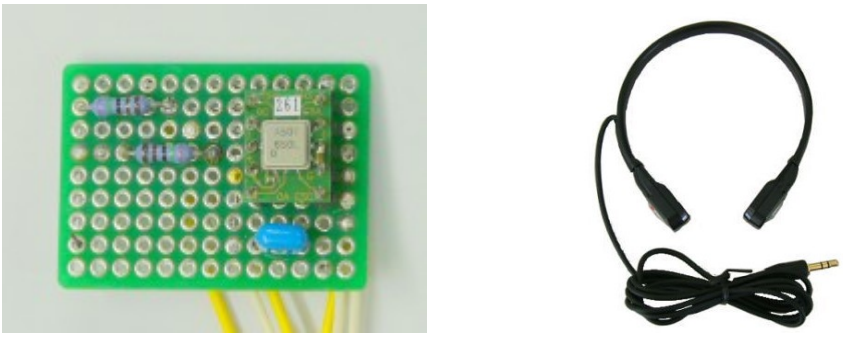
Introduction

The objective of this study is to develop a screening device for the swallowing difficulty (dysphagia) using a magneto-impedance (MI) sensor. The video fluorography (VF) or the video endoscopy are used to diagnose dysphagia. In the other hand, RSST (repetitive saliva swallowing test)[1)] is widely used as a simple test in some facilities where they have no VF apparatus.

The authors have developed a device to automate the RSST using a MI sensor. Availability of proposed method is examined in previous study[2)]. As results of experiments, movement of a laryngeal prominence could be measured using a small magnet and the MI sensor. In this study, we compared the movement by the MI sensor with the other measurement method i.e. video image analysis and swallowing sound recorded by pharynx microphone.

Method

The proposed device consists of a neodymium magnet, a MI sensor (Aichi Micro Intelligent, AMI302) and a personal computer for data acquisition. The MI sensor is capable to measure three -dimensional magnetic field. The magnet is attached on the laryngeal prominence, and the MI sensor is attached on breastbone. Relative position between the magnet and the sensor changes in the subject's swallowing. The magnetic field at the sensor reflects the swallowing.



(a) MI sensor. (b) Pharynx microphone

Fig.1 The device of measurement.

In RSST, the subject is instructed to swallow saliva as fast as possible in 30 seconds. If the subject can swallow less than 3 times, he/she is suggested to need further investigation. In proposed system, basic procedure is same as original RSST except 10 seconds preceding measurement to obtain offset of the sensor output. The offset is subtracted from measured values. In addition, in order to evaluate whether three-dimensional MI sensor can measure swallowing, as shown in Figure 2, we also get the swallowing sound and video recording at the time of measurement. A metal pin (Φ1mm×30mm) is attached on the larynx by surgical tape. The movement of the pin is tracked by a video camera. We also get the swallowing sound at the same time by the throat microphone(Fig.2).

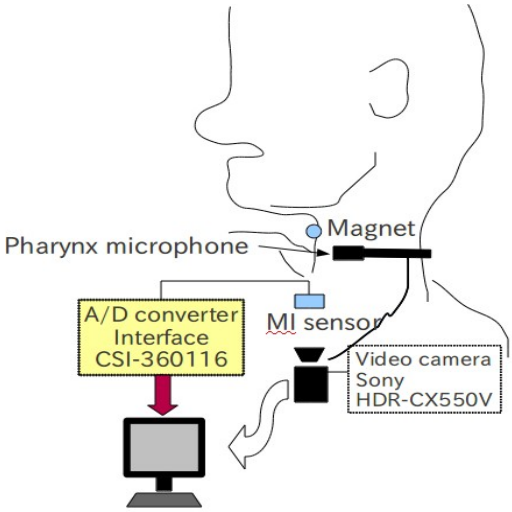


Figure 2. Placement of the measuring device

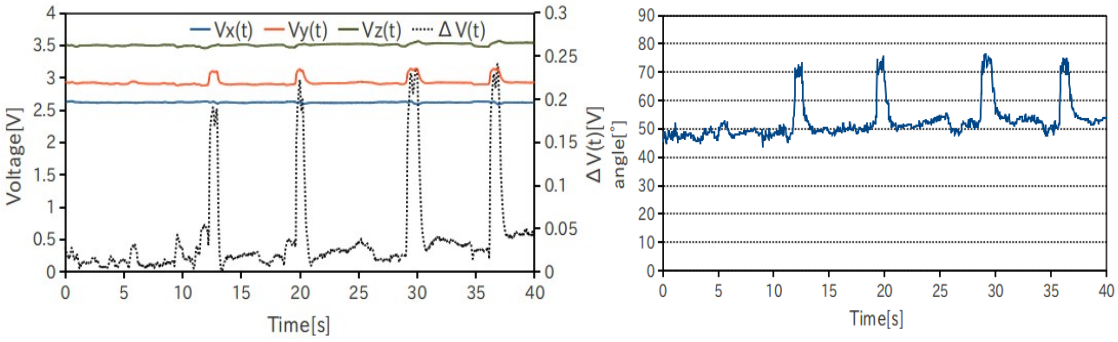
The change of sensor output ΔV(t) is described as

$$\Delta V(t) = \sqrt{(V_x(t) - V_{ox})^2 + (V_y(t) - V_{oy})^2 + (V_z(t) - V_{oz})^2} \qquad (1)$$

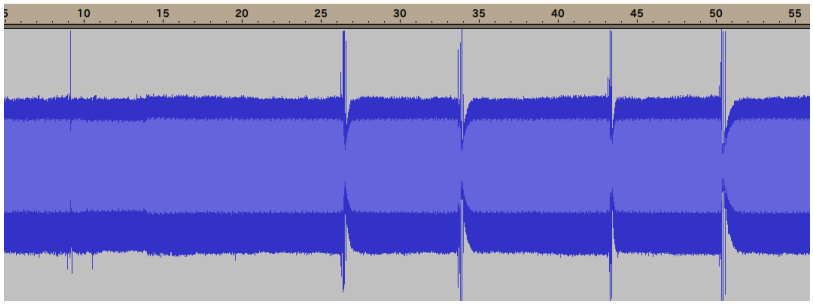
where $V_x(t), V_y(t), V_z(t)$ are sensor output of each axis and V_{ox}, V_{oy}, V_{oz} are offset of them. V_{ox}, V_{oy}, V_{oz} are average during offset period. They consist of geomagnetism and sensor offset.

Results

Fig. 3 and Fig. 4 shows result for healthy adult (23 years old, male).



(a) Output of the MI sensor (b) Change of the angle by the video images

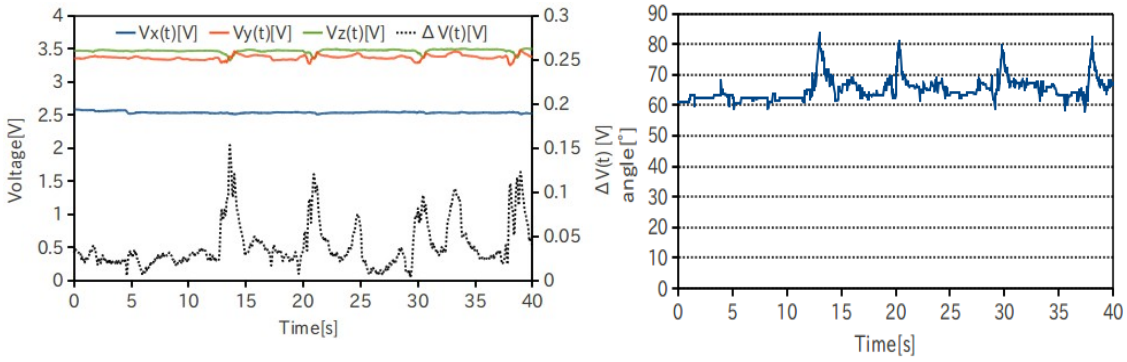


(c) Swallowing sound waveform for healthy adult(23 years old)

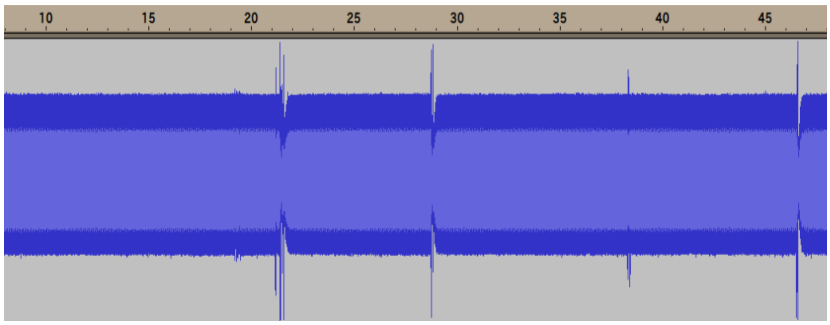
Fig. 3 The measurement result for healthy adult (23 years old)

It is possible to count the swallowing movements from each Fig. 3 (a), (b) and (c). Especially, Fig. 3 a summarizes the variance of 3 magnetic sensors. It is convenient to count using threshold.

Fig.4 shows a result of another subject of healthy adult (24 years old, male). In this subject, waveforms during the swallowing is blurred. It is difficult to apply the threshold to count the swallowing.



(a) Output of the MI sensor (b) Change of the angle by the video images



(c) Swallowing sound waveform for healthy adult(24 years old)

Fig. 4 The measurement result of healthy adult (24 years old)

Difference between two subjects is whether it was able to detect swallowing movement. The results of the first subject, the number of swallowing can be confirmed by each measurement method, but the second results, the measurement result by the sensor can not counted the number of swallowing. However, Fig. 4 (b) and (c) is possible to count the number of swallowing.

Discussion

This result has an interesting interpretation. It could not be measured by the sensor, there is no rotational motion of the magnet, we thought the possibility was moved up and down on the surface of the skin. Figure 5 shows in order to examine this possibility, which represents the locus of the magnet by the moving image. The X-and Y-axis in Figure 5 is the axis of the moving image, when the subject was facing the front, the X-axis was from front to back, the Y-axis was from top to bottom. The video taken from the left as viewed from the subject. As an analysis of Figure 5, that there is no movement on the surface of the skin and do not found rotational motion. Based on these results it is concluded that measured the movement of the non-swallowing by sensor.

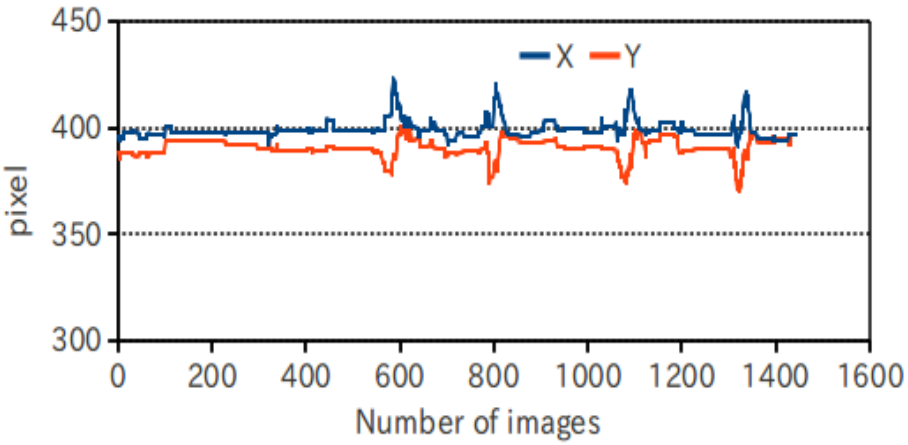


Fig. 5 Locus of movement of the magnet on the surface of the skin

Conclusion

An experimental device for automated RSST using a magnet and magnetic sensor is described. We confirm that the proposed device can measure the movement of the laryngeal prominence. However, it is difficult to count the number of swallowing for some subjects with uncertain movement of the magnet of the larynx.

References

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