Detection of presence in a vehicle cabin using space potential fluctuation

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With the growing social problem of children being left unattended in vehicle cabins, interest in CPD (Child Presence Detection) systems is growing. In this paper, we propose a non-contact detection method of passengers in a vehicle cabin for application to CPD. This method uses a passive sensor based on a field-effect transistor installed in the cabin to detect spatial potential fluctuations caused by body motions and breathing. We have developed a sensor using this method and report on its effectiveness for CPD application in terms of motion and breathing detection and the location of the sensor.

Figure 1 shows the appearance of the sensor unit developed using this method and an example of its arrangement in the cabin. In order to detect spatial potential fluctuations in a non-contact, passive manner, a junction field-effect transistor (J-FET) was selected as the sensor from among commonly used semiconductor devices, taking cost into consideration. 8 mm diameter aluminum electrodes connected to the gate terminals of the JFET, a filter circuit, an amplifier circuit with an amplification factor of 100 times, and a sensor with a built-in sensor. The system consists of a battery to drive the circuit. Output signals are collected by a web data logger. The sensor unit consists of a set of these components, and is placed on the ceiling or the like so that the sensor electrode surface faces the interior of the vehicle.

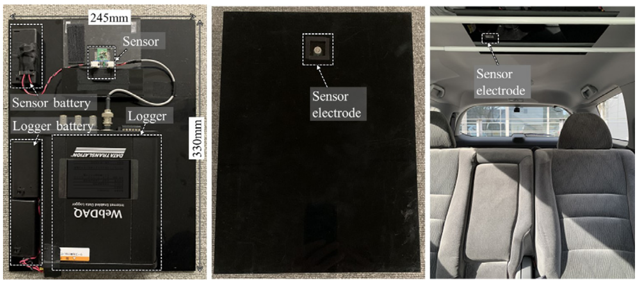

Fig.1 Sensor unit and example of placement in a vehicle cabin

The effectiveness of the system in detecting respiration in adult subjects is to be confirmed. The sensor unit is placed in the center of the ceiling of the rear seat of a passenger car with the engine turned off, and the passenger is seated in the rear seat (behind the passenger seat side). The linear distance from the sensor electrode to the passenger's chest is approximately 620 mm. The passenger faces forward with his/her back against the seat and breathes at a rate of approximately 25 bpm (breaths per minute). This translates to a frequency of approximately 0.4 Hz. As a reference, a respiration sensor is used for synchronous measurement.

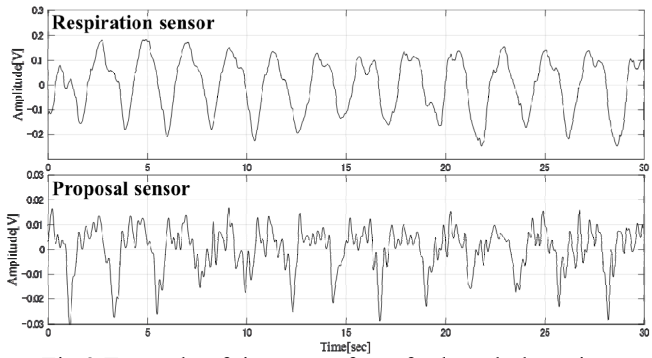

Fig.2 Example of time waveform for breath detection

Figure 2 shows an example of time-axis waveforms measured by a respiration sensor (upper panel) and a sensor using the proposed method (lower panel). A low-pass filter with a cutoff frequency of 4 Hz is applied to the waveforms of this method. The amplitude fluctuates at about the same time as the time waveform of the respiration sensor, which was measured synchronously, indicating that it reflects respiration. Figure 3 shows the results of frequency analysis using the Fast Fourier Transform for the three conditions of no passenger, passenger present (breath-holding), and passenger present (breathing). The highest peak is the breathing component at around 0.4 Hz, and its harmonics appear with this as the main component. In addition, an increase in the overall frequency component can be observed with breath-holding compared to unattended.

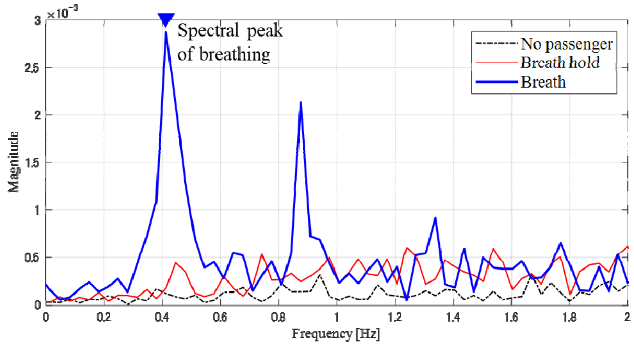

Fig.3 Frequency analysis by FFT for breath detection

From these results, we confirmed the effectiveness of the CPD application of the method proposed in this study for detecting left behind in a vehicle cabin using spatial potential fluctuation..