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研究成果報告書

研究課題名

見守りバイタルビッグデータ収集に資する非接触・無拘束型の敷布感知警報システム開発

Development of a non-contact unobtrusive sheeting sensor and alarm system for collecting vital big data during watching over the elderly

研究期間

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Abstract

Given the rapidly aging population along with the advances in information and communication technologies and artificial intelligence, the physiological and behavioral signals will be realistically monitored at home soon. The most promising signals for the monitoring are considered as follows; (a) blood pressure (BP), (b) electrocardiogram (ECG), (c) respiration (RESP), and (d) bed-exiting motion, body posture and body movement (BDYx). Terming these signals as elderly-care vitals, we targeted to develop a non-contact unobtrusive in-bed system for monitoring the elderly-care vitals using a fabric-sheet unified sensing electrode (FUSE). We set agendas to reach the target as follows: (1) Challenging exploratory research for relative BP estimation based on the non-contact unobtrusive measurement, (2) Technological research of electrode and circuit for longitudinal simultaneous measurements of the elderly-care vitals in the non-contact unobtrusive manner, (3) Transformation of the FUSE into an IoT system with a view to its social implementation and big data storage, (4) Study of element technologies for anomaly detection with the FUSE, (5) Extended studies derived from the original target.

As for agenda (1), two sub-agendas were set: (1)-1 Relative BP estimation using BCG (ballistocardiogram) from the heel, (1)-2 Signal quality enhancement of BCG from the shoulder and its use for the relative BP estimation. For (1)-1, we derived a theoretical formula for mean BP estimation leveraging pulse beat arrival time (PBAT), heart rate (HR) and BCG amplitude, and obtained high correlation (0.96) and small root mean square error RSME (0.75 mmHg) with the derived formula. For (1)-2, we obtained high correlation between systolic BP and estimated relative value ($r = 0.90$) in the case of 80-s analytical segment.

As for agenda (2), successfully proposed principles of capacitive simultaneous measurements of ECG, RESP, and BDYx, and presented high accuracies of them in overnight experiments and in short-time laboratory experiments. Furthermore, we succeeded in developing many technologies such as an novel analog frontend to improve the quality of capacitive ECG through thick clothing.

As for agenda (3), we developed pilot electrodes and measuring devices, then constructed prototype IoT systems consistent with the outline of the target.

As for agenda (4), we investigated new approaches for (4)-1 apnea, (4)-2 detecting bed-exiting motion and its discrimination from failure of the FUSE, (4)-3 detecting cardiac infarction from capacitive ECG recordings, (4)-4 isolating the patient and IoT abnormality.

As for agenda (5), we conducted extended studies on (5)-1 capacitive-coupling impedance spectroscopy, (5)-2 non-contact measurement of cough-associated electromyogram with the FUSE, (5)-3 non-contact measurement of blink-associated electro-oculogram with in-pillow cloth electrode, and (5)-4 detection of atrial fibrillation from capacitive ECG in a clinical setting.