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研究成果報告書

研究課題名

マルチレーダによる多人数の非接触ヘルスケア計測が拓く安心社会

A Multi-Radar Non-Contact Healthcare Monitoring System for Multi-Person Sensing Toward a Safer Society

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Abstract

This research aimed to realize high-accuracy and stable simultaneous non-contact vital-sign monitoring of multiple individuals, which has been difficult to achieve using conventional radar-based approaches. Non-contact sensing without wearable sensors offers significant advantages in terms of user comfort and applicability to healthcare, welfare, education, and monitoring services. However, practical deployment has been hindered by technical challenges such as sensitivity to posture and body motion, signal occlusion in multi-person environments, as well as ethical and privacy concerns.

To address these issues, this study proposed a novel non-contact vital-sign monitoring framework that integrates a radar network consisting of multiple radar systems with a mathematical model of physiological signals. By modeling the relationships among skin displacement waveforms measured from multiple directions, the proposed approach enables robust data association, body orientation estimation, and geometric calibration across radar systems, even in crowded environments. In addition, a signal analysis method focusing on the harmonic components of cardiac signals was introduced, leading to improved accuracy in heartbeat interval estimation.

Throughout the research period, the proposed methods were progressively refined and integrated. In the final year, the system was validated in a real-world environment through simultaneous measurements of up to 16 individuals. Experimental results demonstrated that the proposed system achieved a signal acquisition rate exceeding 90% for respiration and heartbeat measurements, even under varying conditions of subject placement, posture, distance, and occlusion. These results clearly indicate the practical feasibility of multi-person non-contact vital-sign monitoring beyond the limitations of conventional single-radar systems.

In parallel with technical development, this research also addressed ethical and social considerations essential for real-world deployment. Ethical investigations and guideline development were conducted through the Non-Contact Monitoring Sensor Ethics Committee, leading to the formal approval of an ethics and privacy policy in the final year. This framework establishes a foundation for socially acceptable and trustworthy deployment of non-contact sensing technologies.

In summary, this research established a comprehensive framework for non-contact vital-sign monitoring that goes beyond incremental technical improvements. By integrating multi-person capability, real-world validation, and ethical governance, the outcomes of this study provide a foundational basis for future research in non-contact healthcare sensing and contribute to the realization of safe and reliable monitoring technologies in smart societies.