論 文 の 内 容 の 要 旨

論文題目　Higher-order tensor independent component analysis : General framework construction and development of application systems for MIMO remote sensing of vital signs(高階テンソル独立成分分析:汎用枠組みの構築と生体信号のMIMOリモートセンシングのための応用システムの構築)

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This paper proposes a novel method of independent component analysis (ICA), which we name higher-order tensor ICA (HOT-ICA). We newly develop a robust microwave multiple input multiple output (MIMO) radar system, in which HOT-ICA performs separation of multiple target signals to detect respiration and heartbeat. In comparison with millimeter waves, microwaves spread wider with diffraction and propagate even in an environment with obstacles to reach targets. However, it often requires more powerful signal separation because of its lower resolution. HOT-ICA realizes high robustness in self-organization of a separation tensor by utilizing channel information, i.e., the information of physical measurement circumstances concerning, e.g., which transmitting/receiving antennas are used. In numerical and living human experiments, our HOT-ICA system effectively separates the bio signals successfully even in an obstacle affecting environment, which has been a difficult task. The results demonstrate the significance of HOT-ICA in remote sensing. It fully utilizes the high dimensionality of the separation tensor by keeping the tensor structure unchanged to take advantage of the measurement circumstances information.

We also propose direction of arrival (DoA) estimation of a target signal based

on higher-order tensor independent component analysis (HOT-ICA), a signal processing method that adapts to physical changes in the measurement environment for biological signals. By performing the DoA estimation twice for different antenna sets, we can locate the target at the intersection of the two DoA lines, which is useful in multiple target identification. It also leads to target position estimation by using multiple DoA results. This technology can be used as a system to monitor multiple people simultaneously in places such as saunas and identify people whose respiration and heartbeat signals are abnormal.

In addition, we propose a method to deal with not only phase but also polarization information in order to reflect the nature of radio frequency waves more effectively in signal processing. Polarization is the direction of an electric field in space. Polarization includes linear and circular ones. Linearly polarized wave is a polarization in which the electric field always exists in one plane, while circularly polarized wave is a polarization in which the electric field rotates along propagation. We measure vital signals by transmitting microwaves to a human body and receiving backscattering from it. In this situation, we assume that the polarization information reflecting the subject's body shape and movement is different for each subject and expect that the separation performance is improved by processing observed signals with the polarization information compared to the case in which only the phase information is used. Experiments demonstrate the effectiveness of the use of polarization.