Sparsity Based Non-Contact Vital Signs Monitoring of Multiple People Via Radar

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Overview

The rise in chronic health conditions, alongside the increase in the elderly population, emphasizes the importance of long-term monitoring in addition to urgent intervention. Current monitoring devices of vital signs by physical contact have many drawbacks, including an increased transmission of infections and diseases, patientsâ€™ discomfort, and an effect on the measured readings.

Frequency-modulated continuous wave (FMCW) radars have shown great promise in meeting these needs. However, contemporary techniques for non-contact vital signs monitoring (NCVSM) via FMCW radars are based on simplistic models and present difficulties in coping with noisy environments containing multiple objects. Here, by utilizing the sparse nature of the modeled signals in conjunction with human cardiopulmonary features, we provide accurate multi-person localization and NCVSM in a cluttered environment, even using a single channel and a single-input-single-output setup.

Background and Unmet Need

Monitoring human vital signs entails numerous difficulties. First, current monitoring devices are typically in physical contact with the measured body, therefore, may lead to irritation or general discomfort to the patient and can be easily detached. Second, monitoring devices are usually connected to patients by medical staff, whether in clinics or hospitals, through a time-consuming interaction that increases the risk of infections and disease transmission, especially during pandemics such as COVID-19. In addition, the manner of connection greatly affects the results, thus it requires considerable skill and experience. Moreover, many medical teams suffer from high workloads, leading to an increase in mortality, infections, and duration of hospitalization, e.g., in intensive care units.

Remote sensing technology, such as radar systems, can be an ideal solution since they do not require users to wear, carry, or interact with any additional electronic device. Advanced solutions are based on FMCW radars that allow spatial separation and potential monitoring of several individuals simultaneously, which can reduce processing times and costs of using cumbersome hardware for real-time implementations. However, accurate simultaneous extraction of multiple people's cardiopulmonary activity using FMCW radars is still a challenge in terms of performance and currently lacks adequate mathematical modeling, leading to suboptimal solutions.

The Solution

Prof. Eldar Yonina and her team invented a novel method for multi-person non-contact vital signs monitoring using FMCW radar which outperforms current advanced methods, even when only a single transmitter and a single receiver are used [1], [2].

Technology Essence

For non-contact monitoring of multiple peopleâ€™s vital signs (here heart rate and respiration rate), we use mm-wave electromagnetic radiation transmitted by an FMCW radar. By utilizing the sparse nature of the modeled signals in conjunction with typical human cardiopulmonary features, it is possible to accurately localize humans in the radar's Field-of-View (FOV) and reliably monitor their vital signs. The team shows that spatial sparsity allows accurate detection of multiple people and computationally efficient extraction of their Doppler samples, using a joint sparse recovery approach. Given the extracted samples, a dictionary-based approach was used to search for the desired respiration and heartbeat rates over high-resolution grids corresponding to normal cardiopulmonary activity.

Applications and Advantages

- Non-contact and through clothing monitoring.
- Multi-person localization and counting
- Multi-person non-contact vital signs monitoring
- Suitable for medical applications such as lung function, respiration rate and depth, respiratory arrest sleep monitoring, obstructive apnea, heart rate monitoring, and other cardiac and respiratory tests.
- Long-term and continuous monitoring solution.
- Keeps the patientâ€™s privacy and comfort.
- Saves the medical staff valuable time.

Development Status

Prof. Yonina and her team invented a novel method that uses FMCW radar for non-contact vital signs monitoring of multiple people at a different radial distance from the radar [1] and at the same radial distance from the radar, but at different angles [2]. Combining their proposed model with real data of 30 monitored individuals, they demonstrated accurate human localization in a clutter-rich scenario that includes static and vibrating objects. They showed that their monitoring approach outperforms existing techniques based on several statistical metrics.

Market Opportunity

FMCW radar for non-contact vital sign monitoring of multiple people is relevant to several different markets. The main market is the healthcare market, in which the radar has the potential to be used in hospitals, clinics, nursing homes, private homes, and other healthcare settings. This market is rapidly increasing as the elderly population grows. Furthermore, during a pandemic, patients need to be monitored remotely or in isolation, which increases the need for such a solution. Other relevant markets can be the industrial market - monitoring the health and well-being of workers, particularly in high-risk environments such as mines and construction sites and other setting such as public spaces, transportation, and emergency response detecting, for example, stroke, using FMCW radar.

References:

[1] Y. Eder and Y. C. Eldar, "Sparsity Based Multi-Person Non-Contact Vital Signs Monitoring Via FMCW Radar", to appear in IEEE Journal of Biomedical and Health Informatics

[2] Y. Eder, Z.Liu and Y. C. Eldar, "Sparse Non-Contact Multiple People Localization and Vital Signs Monitoring Via FMCW Radar", to appear in IEEE ICASSP 2023

Patent Status

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