Sparse Non-Contact Multiple People Localization and Vital Signs Monitoring Via FMCW Radar
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Motivation and Contributions
- The increase in cardiopulmonary morbidity, disease transmission and burden on medical staff has led to extensive investigation of non-contact monitoring approaches
- Remote technology such as radar does not require users to wear, carry, or interact with any additional electronic device
- We present multi-person non-contact vital signs monitoring (MP-NCVSM) via SIMO FMCW radar, in a noisy environment
- Our approach is based on joint-sparse recovery (JSR) which accurately localizes humans in a clutter-rich scenario involving equidistant people, where known techniques struggle
- Vital Signs-based Dictionary Recovery (VSDR) method is then used to estimate their vitals (Respiration Rate (RR) and Heart Rate (HR)) yielding superior results compared to current NCVSM

Extended SIMO FMCW Model
- We suggest the following signal model based on SIMO FMCW radar:
  \[ y(n,l,k) = \sum_{z=1}^{L} v_z(n,l,k) e^{i(2\pi f_z n T_l + \phi_z(n,l,k))} + w(n,l,k) \]
  - \[ v_z(n,l,k) = \sum_{q=1}^{Q} d_{z,q} e^{i(2\pi f_q n T_l + \phi_q(n,l,k))} \]
  - \[ \phi_q(n,l,k) = \frac{1}{2} \sum_{p=1}^{P} \frac{1}{\lambda p} \sin(2\pi x_{p,q}(n,l,k) T_l) \]
  - \[ \{v_z(n,l,k)\} \] models the possible vibration of each object.
- The set \( \{x_{p,q}(n,l,k)\} \) includes the RR and HR of each human, denoted by \( \{C_z, C_{z'}\} \) for \( Z \leq MP \) humans in the FOV
- Reshaping each L frames \[ Y = CX + W \]

Joint-sparse recovery for multi-person localization
- Ideal window corresponding to normal breathing frequencies
  \[ Y - P(F_{\text{FOV}} F_{\text{Y}}) \]
- Doppler rows recovery
  \[ X = (C_C^H C_C^H)^{-1} C_C^H Y \]
- Phase extraction
  \[ v(l,j) = \text{unwrap}\{v_z(n,j,l)\} \]

Localization Results for Cluttered Scenario
- A simulated environment with three persons (two equidistant and a vibrating fan), and static clutter.
- Only the proposed JSR method indicates the correct locations of the humans!

NCVSM Results
- Example of NCVSM of 3 people simultaneously based on correct automatic human localization
- Both the HR and RR estimates by the VSDR approach show great resemblance to those of the reference, compared to other techniques in which the noisy setup impairs their assessments

Hardware Demonstration
- Example of NCVSM of 3 people simultaneously based on correct automatic human localization
- Sparsity-Based Multi-Person Localization and NCVSM