NOKIA Bell Labs

Category: Presentation/Poster

RF-eye: Multidimensional Tensor Sensing for RF Tomography

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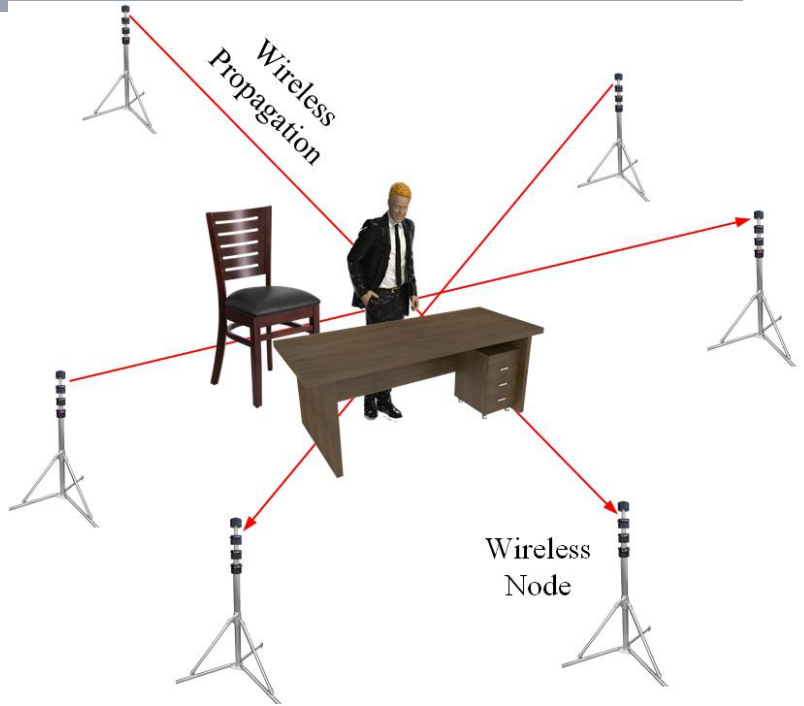
RF-eye: Tensor Sensing for RF Tomography

Abstract

- RF-eye: RF Tomography
  - Infer space information from RF signals.
  - Image a space, monitor human movements.

- What is the human need you are addressing?
  - Intelligent office: detect gestures and translate to actions (e.g. light control).
  - Watch a baby's room, monitor elderly's fall, or control with gestures (interactive games in VR).
  - Non-intrusive monitoring (no cameras or wearables required).



RF-eye by: imaging a space using RF signals

RF-eye: Tensor Sensing for RF Tomography

Vision

- Our vision and unique perspective.
  - RF-eye by tomography: using RF transmissions to sample the room space of interest.
  - A multidimensional tensor sensing problem for space reconstruction.
- Current approaches and differences
  - Compressive sensing [1]: solves a linear inverse problem, which involves huge vectors

  --> Low-rank tensors (our approach): higher resolution & computationally more efficient.
  - RF-Capture [2]: sends a radio signal that bounces off a person and back to the device to generate heat maps.

  --> Imaging (our approch): higher resolution.

[1] Matsuda, Takahiro, et al. "Multi-dimensional wireless tomography using tensor-based compressed sensing." Wireless Personal Communications 96.3 (2017): 3361-3384.

[2] Fadel Adib, Dina Katatbi. Capturing the human figure through a wall. ACM Transactions on Graphics (TOG), 34(6), 219, 2015.

A fine-grained and efficient solution

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Impact

- How will your solution affect/change the world/Nokia?
  - Smart home, smatspaces, and healthcare.
  - Intelligent office: automatic control (light, temperature).

- How does this fit into future X? Which domain?
  - Augmented Human

Augmented proficiency and intelligence.

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Results

- Our Work
  - Capture the latent structures of physical objects with transform-based tensor model.
  - Use RF transmissions to sample the room space of interest.
  - Formulate the RF tomography as a tensor sensing problem.
  - An optimized alternating minimization algrithm to do the imaging task.
- We tested our scheme, based on a data set, including 50 IKEA 3D models [3].

[3] Joseph J.L., Hamed P., and Antonio T.. Parsing IKEA objects: fine pose estimation," International Conference on Computer Vision, 2013.

Efficient multidimensional tensor sensing

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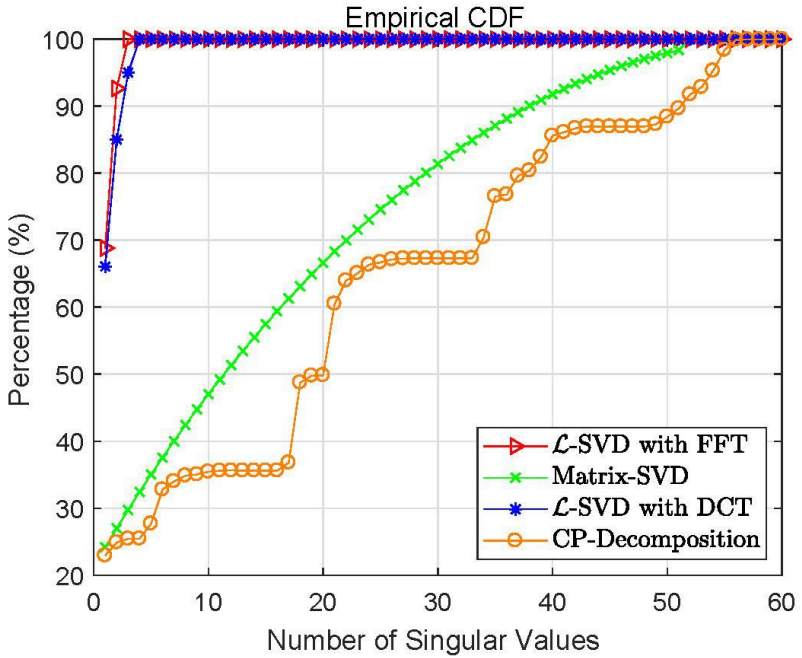
Simulation Results

- Model verification
  - Only lower ranks needed in both Frequency and DCT domains. (size: 60 x 60 x 15)
  - Thus, we use the transform-based tensor model.
- We tested our scheme based on a data set including 50 IKEA 3D models [3].



Low-rank representation in transform domains, e.g., FFT and DCT.

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Simulation Results

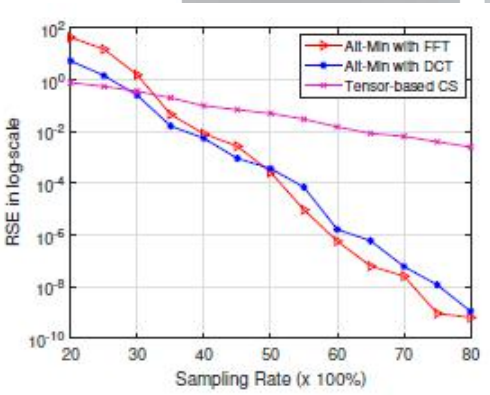

Fig. 4: RSEs vs sampling rates.

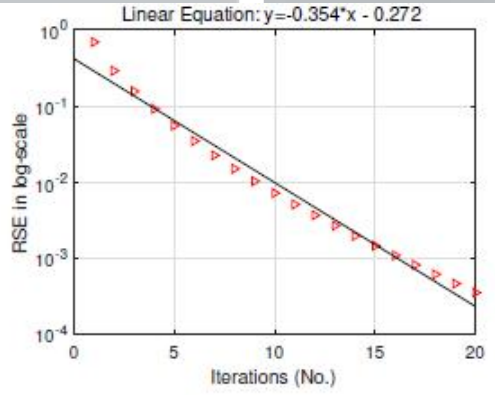

Fig. 5: Alt-Min with FFT.

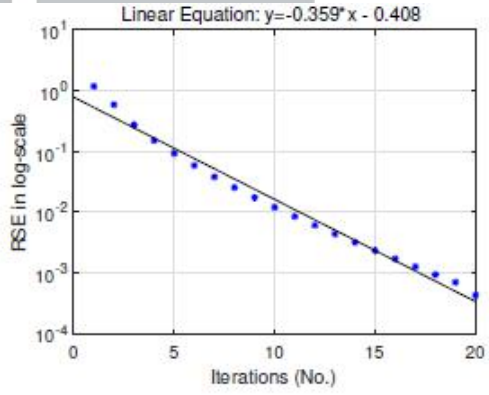

Fig. 6: Alt-Min with DCT.

High accuracy, fast convergence.

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Next Steps

- We would like to implement a prototype system with wifi access points (30~50).
- Key technology developement: Multi-person recognition and localization; human imaging; monitor breathing and heart rate, emotion recognition, etc.
- Identify key gaps/missing elements/risks
  - multiple wifi access points are required.
  - more wireless signals in a room.