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UltrasoundToGo RTD 2013

FNSNF

Compressed sensing based ultrafast ultrasound imaging

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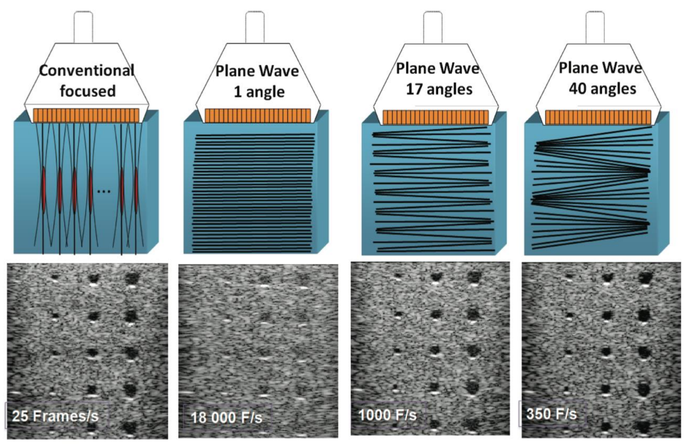
Introduction & Motivation

- The main objective of ultrafast ultrasound imaging techniques is to reach sufficiently high frame rate while keeping high image quality
- State-of-the art techniques:
  - Plane Wave imaging: Space based and Fourier based methods
  - Techniques based on focused beams at different depths

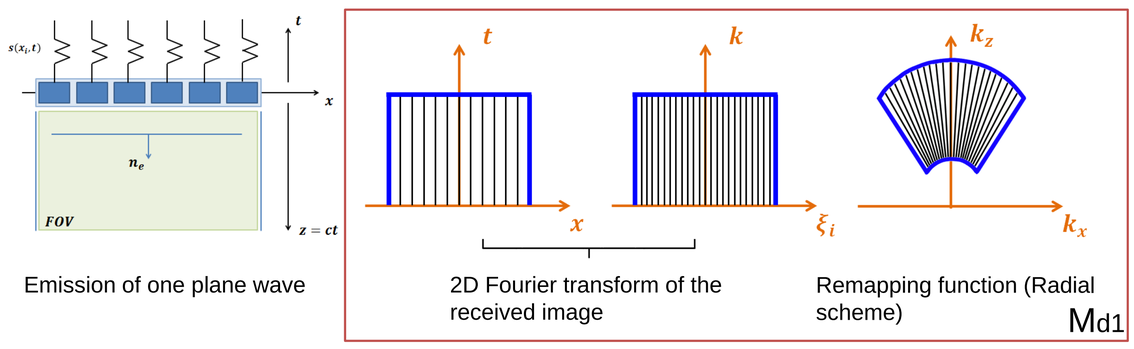


Tanter & Fink, 2014

- Our approach explores reconstruction method based on the **Compressed Sensing framework**.
  - Plane wave imaging with Fourier based beamforming
  - Sparse reconstruction algorithm to retrieve the image

Fourier beamforming poses an inverse problem

- General scheme (Bernard et al., 2014)



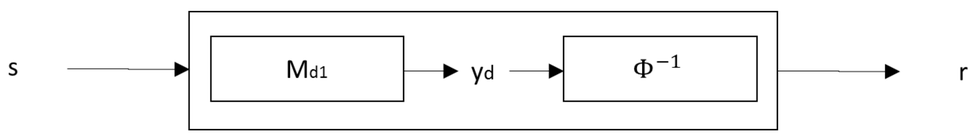
Emission of one plane wave

2D Fourier transform of the received image

Remapping function (Radial scheme)

Md1

Bernard et al, 2014



Unknown Φ^{-1}

- Inverse problem: $y_d = \Phi(r)$ **Ill-posed**
  - Filter back projection $r = \Phi^T(y_d)$
  - Sparse regularization

Solving the ill-posed inverse problem

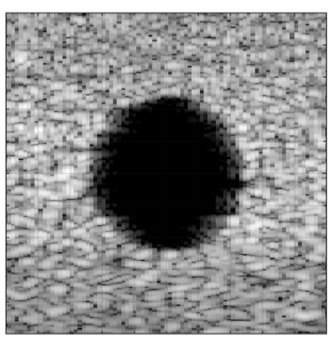
- We exploit the property that the images are sparse in a given basis Ψ. Using the l1 norm as the sparsity measure, we can reconstruct our signal using :

$$\hat{\mathbf{r}} = \arg\min_{\bar{\mathbf{r}} \in \mathbb{C}^N} \|\Psi^H \bar{\mathbf{r}}\|_1 \text{ subject to } \|\mathbf{y} - \Phi\bar{\mathbf{r}}\|_2 \leq \epsilon$$

- The selected basis Ψ is the undecimated wavelet basis
  - Best sparsity property

Study of Contrast to Noise Ratio

- Contrast to Noise Ratio (CNR) measured on synthetic phantoms.
  - Phantom generated using Field II software
  - Non-echogenic object at several depths (20 to 60 mm)
  - CNR Comparison against state of the art methods



Synthetic Phantom

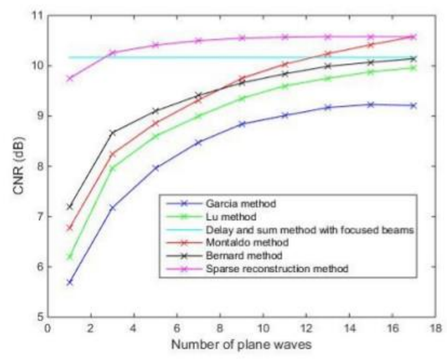


Figure 1. CNR comparison between the proposed method (magenta) and state-of-the-art methods.

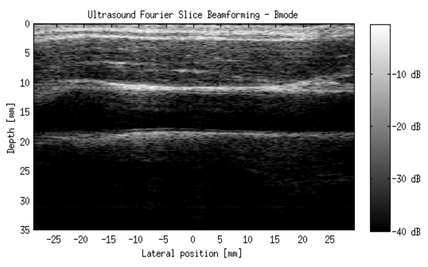
CNR comparison on the synthetic phantom

- **Our method overcomes all the existing methods in terms of CNR**

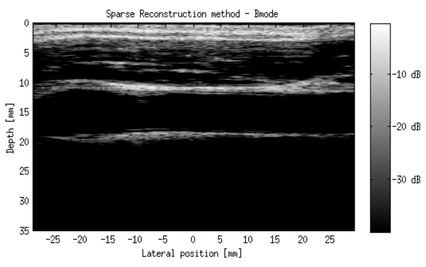
Reconstruction of carotid images

- Ultrasound device:
  - Sonix MDP: sampling frequency 40 MHz
  - Probe L14-5W: emission at 12 MHz, 128 transducers

- Acquisition: one plane wave



Carotid image - Bernard method



Carotid image – Our method

Conclusions

- **Fourier based** approach of the measurement model is presented
- **Sparse reconstruction** is used to solve the ill posed problem induced by the measurement model
- Yield a **Higher contrast** as all the state of the art existing methods by exploiting image sparsity in the wavelet domain
- Perform a **compressed acquisition:** Reaches same image quality as current method with only 3 insonifications (compression ratio of 28)

On-going work

- Improve the measurement model (use of NUFFT)
- Lp regularization instead of L1 regularization
- Investigate new sensing schemes to reduce data rate
- Extension to sectorial and 3D imaging