SAMPL Demonstrations

You are welcome to join us and take part of our live demonstrations

Place: Verasonics booth

Time:

- Tuesday 15:30-16:00
- Wednesday 15:30-16:00
- Thursday 15:30-16:00

Contact Us

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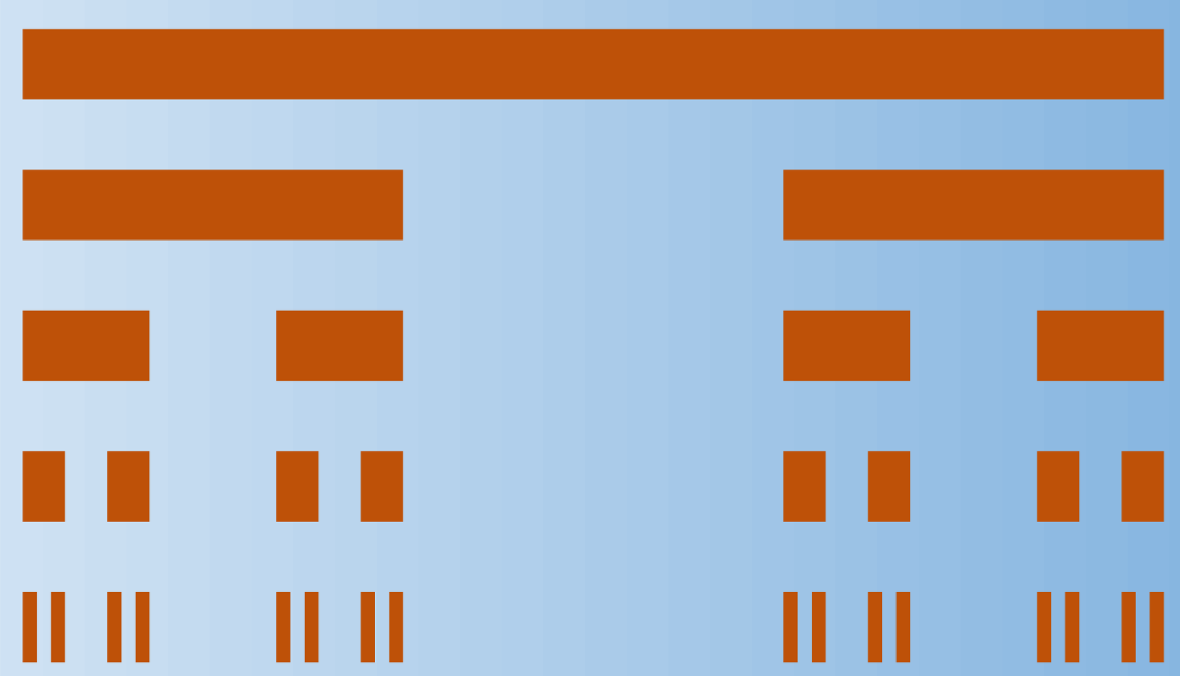
Verasonics®
The leader in Research Ultrasound™

Sparse Array Design for Ultrasound Imaging

Regev Cohen, Yonina C. Eldar



IUS 2018 IEEE International Ultrasonics Symposium
October 22 -25, 2018
Portopia Hotel, Kobe, Japan

SAMPL – Headed by Yonina C. Eldar
Sampl.technion.ac.il

Sparse Doppler Sensing

Challenges in Spectral Doppler

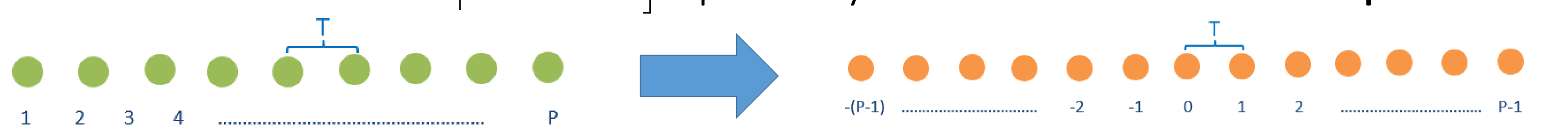
- **Spectral Resolution** – Large number of Doppler transmissions is required.
- **Alternating Strategy** – Doppler and B-mode both must be displayed at the same time.
- **Frame Rate** – We need to identify rapid temporal variations in the blood flow and track tissue movement.
- **Lateral Velocity** – flow perpendicular to the beam is not usually measured.
- **Spatial Coverage** – In focused acquisition, velocity estimation can be performed only on points on the acquisition line.
- **Clutter Removal** – Reflections from the vessel walls degrade our estimation

Main Goal

Recovering the blood spectrum while reducing the number of transmissions.

Sparse Doppler Transmission Strategy based on the Difference Array

- The blood spectrum is given by the Fourier transform of the signal autocorrelation.
- The autocorrelation $\boldsymbol{R}[d] = E\left[\boldsymbol{y}[p]\bar{\boldsymbol{y}}[p-d]\right]$ depends only on the **differences between samples**



- We introduce a sparse transmission scheme whose **difference array is full**

$$U = [U_A \;\; U_B] \rightarrow U_A = \{1, ..., A\}, \quad U_B = \{n(A+1) : n = 1, ..., B\}.$$

- This allows to recover the autocorrelation while reducing the number of transmission to $A+B$:

$$\min_{A,B} A + B \quad s.t. \; P = (A+1)B \rightarrow A = \sqrt{P} - 1, B = \sqrt{P}.$$

- The Doppler gaps created can be used for B-mode or for other Doppler sequences at different directions.
- **For more details:**

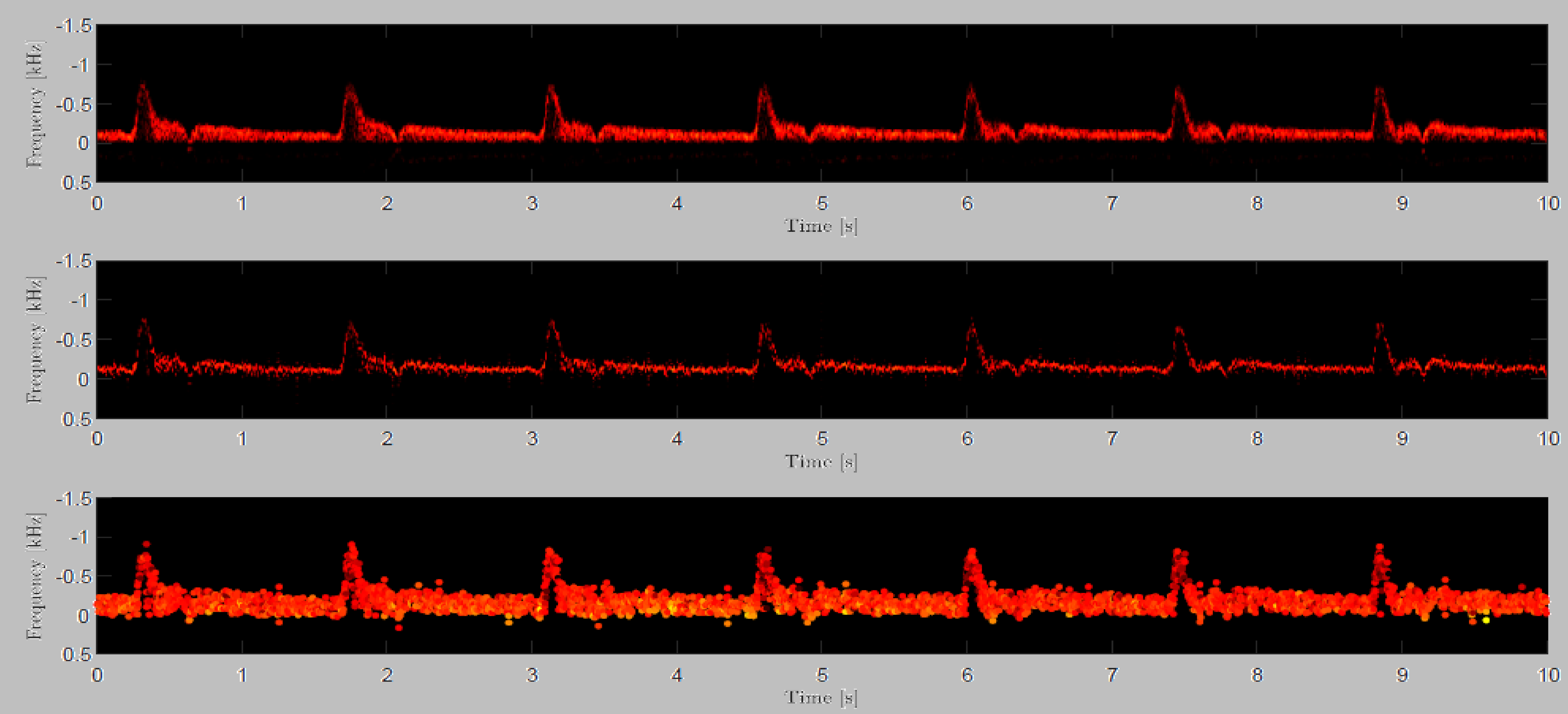
Cohen, R. and Eldar, Y.C. "**Sparse Doppler Sensing based on Nested Arrays".** To appear in IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control .

In-vivo Results – Axial Flow of Carotid Artery

Welch – 128 Pulses

NEST – 35 Pulses

NESPRIT – 35 Pulses



Sparse Convolutional Beamforming

Main Limitations of Standard Delay and Sum (DAS) Beamforming

- **Low Image Resolution.**
- **Low Image Contrast.**
- **Large Number of Elements (Receive Electronics) –** increase in size, power and cost.

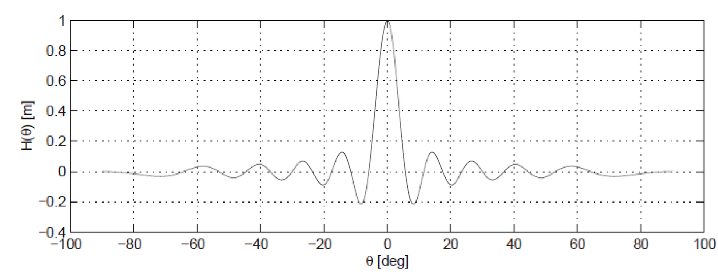
Main Goal

Reducing the number of receive elements while improving image quality.

Sparse Convolutional Beamforming based on Cantor Arrays

- Image quality is governed by the beam-pattern of the beamformer:

$$H(\theta) = \sum_{n=-(N-1)}^{N-1} e^{-2\pi j \frac{f \sin\theta}{c} n d_x}$$



- The beam-pattern can be represented as polynomial $H(x) = \sum_{n=-(N-1)}^{N-1} x^n$:
  - Improve image quality : $H(x)H(x) = \left(\sum_{n=-(N-1)}^{N-1} x^n\right)\left(\sum_{n=-(N-1)}^{N-1} x^n\right) = \sum_{n=-(2N-1)}^{2N-1} w_n x^n$
  - Reduce elements $N = AB$: $H(x) = \left(\sum_{n=-(A-1)}^{A-1} x^n\right)\left(\sum_{n=-(B-1)}^{B-1} x^{nA}\right) = H_A(x)H_B(x)$

Product of polynomials = discrete convolution

Convolution of received signals!

- We propose a **non-linear beamformer** which is based on the **convolution of received signal**s. This allows
  - **Significant element reduction.**
  - **Improved image quality – enhanced contrast and twice the standard resolution.**
- **For more details:**

Cohen, R. and Eldar, Y.C. "**Sparse Convolutional Beamforming for Ultrasound Imaging".** To appear in IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control.

In-vivo Cardiac Data

DAS – 64 Elements

SCOBA –16 Elements