Learning of Direction of Arrival Estimation Trends

From real world radars to state-of-the-art theoretical concepts introduced in the MSCSP program

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Introduction

- Before Ilmenau : Mumbai
- Before TU Ilmenau : Don Bosco Institute of Technology
- Before HiWi's : Research scientist at **S**ociety for **A**pplied **M**icrowave **E**lectronic **E**ngineering and **R**esearch (SAMEER), Mumbai, in the Atmospheric Radar and Instrumentation Division

Churchgate station,Mumbai [I]

Professional Background

SAMEER

[S]

- Projects:
  - Development and testing of **Ka-band cloud profiling** RADAR[1]

Professional Background

SAMEER [S]

- Projects:
  - Development and testing of **Ka-band cloud profiling** RADAR[1]
  - Development of a 576 element **electronically steered** phased array stratospheric – tropospheric (ST) RADAR

Professional Background

SAMEER [S]

- Job focus:
  - Designing and implementing a starvation free CAN network
  - Troubleshooting of the experimental Ka Band RADAR for monsoon experiments[1]
  - Building a digital receiver for RADAR applications using FlexRIO®
  - Design and testing of microwave components
  - Antenna design and testing

Why MSCSP ?

- Focus on physical layer processing
- Strong research focus on array based processing
- Work with a diverse group of people

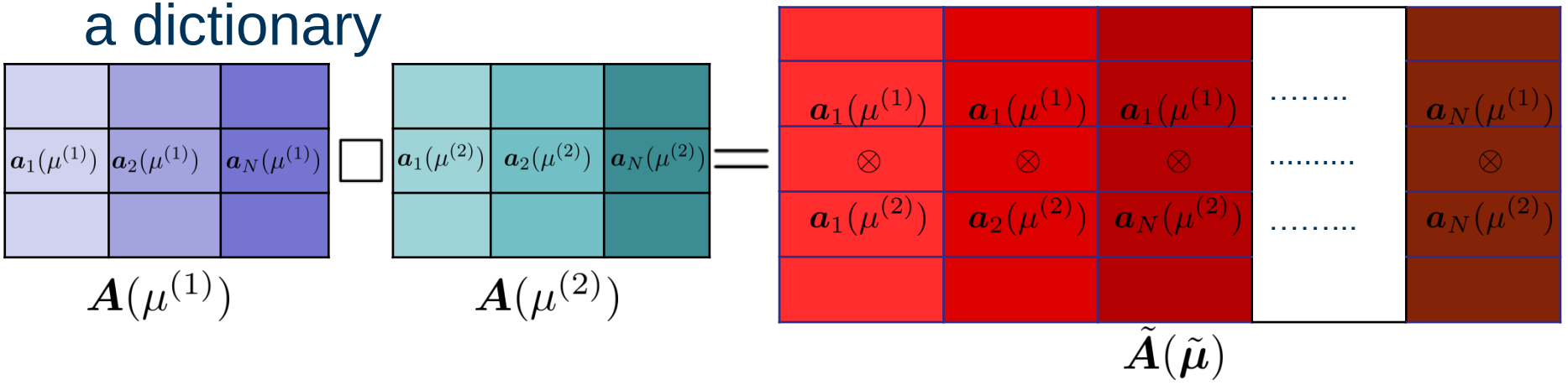
- Lovely Ilmenau weather…….

Research focus

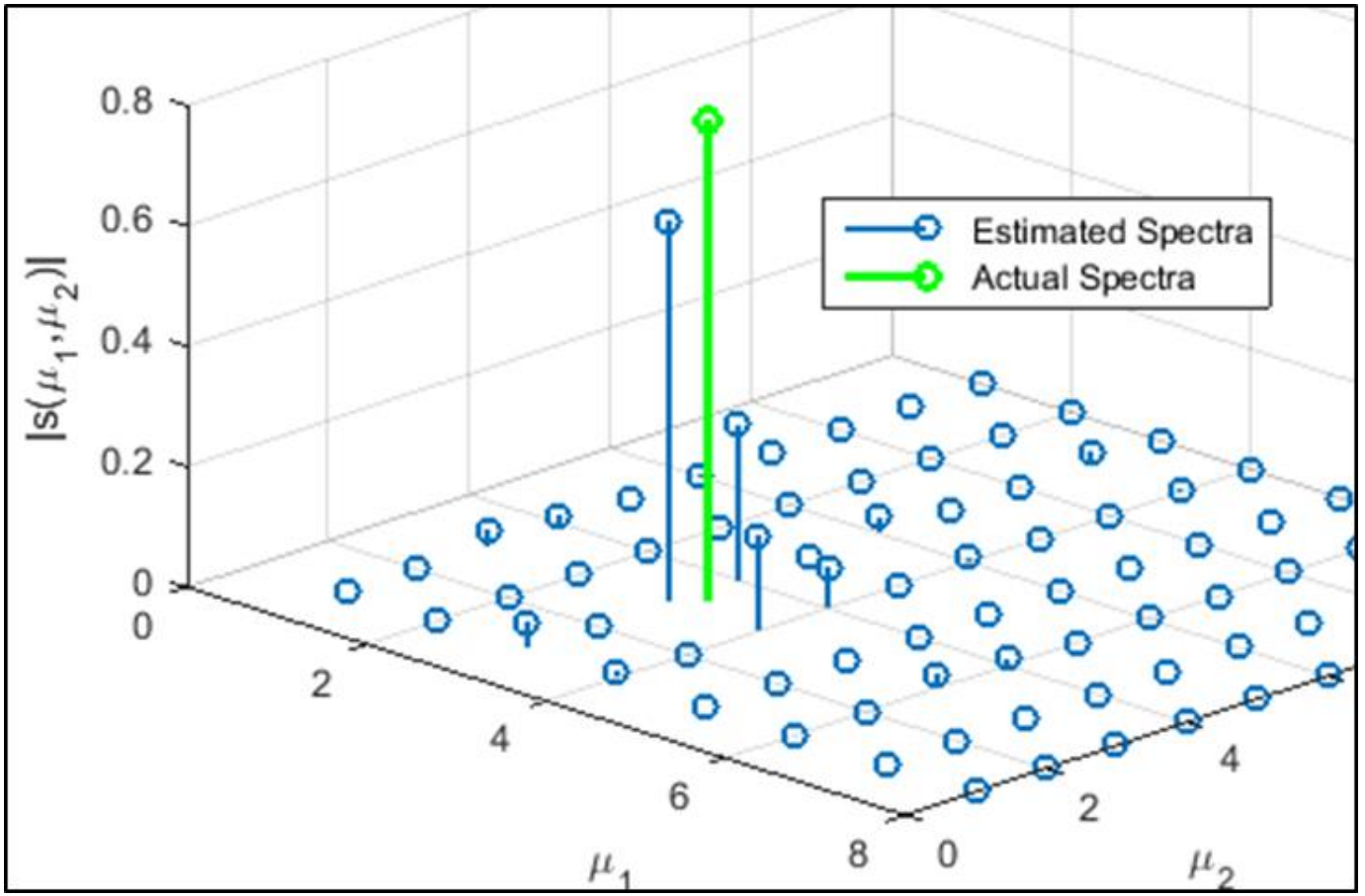
- Compressive Sensing based DoA estimators[4]
- Estimators can provide high resolution and better accuracy of estimation
  - Low Number of snapshots
  - No a-priori information on the number of source
  - Highly correlated sources
- Sparse models require the **discretization** of the spatial spectrum
  - This works well for on-grid case
  - Off-grid model mismatch

Research Focus

- Multidimensional DoA using sparse representation
- Research highlights
  - Single source considerations
  - Employing NC (Non-Circular) preprocessing[3]
  - Using block wise Tracy-Singh operator [2]($\square$) to create a dictionary



Research Focus (Results)



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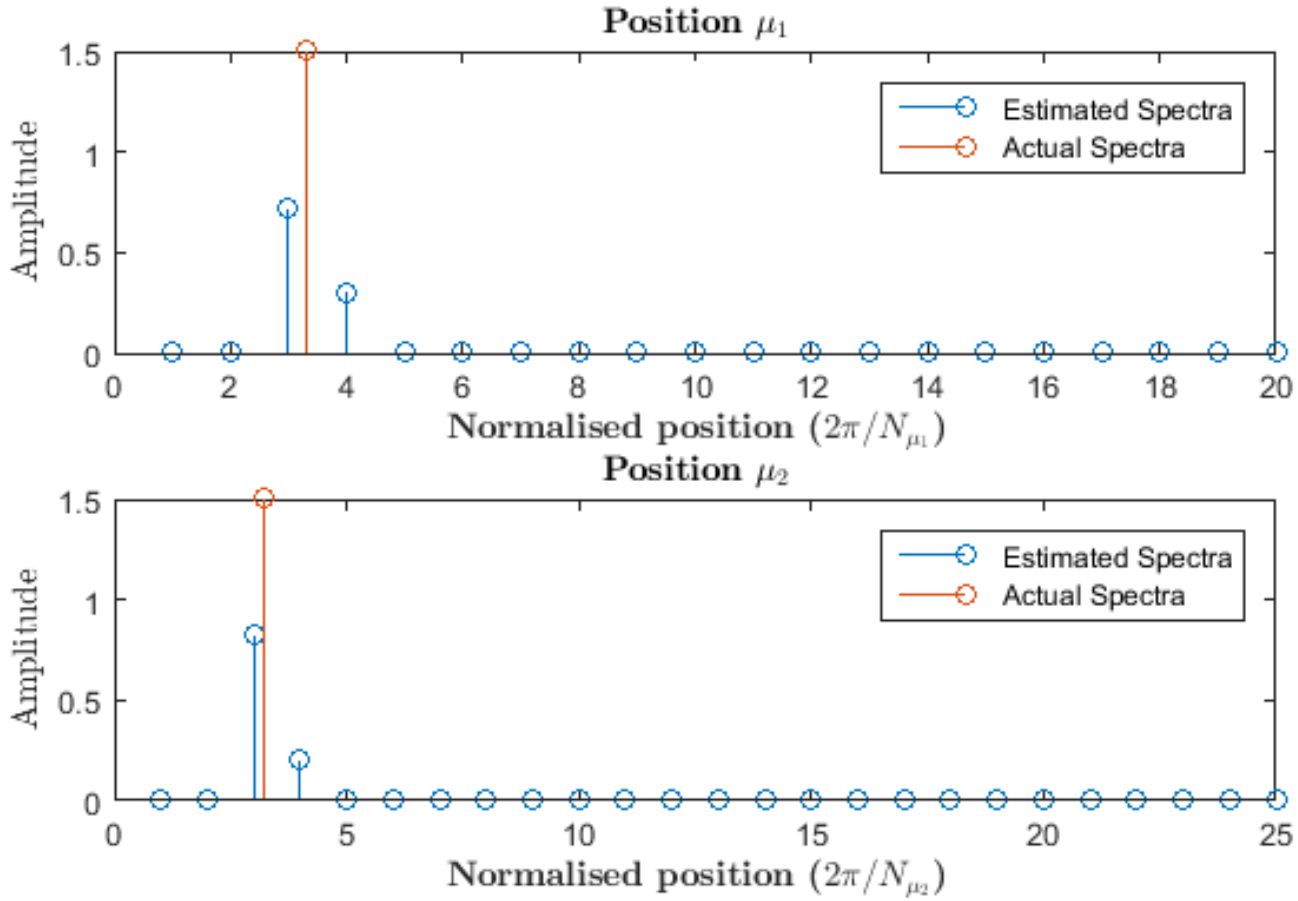
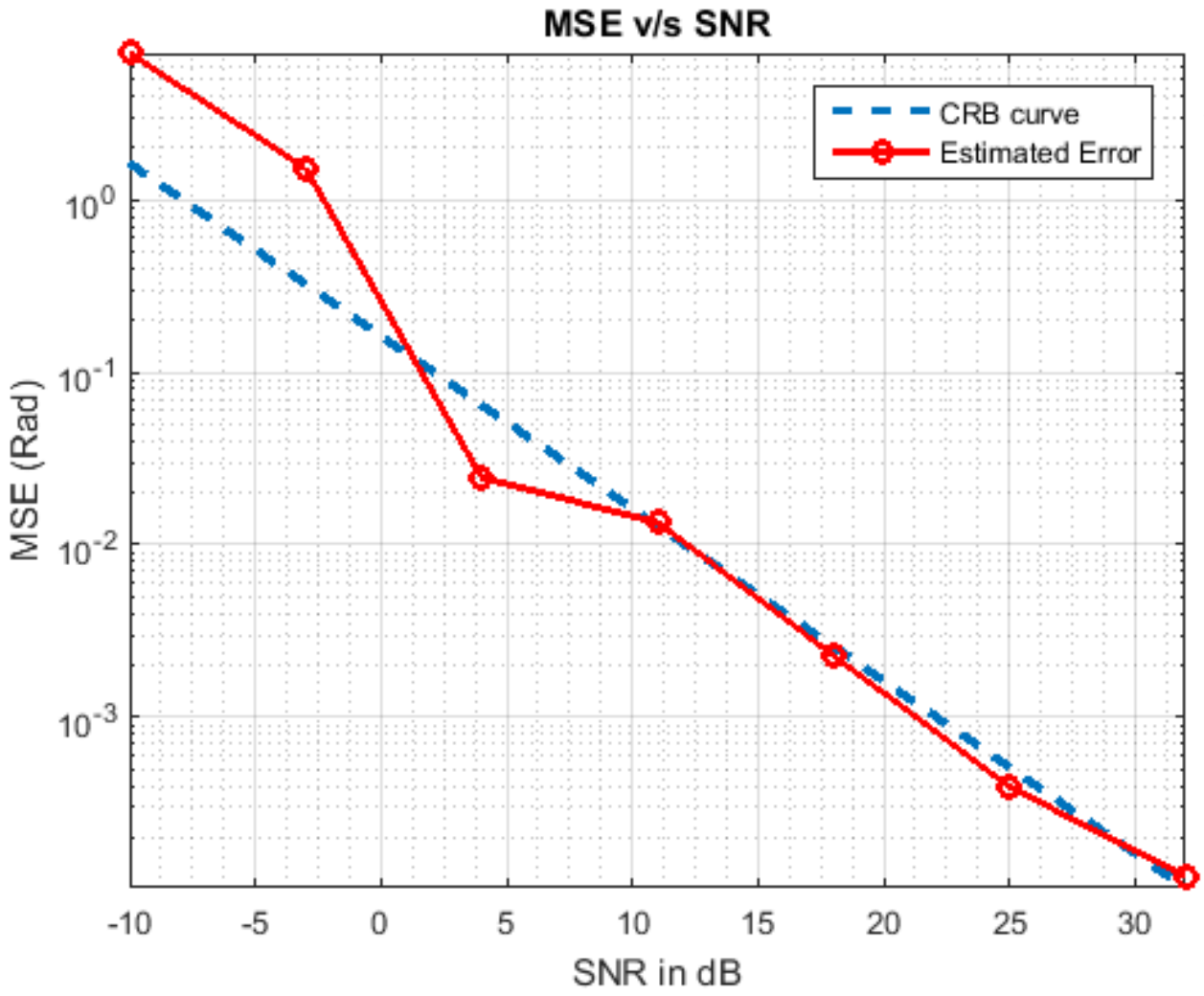


Simulation Parameters:

- Array Elements: $M_1 = 5; M_2 = 4$
- Oversampling Factor: $P_{\mu 1} = 5; P_{\mu 2} = 5$
- Number of snapshots: $T = 1$
- SNR = 30
- Algorithm used: **BPDN**

Research Focus (Results)



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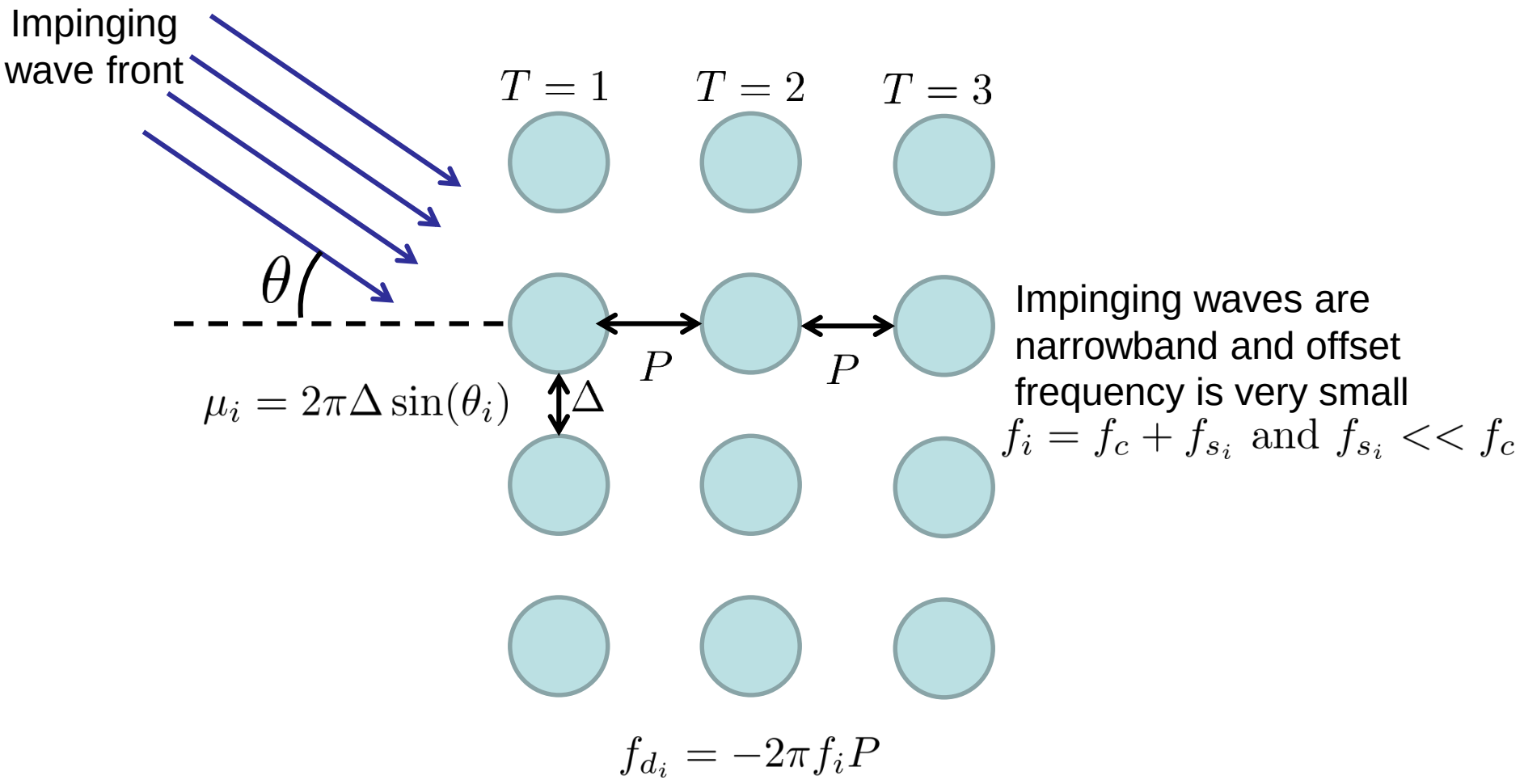
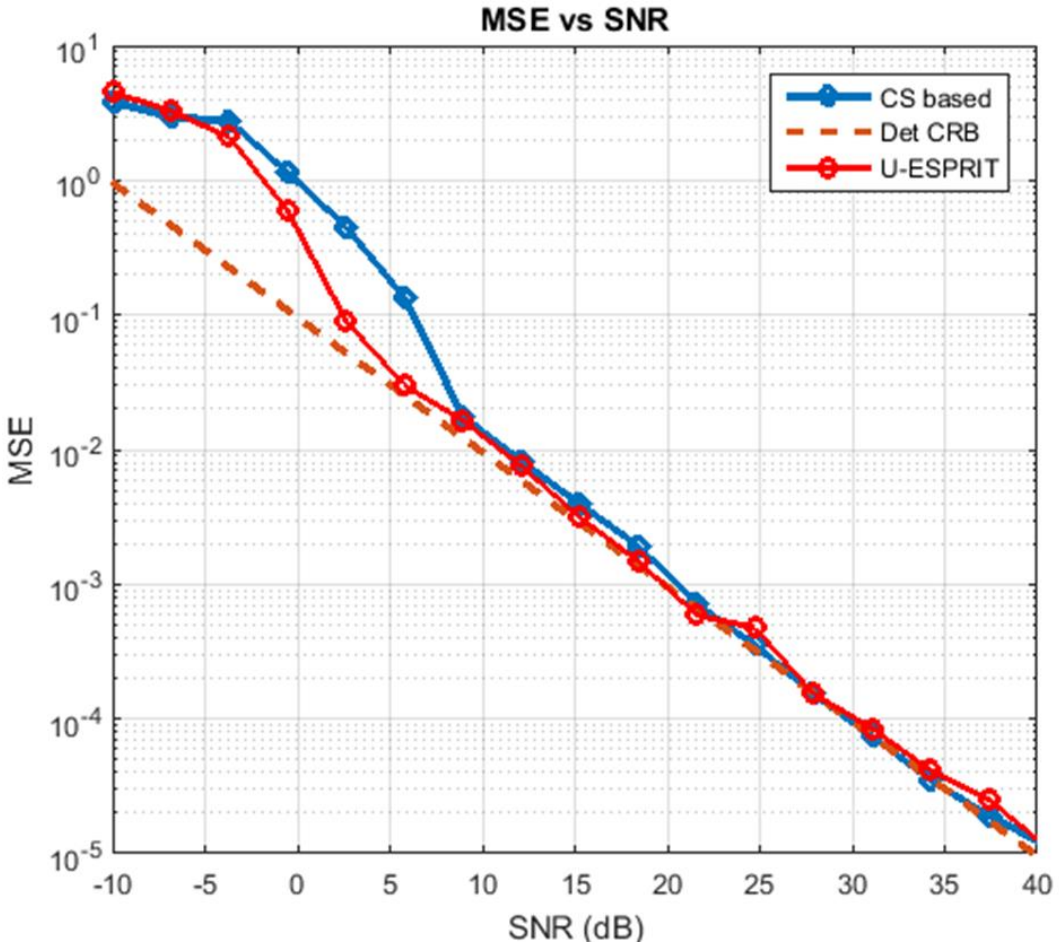
Research Focus

- Compressive sensing based **joint** DOA and frequency offset estimation
- Carrier offset is a common phenomenon in practical systems
  - Doppler
  - Oscillator jitter
- Joint estimator sees use in radar and channel estimation applications

Research Focus



Research Focus (Results)



Simulation Parameters CS:

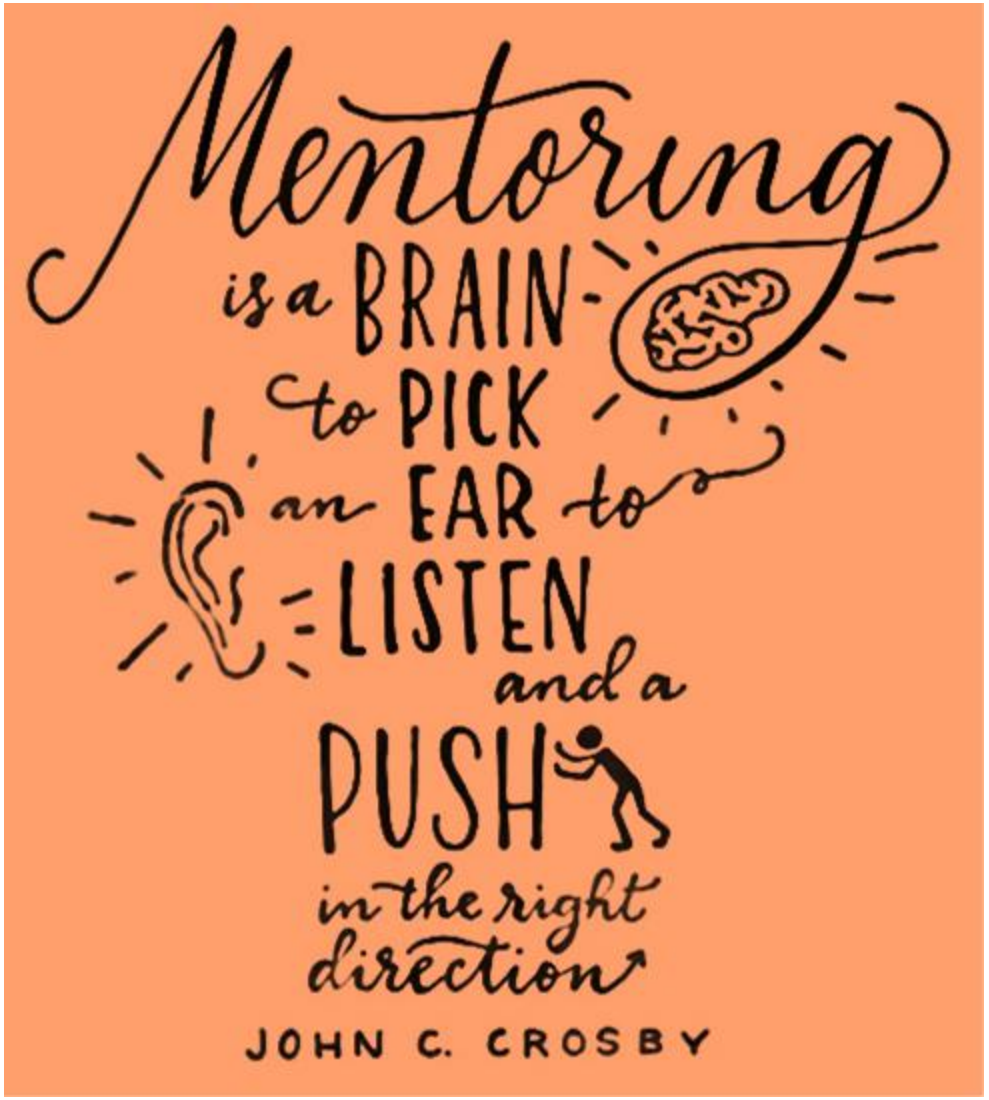
- Array Elements: $M = 4$
- Oversampling Factor: $P_\mu = 4$
- Number of snapshots: $T = 3$
- Oversampling Factor: $P_{fd} = 5$
- Algorithm used: **BPDN**

Simulation Parameters UE

- For Spatial smoothing
  $L_{\text{sub}}\mu = 3$
  $L_{\text{sub}}fd = 2$

MSCSP for me ?

- Strong mentors



[I]

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- Lots of research

MSCSP for me ?

- Strong mentors
- Lots of research
- Great colleagues

Meaningful growth requires challenge and stress

References

[1] A. Agarwal *et al*., "Monsoon cloud observations using a low power vertical looking Ka Band Cloud radar," *2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, Beijing, 2016

[2] D.S. Tracy, R.P. Singh, “A new matrix product and its applications in matrix differentiation*”* *Statistica Neerlandica*, 26 (1972), pp. 143–157

[3] J. Steinwandt, F. Roemer, and M. Haardt, ``Sparsity-based direction-of-arrival estimation for strictly non-circular sources," in *Proc. IEEE Int. Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Shanghai, China, Mar. 2016.

[4] M. Ibrahim, F. Roemer, R. Alieiev, G. Del Galdo, and R. S. Thomae, “On the estimation of grid offsets in CS-based direction-of-arrival estimation” *Proc. IEEE Int. Conf. Acoustics, Speech and Sig. Processing (ICASSP)*, Florence, Italy, May 2014.

[I] Images from “https://images.google.com”

[S] SAMEER logo “www.sameer.gov.in”