

Learning of Direction of Arrival Estimation Trends

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

Jason Candido Fernandes

Introduction

- Before Ilmenau : Mumbai
- Before TU Ilmenau : Don Bosco Institute of Technology
- Before HiWi's : Research scientist at **Society for Applied Microwave Electronic Engineering and Research (SAMEER)**, Mumbai, in the Atmospheric Radar and Instrumentation Division



Churchgate station, Mumbai [I]

Professional Background

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



Professional Background

- 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



- 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

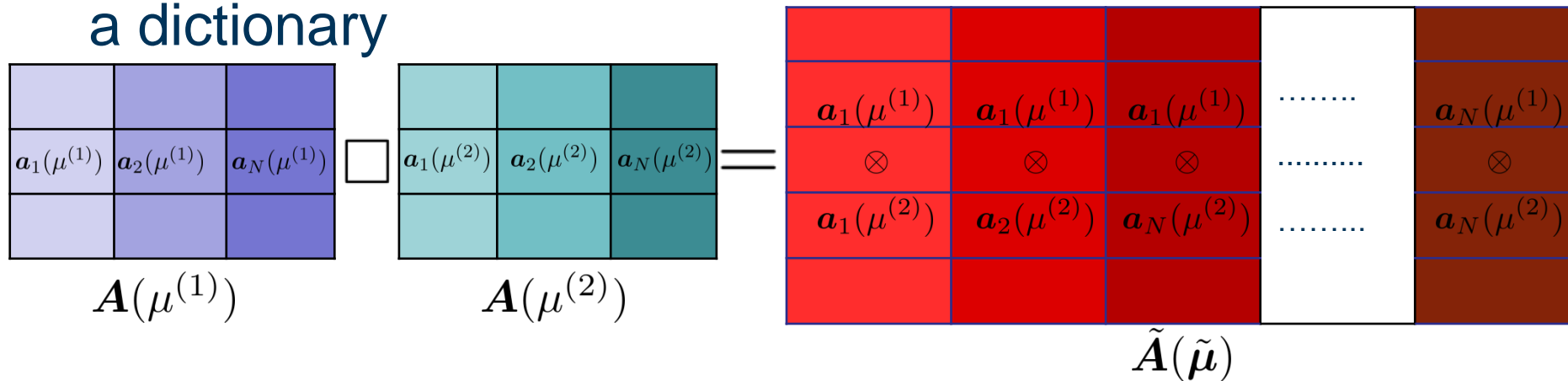
- Lovely Ilmenau weather.....

Research focus

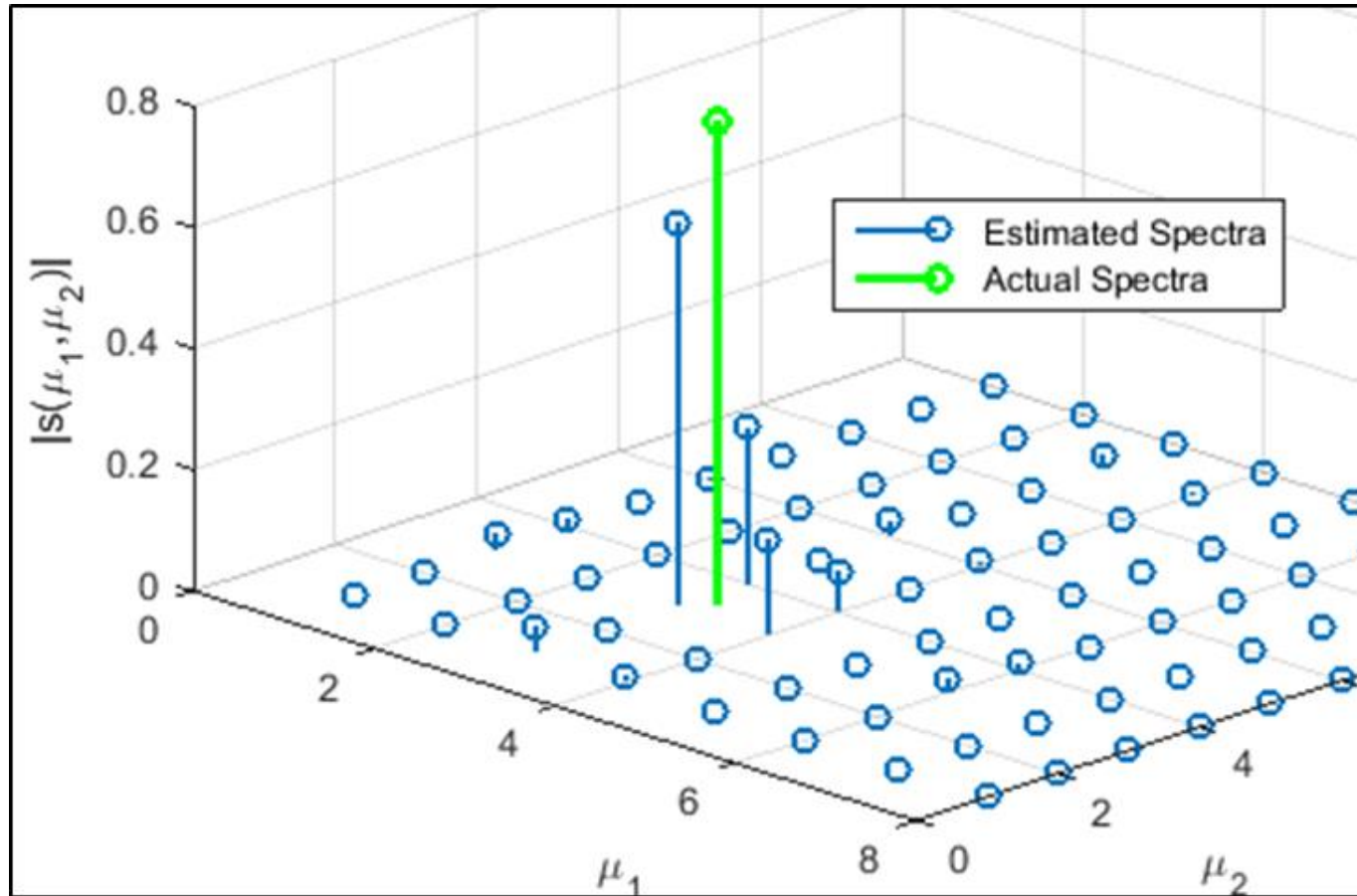
- Compressive Sensing based DoA estimators^[4]
- Estimators can provide high resolution and better accuracy of estimation
 - Low Number of snapshots
 - No a-priori information on the number of source
 - Highly correlated sources
- Sparse models require the **discretization** of the spatial spectrum
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

Research Focus

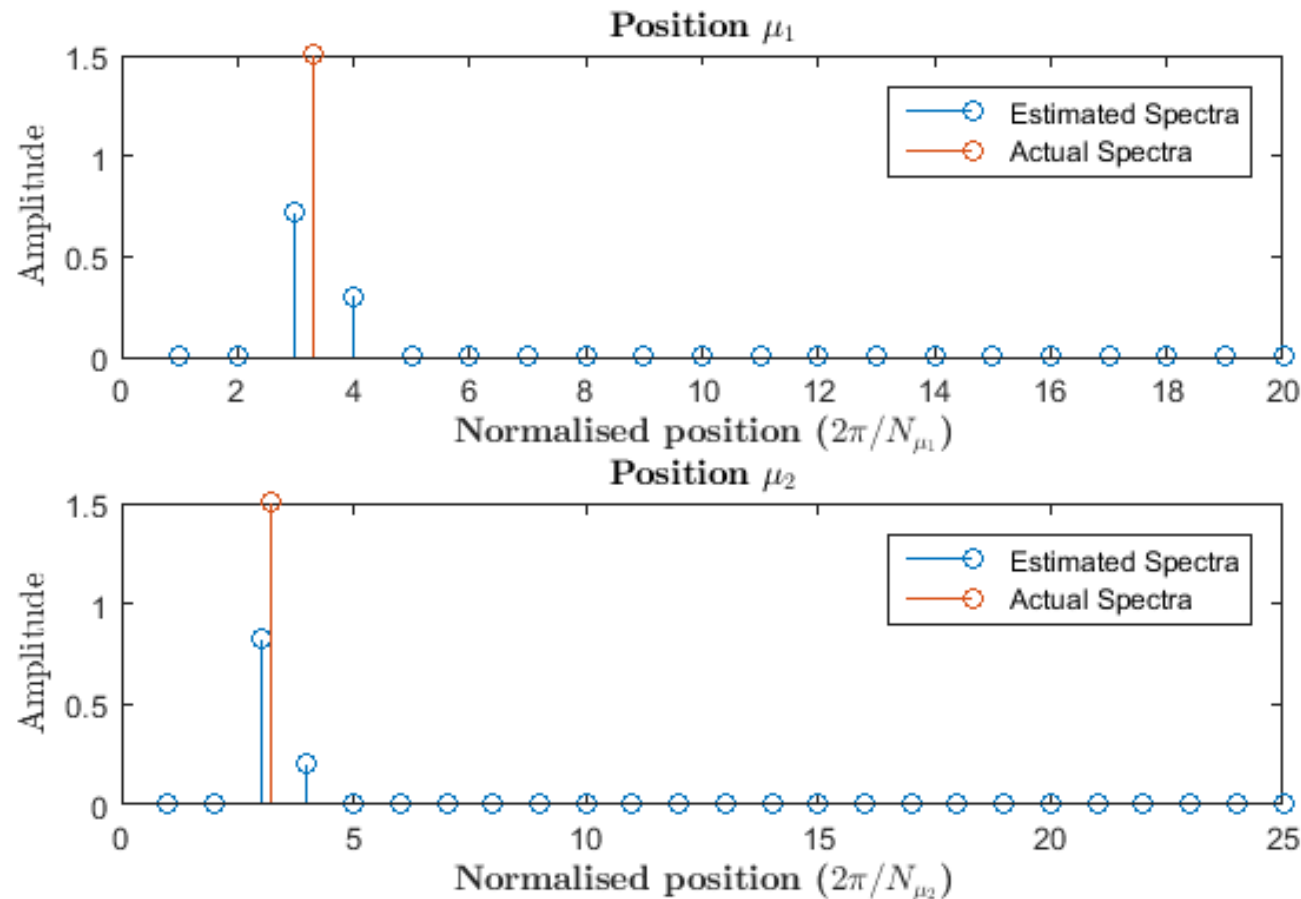
- Multidimensional DoA using sparse representation
- Research highlights
 - Single source considerations
 - Employing NC (Non-Circular) preprocessing^[3]
 - Using block wise Tracy-Singh operator ^[2](\square) to create a dictionary



Research Focus (Results)



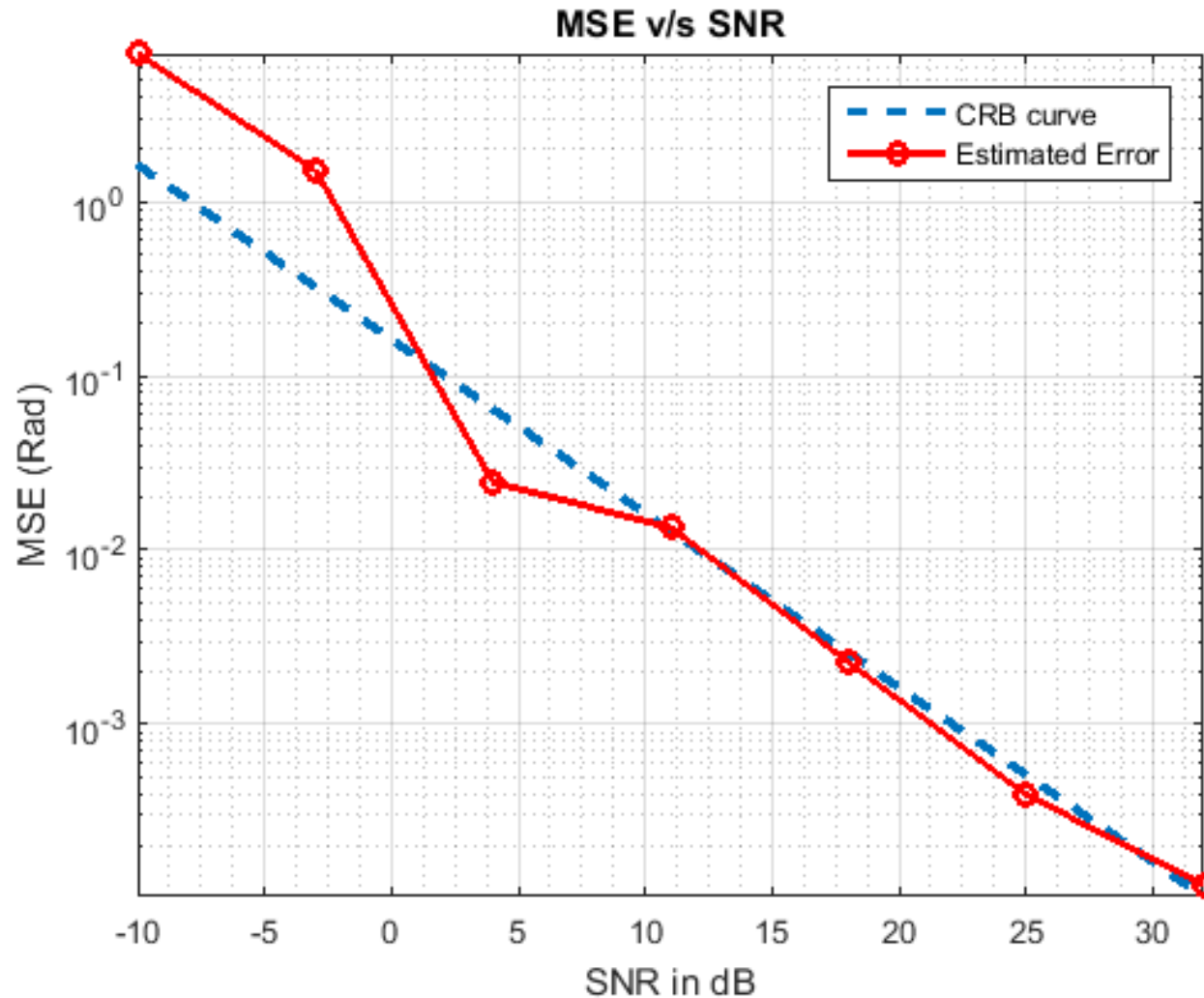
Research Focus (Results)



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)



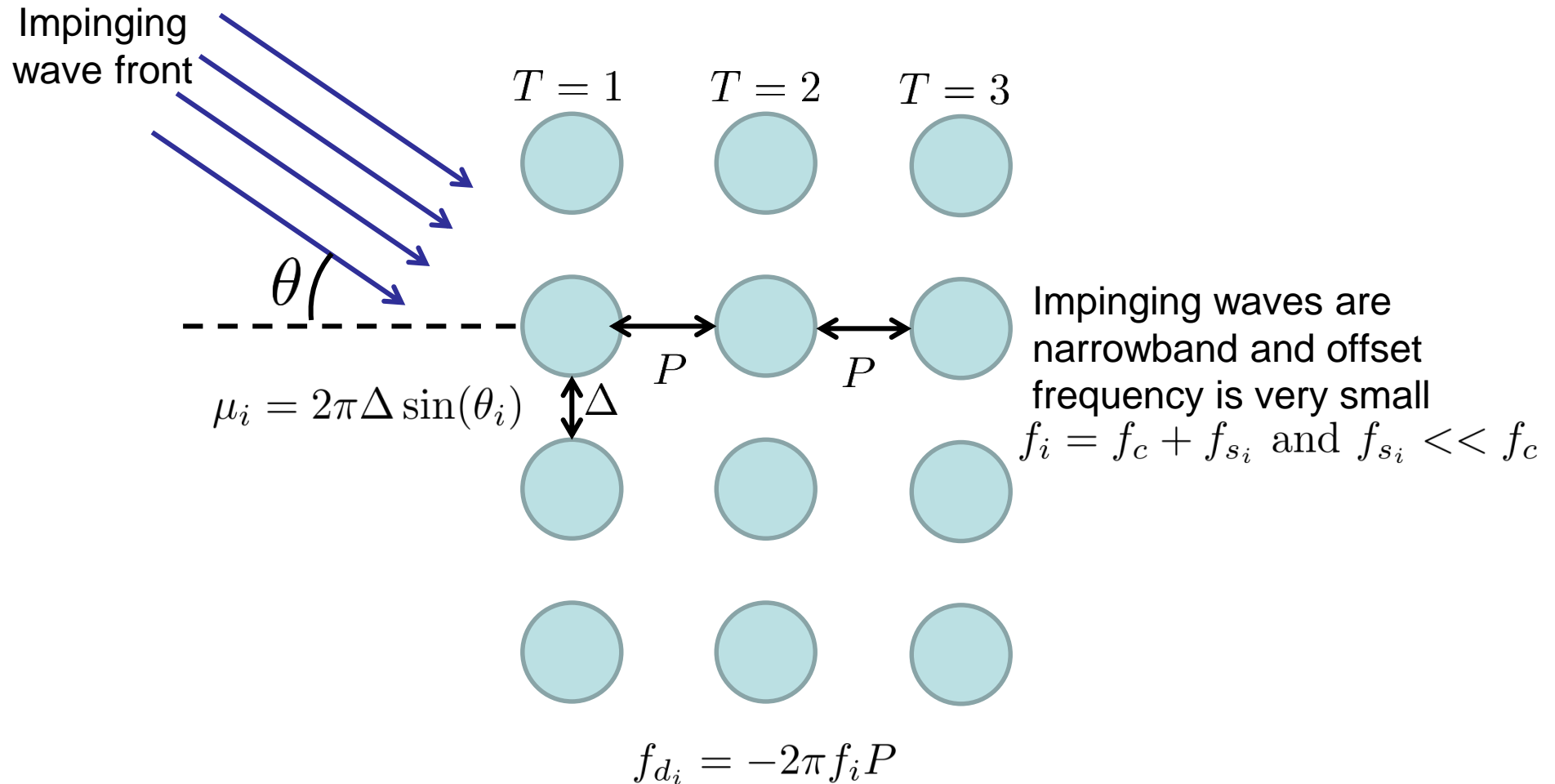
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- Array Elements:
 $M_1 = 5; M_2 = 4$
- Oversampling Factor:
 $P_{\mu 1} = 5; P_{\mu 2} = 5$
- Number of snapshots:
 $T = 1$
- Algorithm used:
BPDN

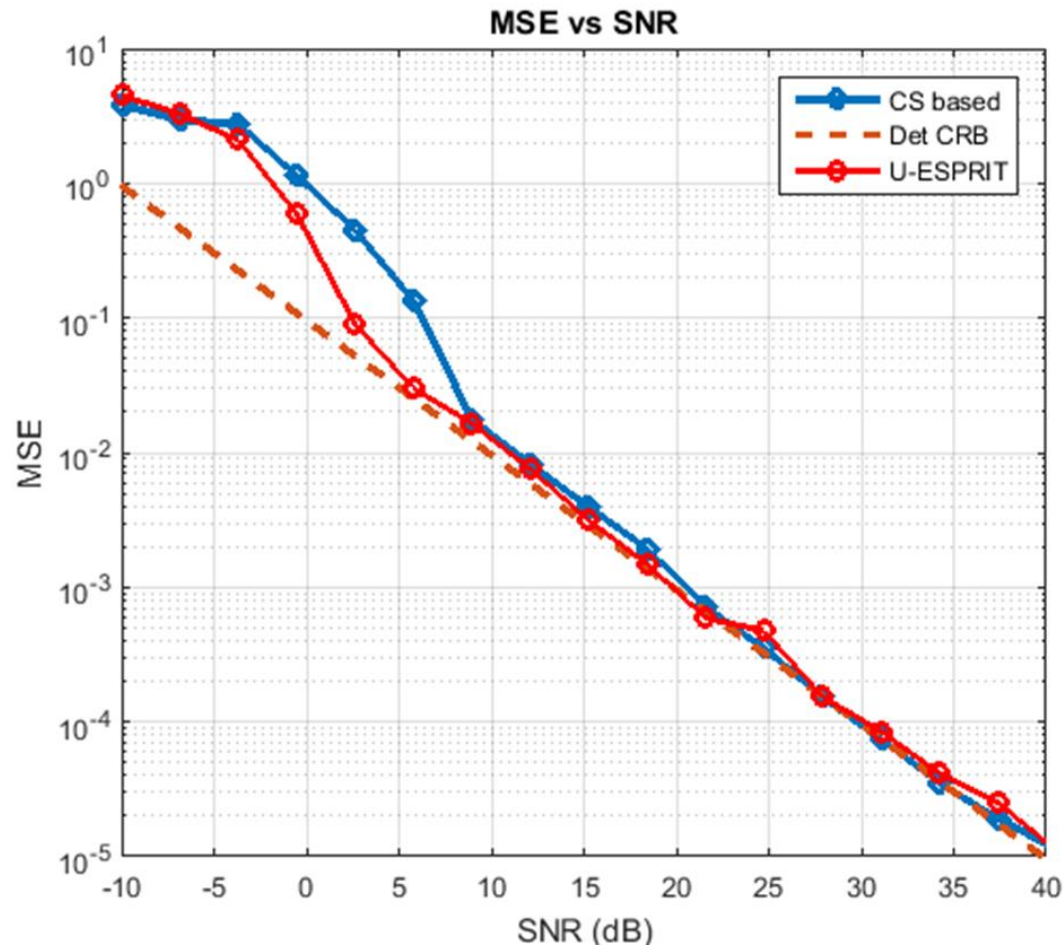
Research Focus

- 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:

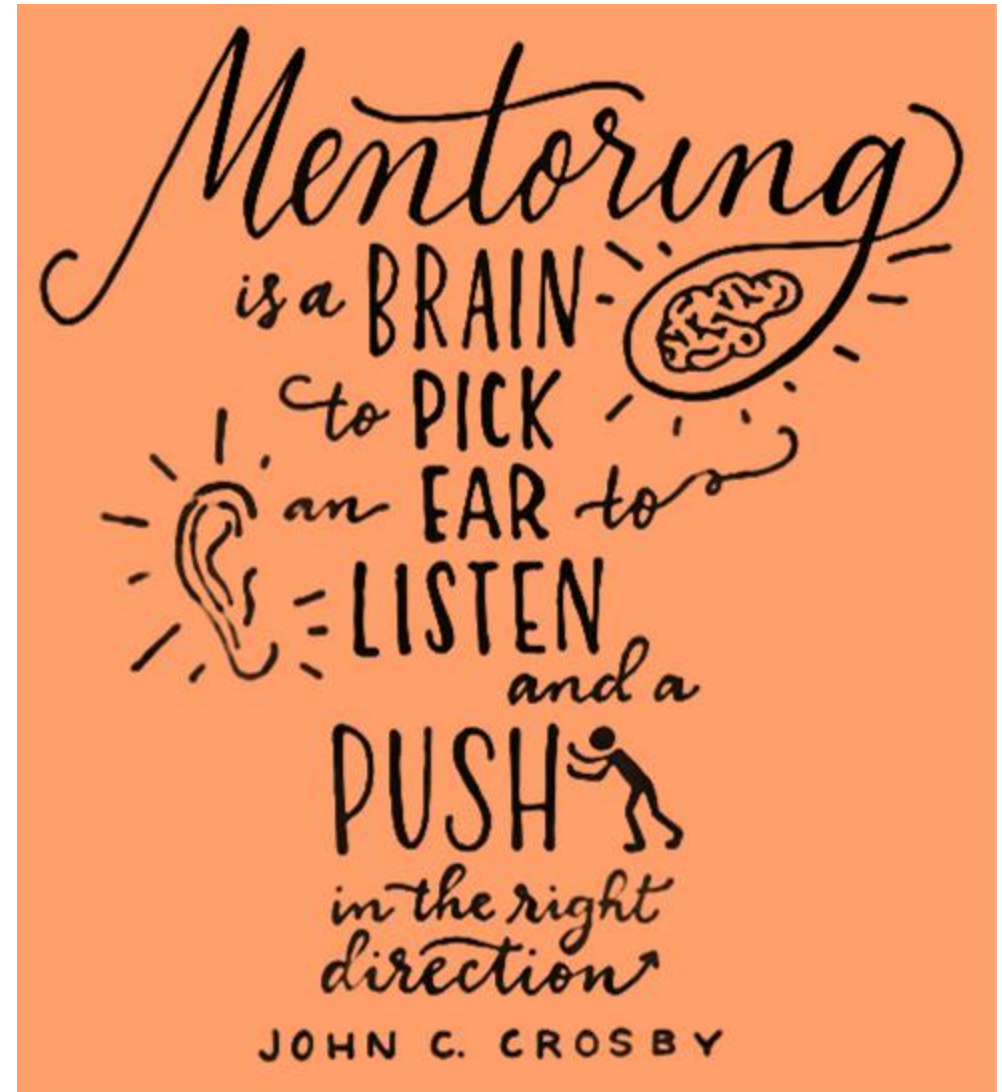
- Array Elements:
 $M = 4$
- Oversampling Factor:
 $P_{\mu} = 4$
- Number of snapshots:
 $T = 3$
- Oversampling Factor:
 $P_{fd} = 5$
- Algorithm used: **BPDN**

Simulation Parameters UE

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

MSCSP for me ?

- Strong mentors



[1]

MSCSP for me ?

- Strong mentors
- Lots of research

Survey on Indoor Positioning Techniques

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I. ABSTRACT
Observing the current trends on automation and ubiquitous computing the need for localization and navigation become the prime focus of a lot of applications. Cr the field of indoor localization has developed different methods, however owing to the limited hardware and changing sensing environment, a common technique that can be universally applicable is still missing.

Survey on Resource Management for an Underlay D2D Network

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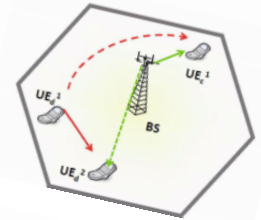
Multi-Dimensional Sparsity based Direction-of-Arrival Estimator Exploiting Strictly Non-Circular Sources

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Supervisor: M.Sc. Jens Steinwandt
Responsible Professor: Prof. Martin Haardt

Abstract: The field of direction-of-arrival (DOA) estimation is of high research interest for various applications. The use of compressed sensing representations of the signals has brought about the use of sparse recovery algorithms to solve DOA estimation problems. Sparse recovery algorithms offer inherent advantages over conventional DOA estimation methods.

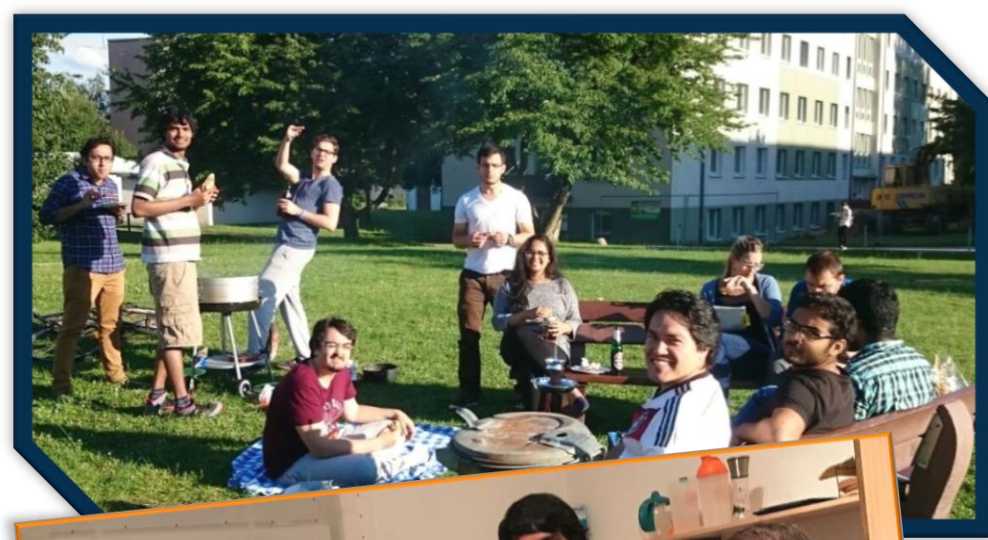
Abstract: The use of sparse representation in direction of arrival (DoA) estimation has been around for a while. This exploits the angular sparsity of the impinging wave algorithm as proposed in [1] uses standard ESPRIT to estimate jointly the frequency and angle of the incoming signals. In the signal model is considered with unitary ESPRIT with

Efficient available led to D2D network



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"