Co-existence of MIMO Radar and Communication Systems: Real-Time Framework for Interference Control

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Spectrum Sharing Around the Globe (1/2)

Geographical Area

Population

Economy

Releasing radar bands is not feasible, and data-base approaches are more attractive. (Radar remains the primary user)

Spectrum Sharing Around the Globe (2/2)

Releasing radar bands is less expensive compared to data-base approaches. (Radar becomes the a secondary user)

Can radar operate as a secondary user?

Objectives

Design a MIMO radar as a secondary user with interference avoidance (and control) capabilities

Suggest a timing framework to enable such a MIMO radar design

We propose a MIMO radar pre-coder design based on a steepest descent approach

Why MIMO Radar?

MIMO vs Phased array

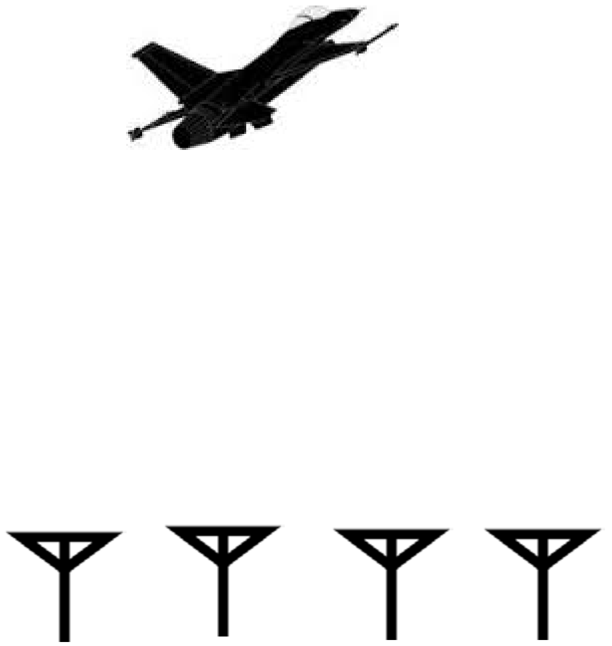
1. Improved parameter identifiability

Higher target resolution.

2. Better beam-pattern matching designs, lower side lobes

3. Improved interference rejection capabilities

MIMO radar provides higher degree of freedom in design, and more flexibility in trade-off in the spectrum sharing



Previous Literature: Opportunistic MIMO Radar Interference Control

2012

Null-space projection

[S. Sodagari et al., Globcomm 2012]

2013

Subspace expansion

[A. Babaei et al. ICC 2013]
[A. Babaei et al., Globcomm 2013]

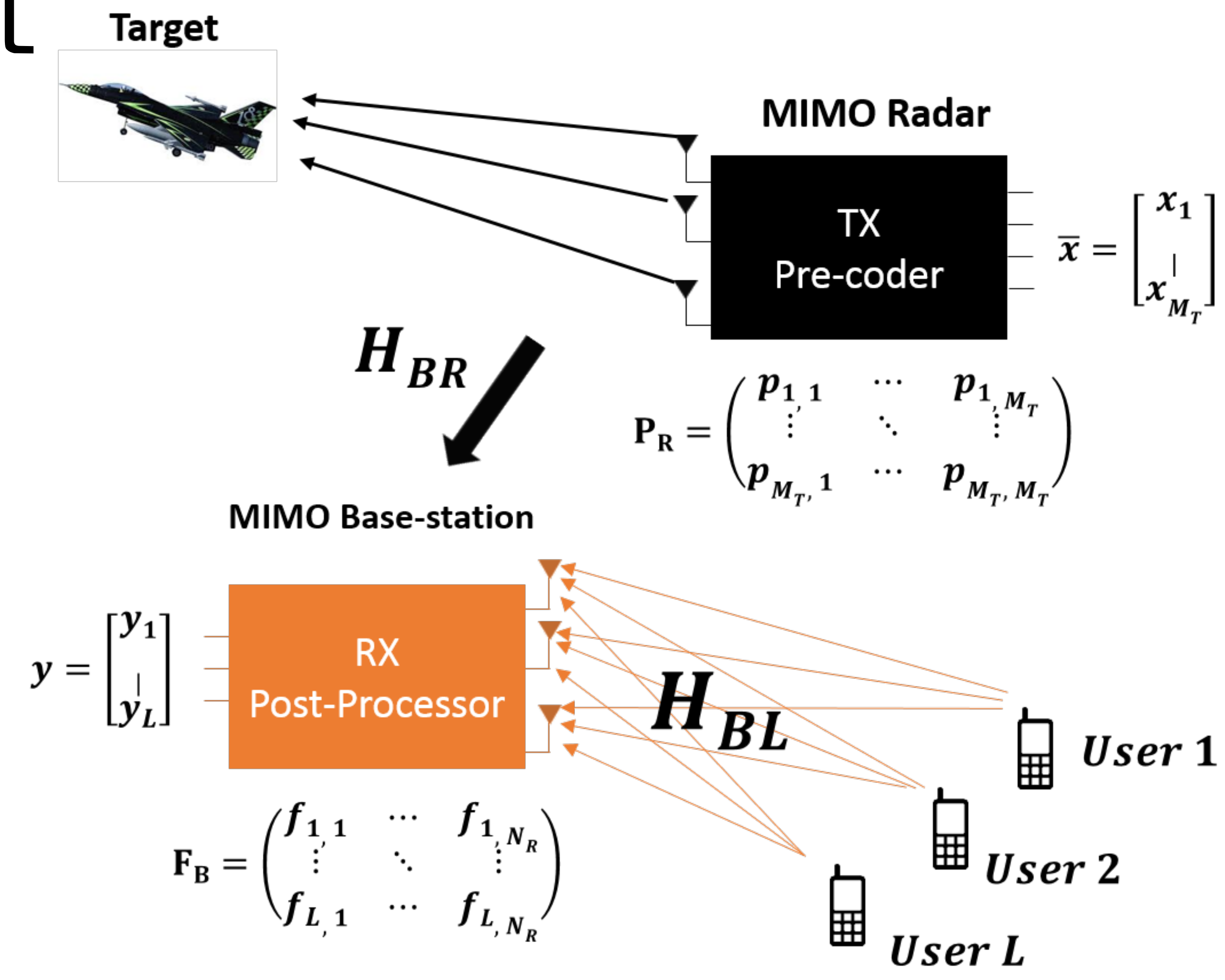
2015

Polynomial Subspace Expansion

[M. Hirzallah, T. Bose, Winncomm 2015]

The computational complexity is high!!
Can we reduce it?

System Model

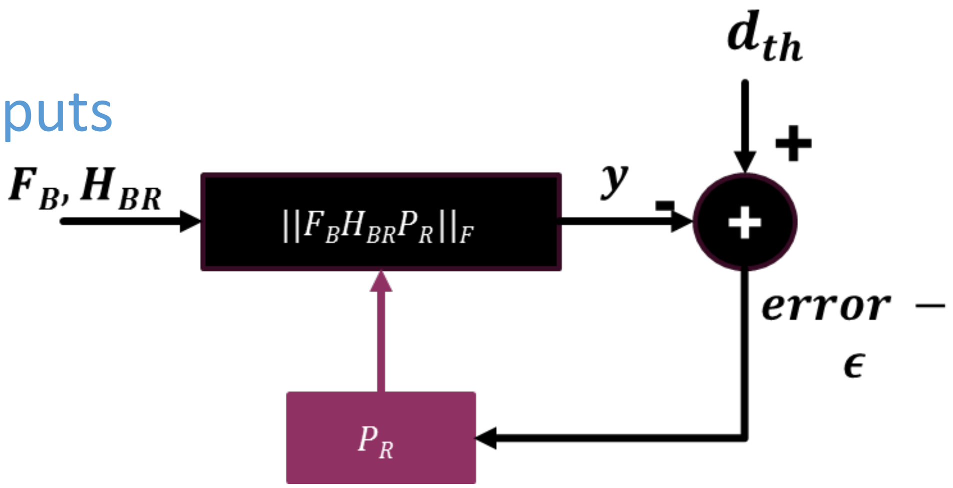


Pre-coder Design

$$d_{th} = ||F_B H_{BR} P_R||_F$$

Tolerable level of interference

Inputs



Steepest descent (SD) solution

$$P_R[k+1] = P_R[k] + 2\mu\, \epsilon[k] \cdot ||F_B H_{BR}||_F \cdot P_R[k]$$

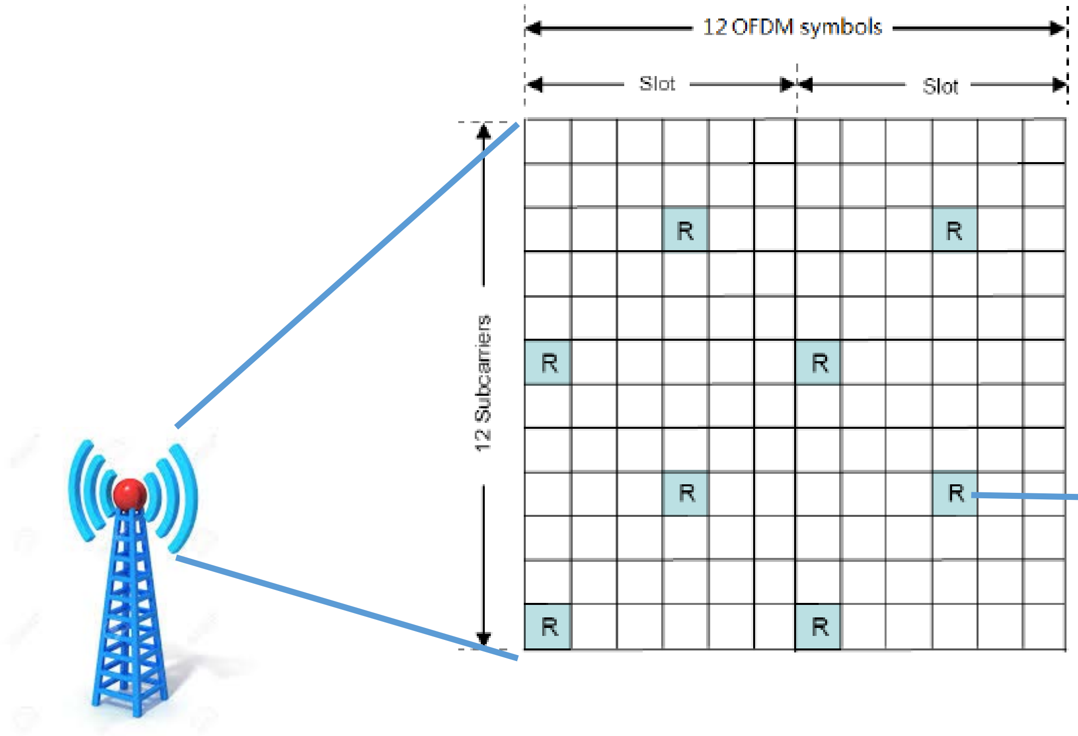
Derivations are in the paper

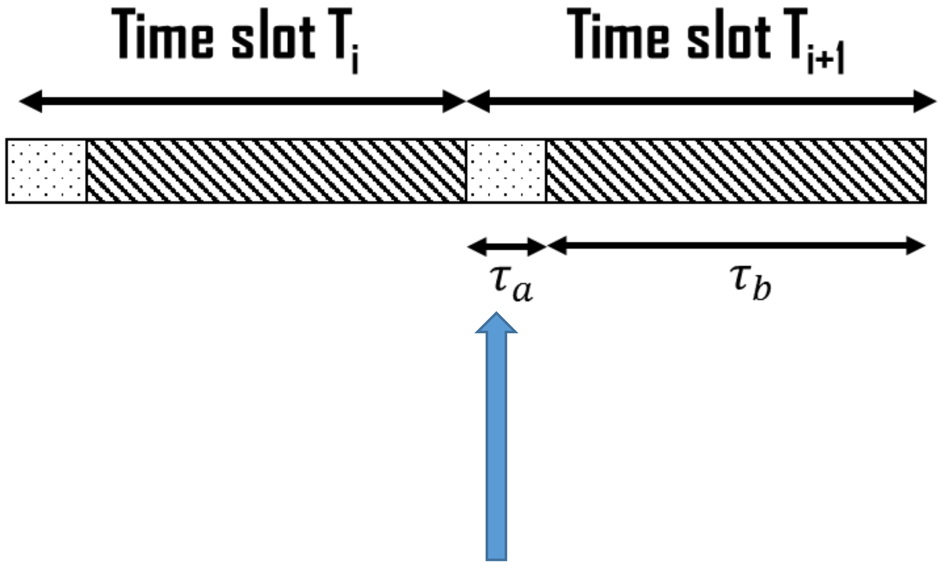
N… …ion

$$\cdot \left|\left|F_B H_{BR}\right|\right|_F \cdot P_R[k]$$

How to obtain inputs $F_B H_{BR}$?

Time Framework





Radar overhears reference symbols (RS) for a time period τ_a to estimate $F_B H_{BR}$

Algorithm: SD based interference control

Algorithm 1 SD-based interference control

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procedure DESIGN RADAR'S PRE-CODER P_R
Start new time slot T_i:
Inputs: d_th^(i), F_B^(i), and H_BR^(i)
State the error tolerance δ^(i) and the convergence factor μ^(i):
        δ^(i) = 0.01, 0 ≤ μ^(i) ≪ 1
State the initial pre-coder settings, P_R^(i)[k = 0]:
        P_R^(i)[k = 0] = randn(M_T) + j randn(M_T), or
        P_R^(i)[k = 0] = P_R^(i−1)
Keep updating the radar' pre-coder using (6) or (10) and
stop when |d_th^(i) − ||F_B^(i) H_BR^(i) P_R^(i)[k]||_F| ≤ δ^(i) is satisfied
Outputs:
        P_R^(i)
Channel changes
        loop to: start a new time slot, T_{i+1}
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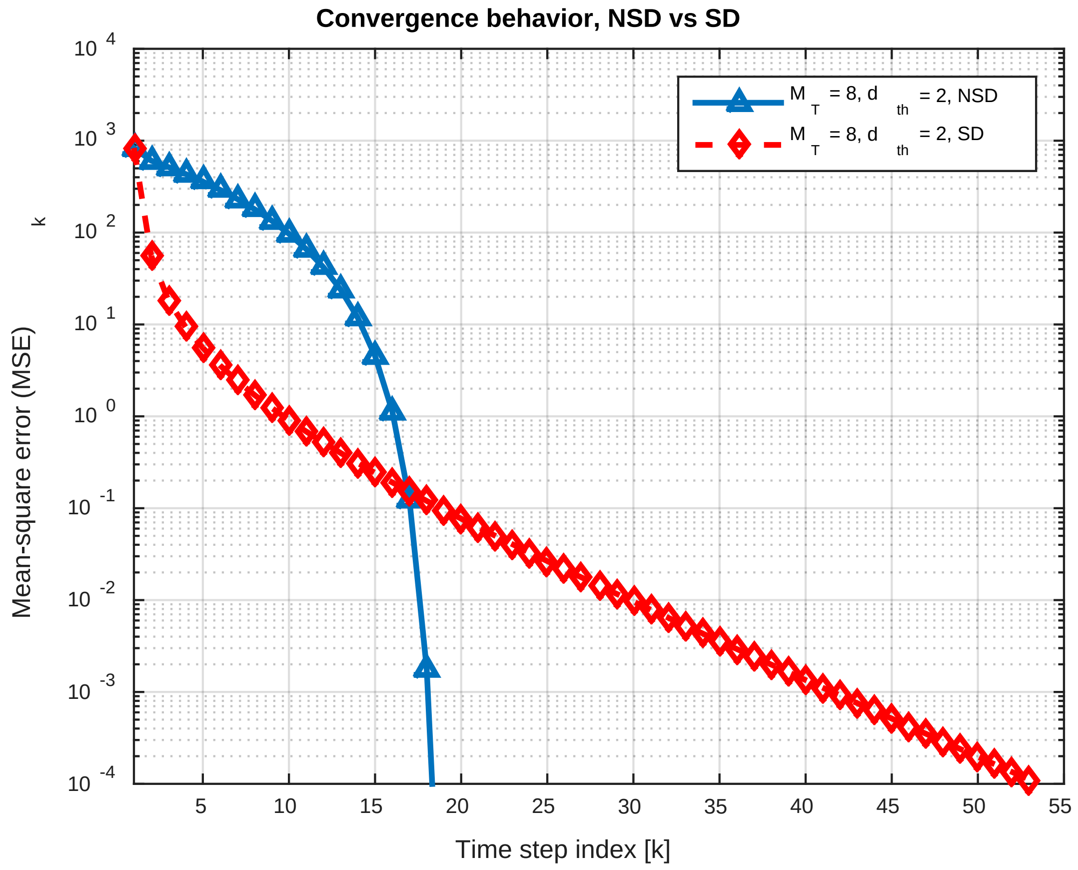
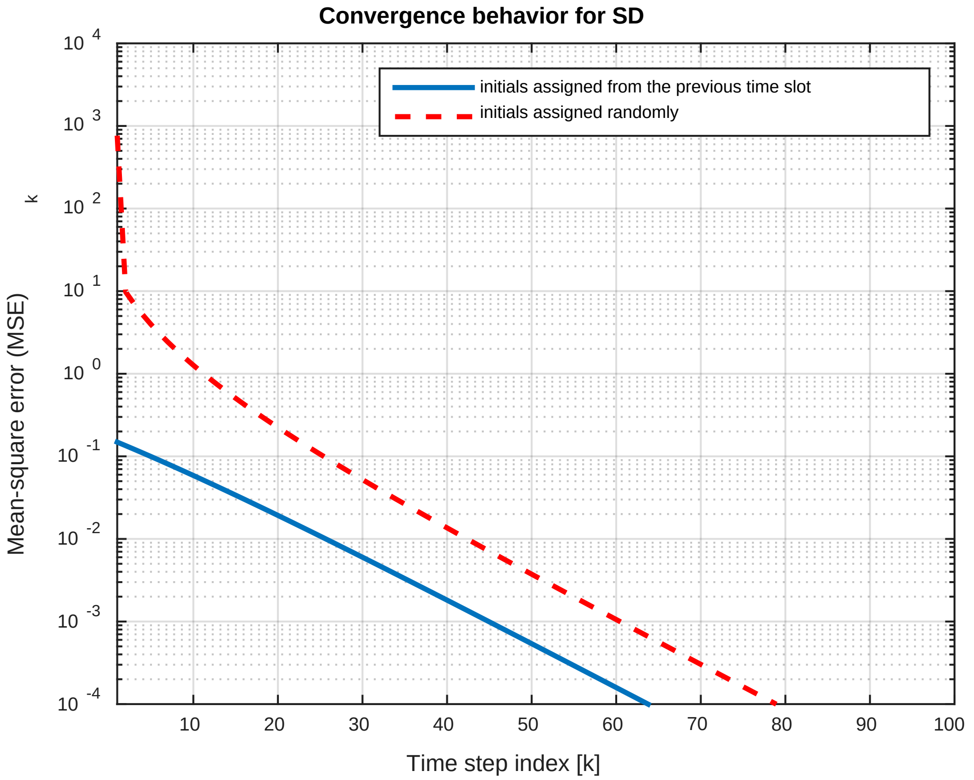
Numerical Results (1/3)

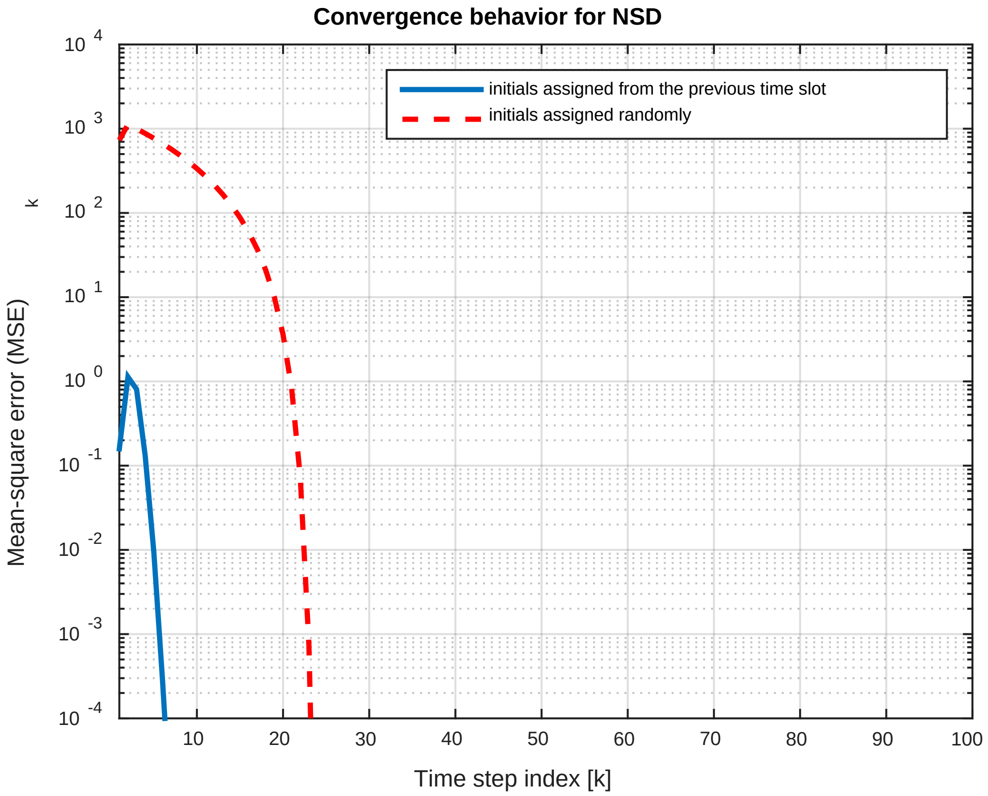


Steepest descent (SD) vs normalized steepest descent (NSD) performance

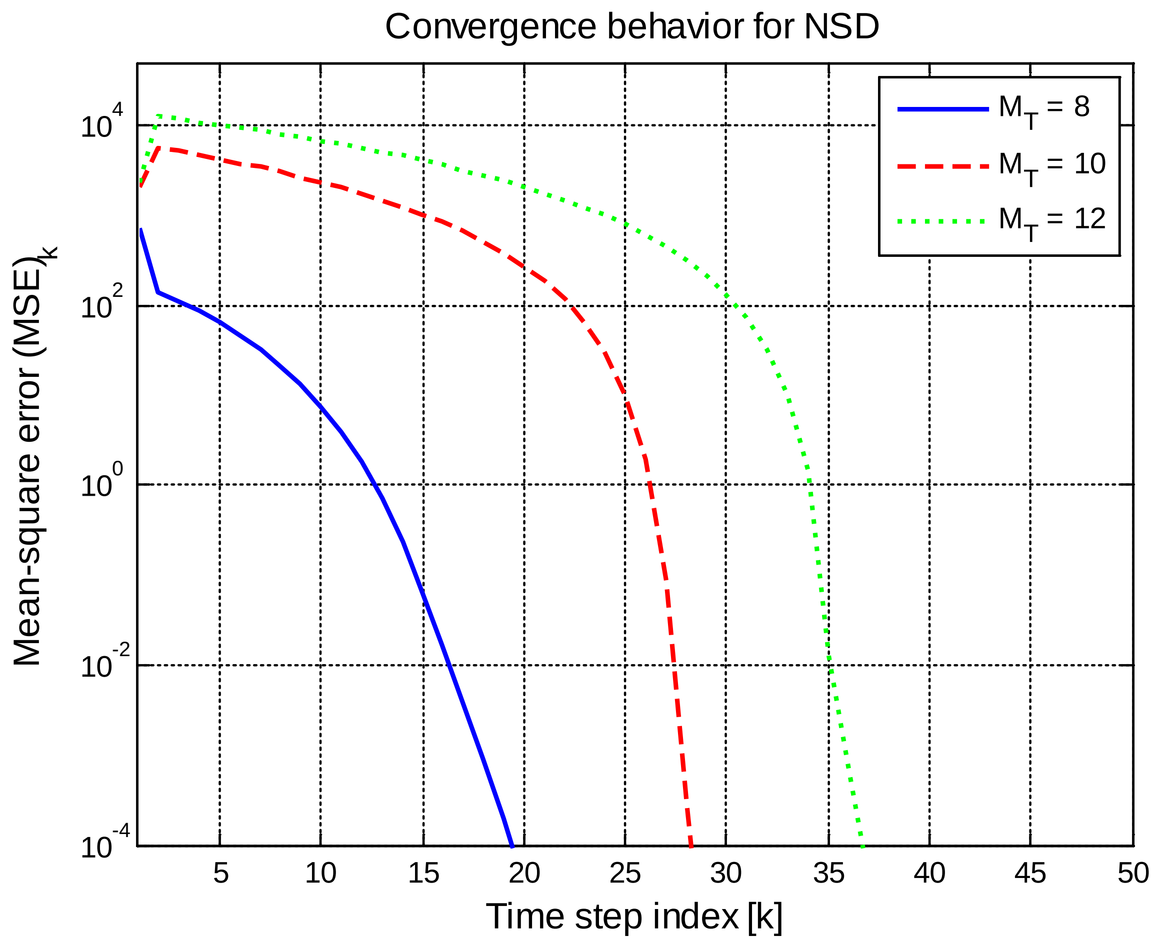
Numerical Results (2

Effect of initial settings on both designs





Numerical Results (3/3)



Scalability of the solution with the increase in the number of antennas

Conclusions & Future Work

- We have presented an secondary user MIMO radar scheme, where we reduce the interference caused into communication receiver
- We have derived two pre-coder solutions based on a steepest descent approaches
- Our future work will include an investigation for the performance of MIMO radar under the proposed scheme

Questions?