Performance Evaluation of MIMO Detectors over Impulsive Noise

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Presenter

- Danilo S. Pena received his B.Sc. degree in 2012 and his M.Sc. degree in 2014, where he worked on signal processing and embedded systems projects. He obtained his Ph.D. degree in signal processing in 2019, where his research involves statistical signal processing, optimization, and array signal processing. He developed a novelty method for source localization based on acoustic signals over severe conditions at the Federal University of Rio Grande do Norte (UFRN), Brazil. Currently, he works as an R&D engineer in the Protocol TG at Sidia in Brazil.

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Sidia Research

- Topics where Sidia has published
  - MIMO detectors
  - MIMO antennas
  - Massive MU-MIMO systems
  - Beamforming
  - mmWave systems
  - UE power consumption
  - Machine Learning applied to LTE networks

Agenda

- Introduction
- MIMO System
- Impulsive Noise
  - Symmetric α-Stable Model
  - Gaussian Mixture Model
- MIMO Detectors
- Results and Discussions
  - Noise Model Analysis
  - Impulsiveness Analysis
- Conclusions

Introduction

- Scope: MIMO detectors over impulsive noise. Traditional detectors depend on second-order statistical noise assumptions (Gaussian noise). They suffer severe degration over non-Gaussian scenario.

- Goal
  - <u>Analyze the performance of traditional MIMO detectors over non-Gaussian noise scenarios.</u>

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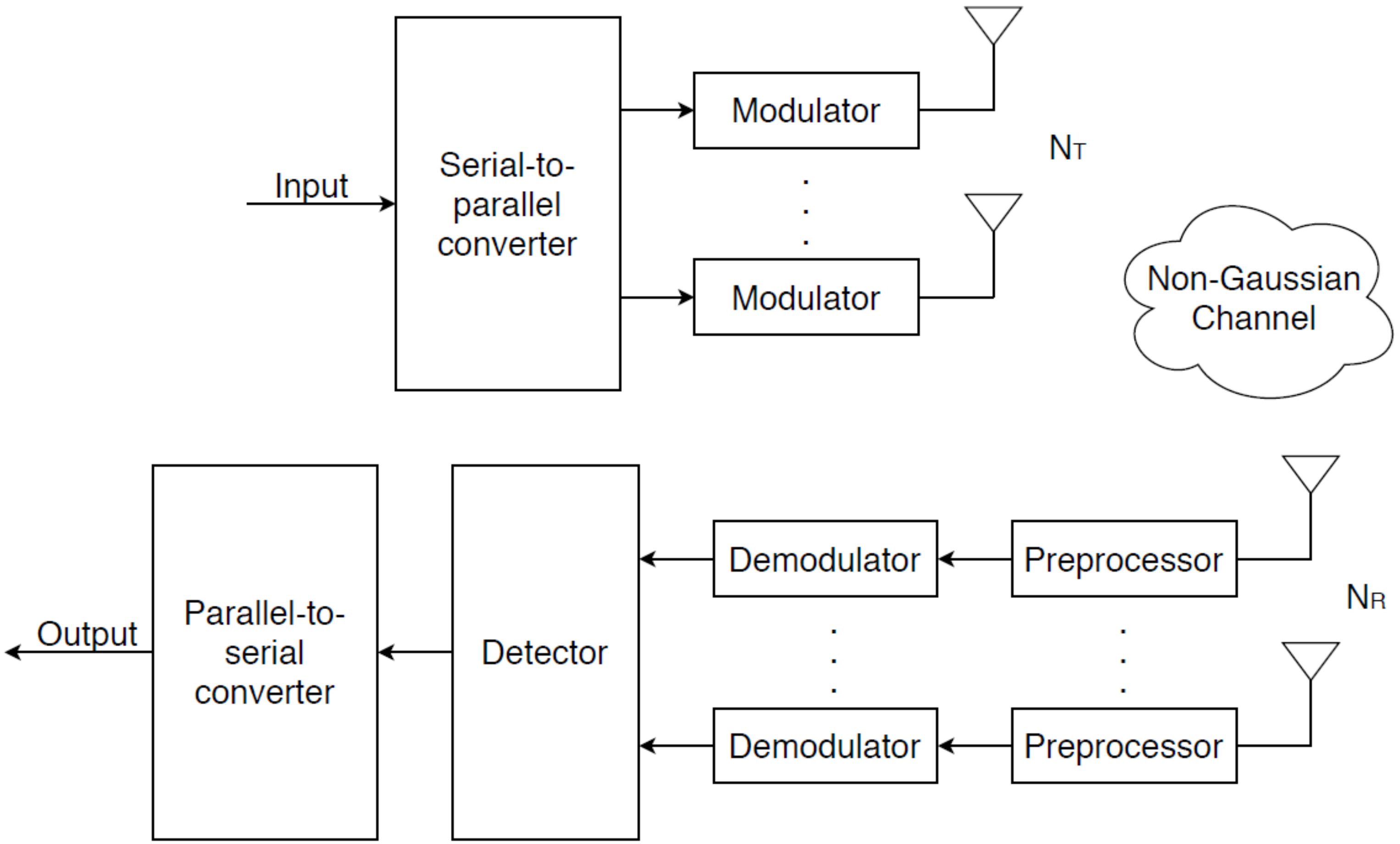
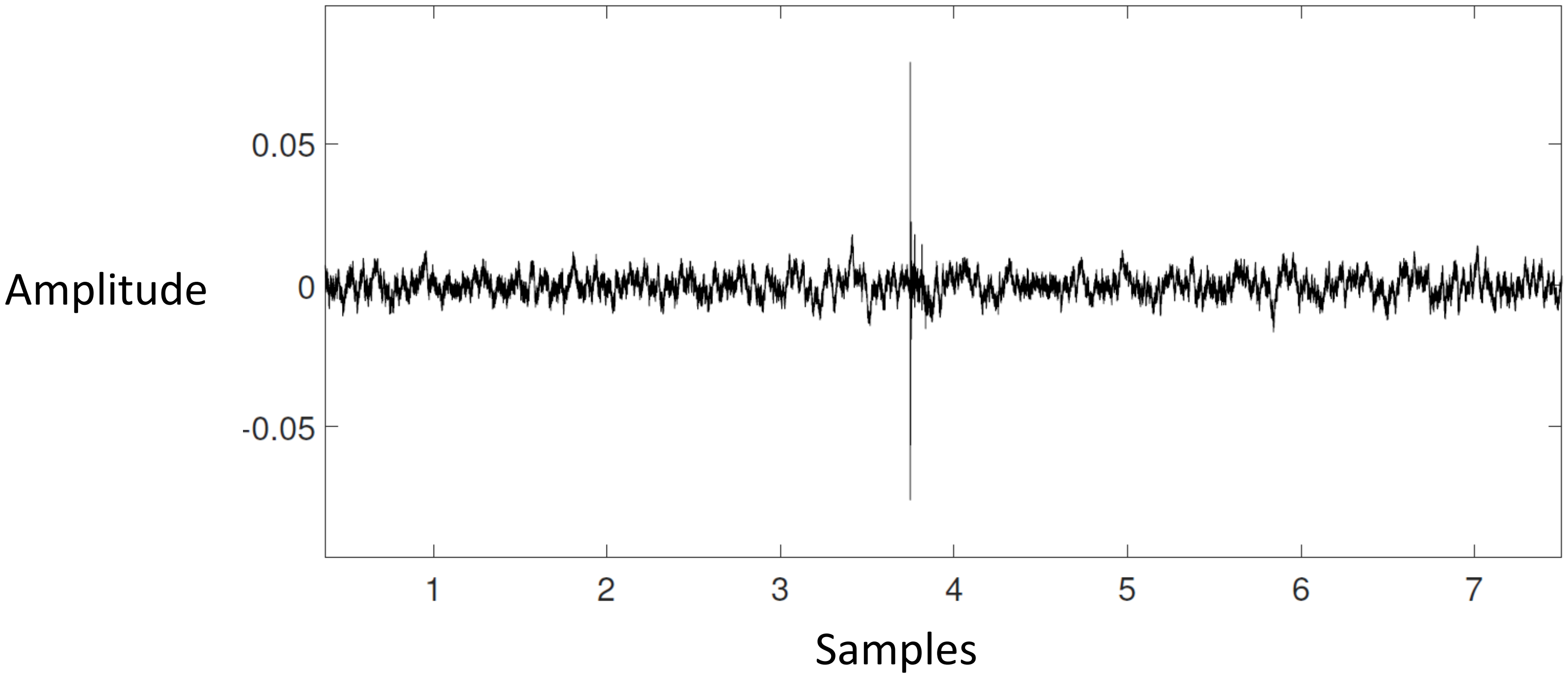
MIMO System



Input
Serial-to-parallel converter
Modulator
Modulator
NT
Non-Gaussian Channel
Output
Parallel-to-serial converter
Detector
Demodulator
Demodulator
Preprocessor
Preprocessor
NR

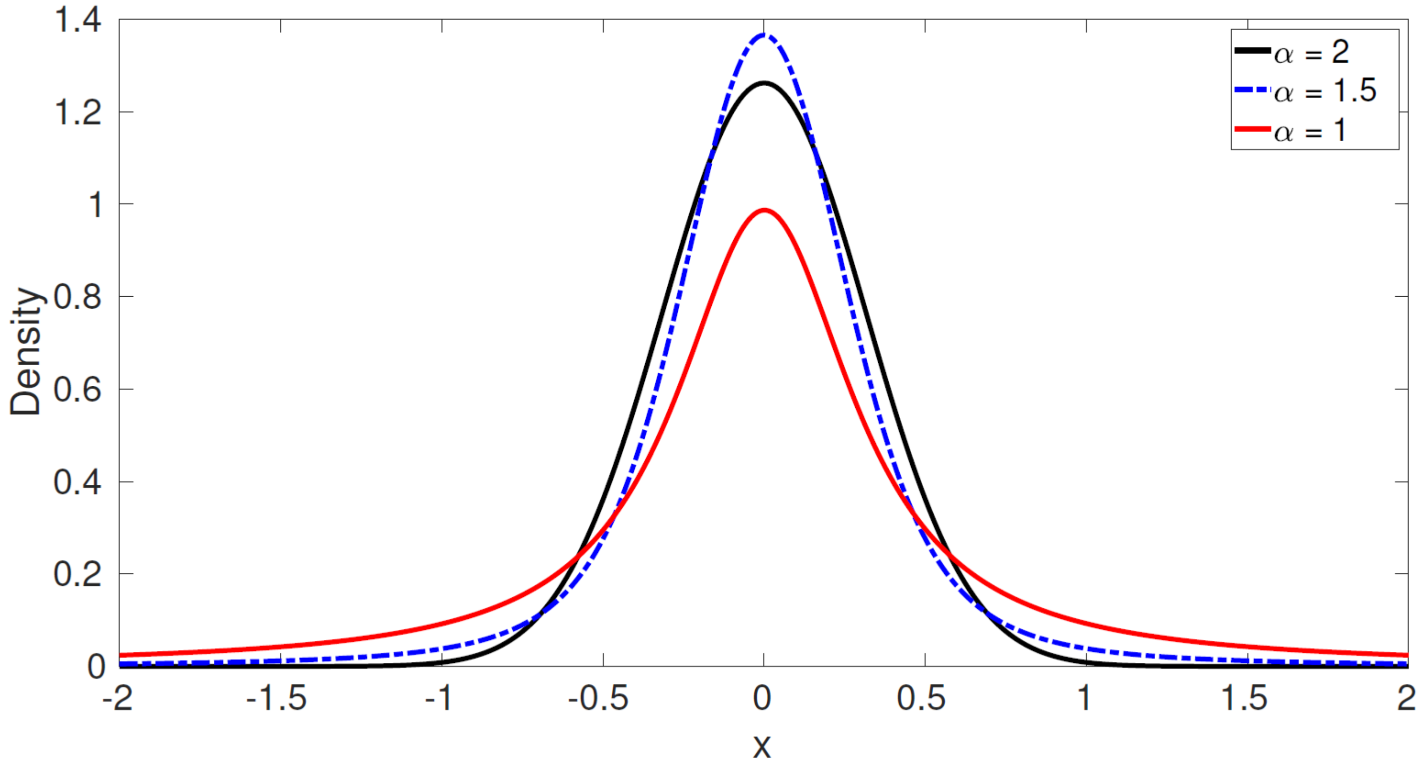
Impulsive Noise

- Example of impulsive noise (with high impulsiveness)



Impulsive Noise

- Symmetric α-Stable (SαS) Model



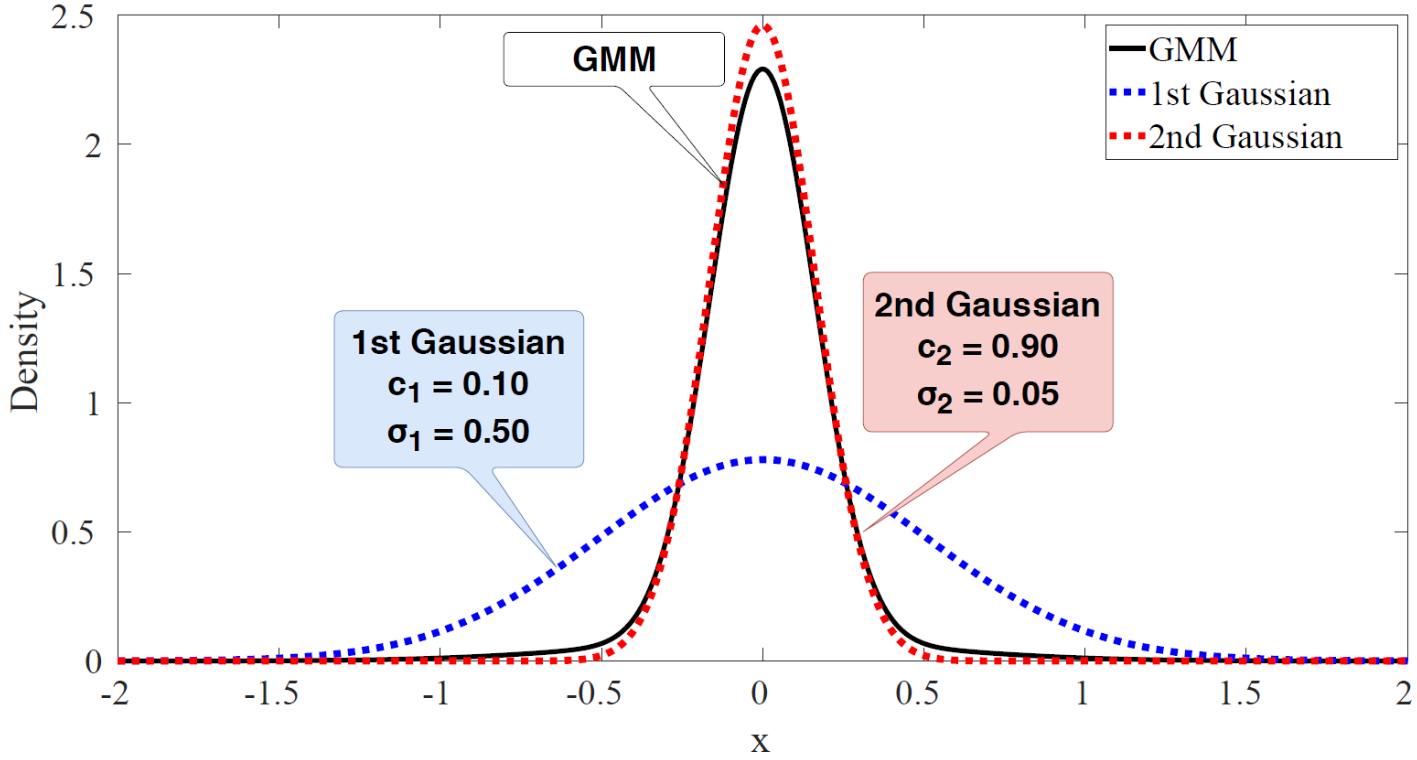
Probability distribution function of symmetrical α-stable with $\beta = \delta = 0$ and $\gamma = 1$.

$\downarrow$ α

$\uparrow$ impulsiveness

Impulsive Noise

- Gaussian Mixture Model (GMM)



Probability distribution function of gaussian mixture model with two gaussians with parameters $\mu_1 = \mu_2 = 0, \sigma_1 = 10$ and $\sigma_2 = 1$.

MIMO Detectors

- Maximum Likelihood Detector (MLD)

$$\hat{\boldsymbol{s}}_{\mathrm{MLD}} = \arg\min_{\boldsymbol{s}} \left| y_m - \sum_{n=1}^{N_T} h_{mn} s_n \right|^2$$

- Minimum Mean-Square-Error Detector (MMSE)

$$\hat{\boldsymbol{s}}_{\mathrm{MMSE}} = \boldsymbol{W}^H \boldsymbol{y}_m \qquad J(\boldsymbol{W}) = E\left[|| \boldsymbol{s}_{\mathrm{MMSE}} - \boldsymbol{W}^H \boldsymbol{y}_m ||^2 \right]$$

- Inverse Channel Detector (ICD)

$$\hat{\boldsymbol{s}}_{\mathrm{ICD}} = \boldsymbol{H}^{-1} \boldsymbol{y}_m$$

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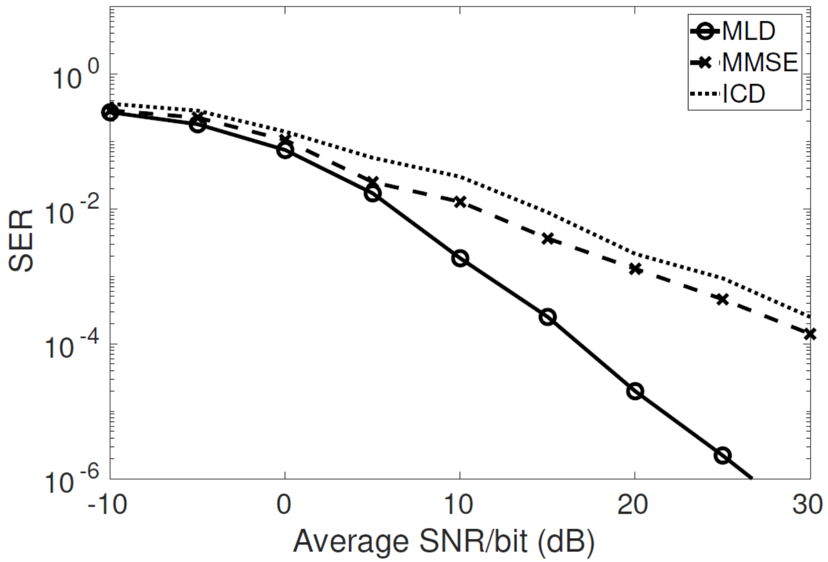
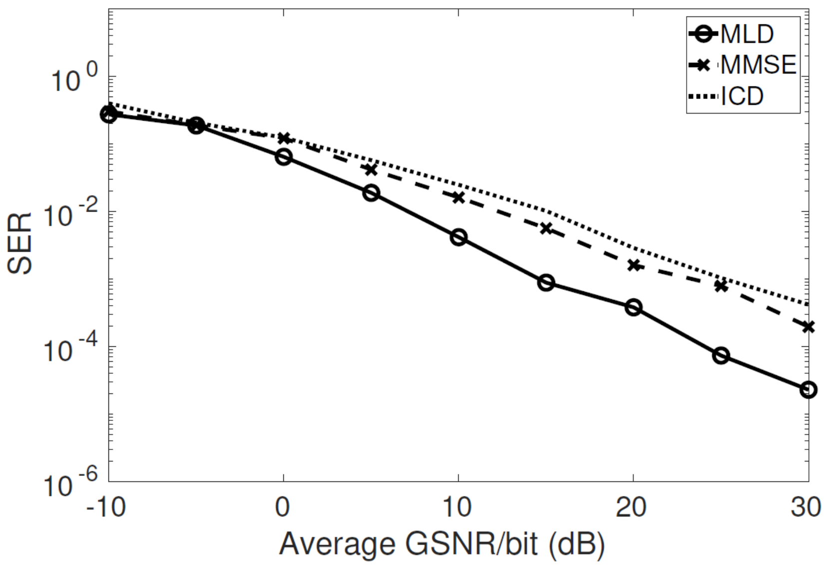
Results

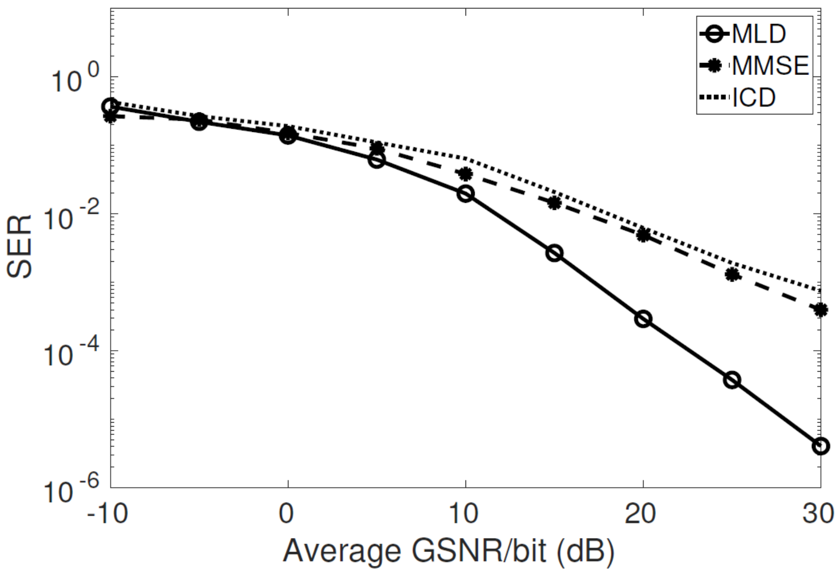
- MIMO detectors performance comparison among the noise models.



Gaussian model



α-Stable model
$(\alpha = 1.9)$

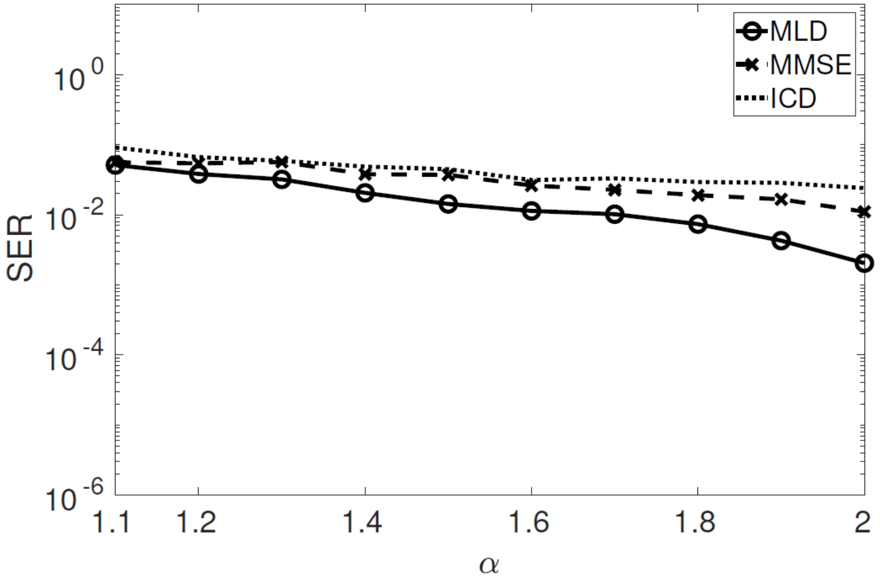


GMM
$(\xi = 10)$

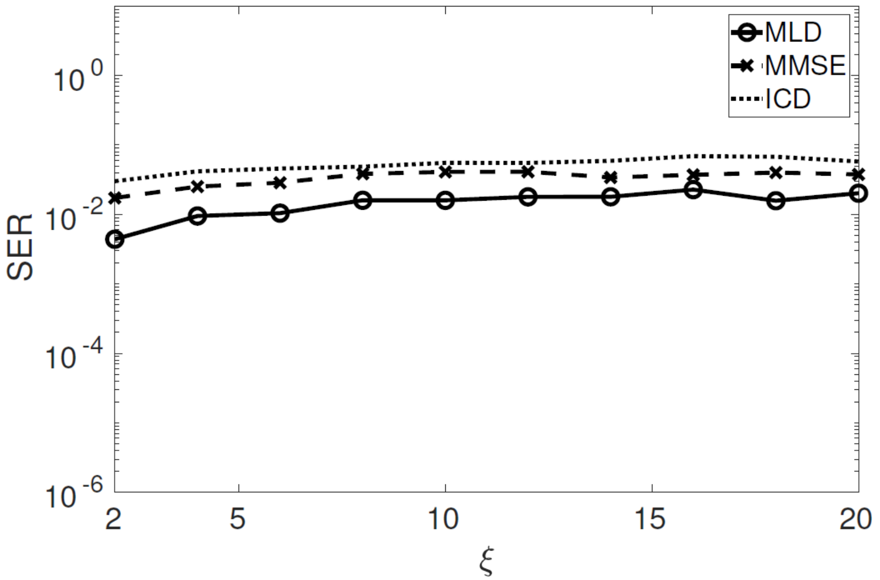
SER: Symbol Error Rates;
ξ: noise parameter (GMM);
α: noise parameter (SαS).

Results

- Impulsiveness evaluation based on the noise parameters.



SαS model



GMM

SER: Symbol Error Rates;
ξ: noise parameter (GMM);
α: noise parameter (SαS).

Conclusions

- We concluded that the MIMO detectors have high error rates in impulsive noise scenarios making them infeasible for current wireless systems. Depending on the noise power (GSNR), the detectors work well for impulsiveness levels that are not too severe. The detectors can be more sensitive in relation to the impulsiveness level represented by their parameters. Studies in impulsive noise scenarios must pay attention for not only the GSNR value, but also for the impulsiveness level considered and how it impacts the detectors.
- Future works
  - Investigate the Gaussian mixture model including the number of Gaussian components and its effect in impulsive noise fitting;
  - Investigate adaptive detectors based on the impulsiveness parameters.

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