2024 Workshop on Communication, Sensing, and Allocation in Future Wireless Systems

Jointly sponsored by:

October 7th-8th, 2024

October 7th, 2024


08:45-09:00:
Opening Session
Prof. Dr. André de Almeida
Prof. Dr.-Ing. Tarcisio Maciel

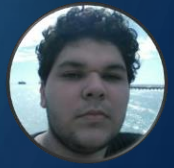
09:00-09:40:
An Efficient Channel Training Protocol for Channel Estimation in Double RIS-Aided MIMO Systems
M. Eng. Gerhard Nwalozie, TU Ilmenau

09:40-10:20:
Maximum Likelihood Estimation of a Low-Rank Probability Mass Tensor from Partial Observations
Univ.-Prof. Dr.-Ing. Martin Haardt, TU Ilmenau
M.Sc. Joseph Chege, TU Ilmenau


10:20-10:40: Coffee-break

10:40-11:20:
Bayesian Estimation of a Probability Mass Function Tensor with Automatic Rank Detection
M.Sc. Joseph K. Chege, TU Ilmenau

11:20-12:00:
Low-Complexity Tensor-Based Monostatic Sensing for RIS-Assisted Communication Systems
M. Sc. Kenneth Benício, UFC



12:00-14:00: Lunch

14:00-17:00: Technical meetings, discussions, and planning

Organization:

Northeast Brazil IEEE SPS Chapter

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09:00-09:40:

Power Allocation for Uplink Sensing and Communication in Cell-free ISAC Systems with Multi-Antenna Users and Multibeam

Dr. Roberto Antonioli, UFC

09:40-10:20:

Joint Channel and Symbol Estimation for Hybrid RIS Wireless Communications

Prof. M. Sc. Amarilton Magalhães, IFCE/UFC

10:20-10:40: Coffee-break

10:40-11:20:

Tensor Decomposition-Based Machine Learning Approach for Epilepsy Seizure Detection Using Electroencephalography Signals

M.Sc. Raul Victor Paiva, UFC

11:20-11:40:

Welcome to the Northeast Brazil IEEE SPS Chapter

Prof. Dr. André de Almeida, UFC

11:40-14:00: Lunch

14:00-16:45: Technical meetings, discussions, and planning

16:45-17:00:

Closing Session

Prof. Dr. André de Almeida

Prof. Dr.-Ing. Tarcisio Maciel

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An Efficient Channel Training Protocol for Channel Estimation in Double RIS-Aided MIMO Systems

This presentation considers a double-RIS (D-RIS)-aided flat-fading MIMO system and proposes an interference-free channel training and estimation protocol, where the two single-reflection links and the one double-reflection link are estimated separately. Specifically, by using the proposed training protocol, the signal measurements of a particular reflection link can be extracted interference-free from measurements of other reflection links. Therefore, the MIMO channels involved in a particular reflection link can be estimated interference-free from the extracted measurements using, e.g., a known state-of-the-art method. Simulation results are provided showing the effectiveness of the proposed channel training protocol.

M. Eng. Gerhard Nwalozie, TU Ilmenau

Maximum Likelihood Estimation of a Low-Rank Probability Mass Tensor from Partial Observations

Estimating the joint probability mass function (PMF) of a set of random variables from partially

observed data is a crucial part of statistical learning and data analysis, with applications in areas such as recommender systems and data classification. Recently, it has been proposed to estimate the joint PMF based on the maximum likelihood (ML) of the data, fitted to a low-rank canonical polyadic decomposition (CPD) model of the joint PMF. To this end, we have developed a hybrid alternating-directions expectation-maximization (AD-EM) algorithm to solve the ML optimization problem, consisting of computationally more expensive AD iterations followed by an EM refinement stage. It is well known that the convergence rate of EM decreases as the fraction of missing data increases. In this talk, we also address the slow convergence of the EM algorithm. By adapting the squared iterative methods (SQUAREM) acceleration scheme to the context of PMF estimation, we propose the SQUAREM-PMF algorithm to speed up the convergence of the EM algorithm. Moreover, we demonstrate that running the computationally cheaper EM algorithm alone after an appropriate initialization is sufficient. Numerical results on both synthetic and real data in the context of movie recommendation show that our algorithm outperforms state-of-the-art PMF estimation algorithms.

Univ.-Prof. Dr.-Ing. Martin Haardt, TU Ilmenau

M.Sc. Joseph Chege, TU Ilmenau

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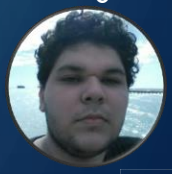
Bayesian Estimation of a Probability Mass Function Tensor with Automatic Rank Detection

Estimating the probability mass function (PMF) of a set of discrete random variables using a low-rank model for the PMF tensor has recently gained much attention. However, detecting the rank (model order) of the PMF tensor from observed data is a challenging problem. While classical techniques such as the Akaike and the Bayesian information criteria (AIC and BIC) may be applied in this regard, they require testing a number of candidate model orders before selecting the best one, a procedure which is computationally intensive for large datasets. In this work, we propose an algorithm to estimate the PMF tensor and implicitly detect its rank. We specify appropriate prior distributions for the model parameters and develop a deterministic algorithm which enables the rank to be detected as part of the inference. Numerical results using both synthetic and real data demonstrate that, compared to classical model selection techniques, our approach is more robust against missing observations and is computationally efficient.

M.Sc. Joseph K. Chege, TU Ilmenau

Low-Complexity Tensor-Based Monostatic Sensing for RIS-Assisted Communication Systems

This work proposes a tensor-based parameter estimation algorithm for sensing in a reconfigurable intelligent surface-assisted system. We present a higher-order singular value decomposition-based solution that exploits the tensor structure of the received echo signal to jointly estimate the target's delay, Doppler, and angular information. Our tensor-based solution can estimate the parameters individually at low complexity, benefiting from parallel computation. Complexity analysis is carried out in comparison with a baseline scheme that does not exploit the intrinsic multilinear structure of the sensed signal. Simulation results show that our proposed tensor-based method can achieve the same performance as the reference method while drastically reducing the computational complexity.



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Power Allocation for Uplink Sensing and Communication in Cell-free ISAC Systems with Multi-Antenna Users and Multibeam

In this work, we evaluate the uplink communication of cell-free systems supporting integrated sensing and communications, i.e., when users transmit simultaneously sensing and communication signals while the access points act as receivers for both. To this end, multi-antenna users employ a multibeam solution for transmitting independent sensing and communication symbols, while adopting either singular value decomposition or angular beamforming. By means of Monte Carlo simulations, we show that the performance of the proposed multibeam solution yields high performance in terms of signal-to-interference-plus-noise ratio for both communication and sensing as well as a low spatial frequency error obtained via angular estimation using the multiple signal classification algorithm.

Dr. Roberto Antonioli, UFC

Joint Channel and Symbol Estimation for Hybrid RIS Wireless Communications

In the past few years, advanced architectures for reconfigurable intelligent surfaces (RIS) were proposed in the literature to incorporate sensing capabilities. A promising architecture is the hybrid sensing and reflecting RIS, or simply hybrid RIS (HRIS). This enables HRIS to have signal processing capabilities, which can be used to partially solve the channel estimation (CE) task. By empowering the HRIS with joint symbol detection and CE functions, this work proposes a semi-blind approach to the HRIS-assisted MIMO wireless communication system based on an iterative receiver. Simulation results indicate performance comparable to the state-of-the-art methods regarding normalized mean square error and symbol error rate.

Prof. M. Sc. Amarilton Magalhães, UFC

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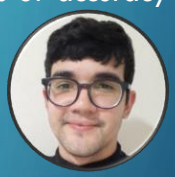
Tensor Decomposition-Based Machine Learning Approach for Epilepsy Seizure Detection Using Electroencephalography Signals

Epilepsy is a chronic neurological disorder that affects a significant portion of the psychiatric population and can have life-threatening consequences. It presents a major public health challenge, placing considerable financial strain on affected families and healthcare systems. This highlights the critical role neurologists play in diagnosing epilepsy, particularly through the analysis of Electroencephalography (EEG) signals. EEG data can be represented as a tensor, capturing dimensions such as amplitude, time, channels, and patients. This multi-dimensional structure leads to high storage demands and significant computational costs when training reliable machine learning models. In this case, tensor decomposition models, such as Parallel Factor Analysis (PARAFAC) and Tucker decomposition, are useful for compressing data while preserving essential information, enabling efficient training of machine learning models in terms of accuracy and processing time.



M.Sc. Raul Victor Paiva, UFC

Welcome to the Northeast Brazil IEEE SPS Chapter

The IEEE Northeast Brazil Section Signal Processing Society (SPS) Chapter was formed in August 2024. The new chapter, hosted at the Federal University of Ceara (UFC), will provide exciting opportunities for students, professionals, and practitioners to network, research, and collaborate on projects with others interested in signal processing. In this talk, we will discuss the IEEE Signal Processing Society and our recently created SPS Chapter. We will also provide information on planned events for 2024/2025.

Prof. Dr. André de Almeida, UFC

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