CURRICULUM VITAE

Ali Hashemi, PhD. Candidate

Technische Universität Berlin

Berlin / Germany

Berlin International Graduate School in Model and Simulation based Research (BIMoS)

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Personal Information

Marital Status	Married
Place and date of Birth	Shiraz, 04 November 1988

Address:
MA 574, Applied Functional Analysis Research Group (AFG)
Level 5, Institut für Mathematik
Technische Universität Berlin (TU-Berlin)
Strasse des 17. Juni 136, Berlin, Germany, P.O. 10623

Research Interests

Recent

- Compressed Sensing and Inverse problems with the focus on Co-Sparsity
- Big Data Analysis
- High-Dimensional Data Analysis
- Sparse Signal Representation and Frame Theory
- Machine Learning with the focus on Deep Learning
- Biomedical Signal and Image Processing

Past

- Spectrum Sensing in Cognitive Radio Networks
- Wireless Sensor and Networks

Relevant Courses taken:

Digital Communication Systems, Adaptive Filters, Blind Source Separation & Independent Component Analysis, Practical Compressed Sensing, Pattern Recognition and Feature Extraction, Numerical Optimization, Coding Theory, Wireless Communication Systems, Wireless Networks, Computer Networks

As an engineer, I am very interested in the practical side and eager to translate theory to practice by building devise systems in Communication and Biomedical areas.

Education

2016 - Present Doctor of Philosophy (PhD), Institut für Mathematik,
Berlin International Graduate School in Model and Simulation based Research (BIMoS)
TECHNISCHE UNIVERSITÄT BERLIN (TU-Berlin), Berlin / Germany
Thesis Title: "Inverse Problems, Co-Sparsity and Compressed Sensing with Side Information"
Thesis Supervisors: Prof. Dr. Gitta Kutyniok

2011 - 2013 Master of Science, Electrical Engineering, Communications (Grade Point Average: 17.05/20.0)
SHARIF UNIVERSITY OF TECHNOLOGY, Tehran / Iran
Thesis Title: "Compressed Spectrum Sensing in Cognitive Radio Networks"
Thesis Supervisors: Prof. Masoumeh Nasiri Kenari and Dr. Masoud Babayi-zadeh

Abstract: *By exploiting the cyclostationary features, we proposed a sensing algorithm based on the entropy of the cyclic spectrum of the received signal, which works quite well in low SNR regime. Then, we generalized the proposed scheme to the cooperative Multi-antenna systems and evaluated the performance of the sensing algorithm in the various channels. Our results demonstrated that the proposed algorithm outperforms the other well-known schemes such as the energy and cyclostationary detectors, especially at the low SNR regime. Furthermore, by exploiting the compressed sensing algorithms and the sparsity feature of the received signal spectrum in wideband spectrum sensing, we proposed a proper sensing algorithm which quite well overcomes wideband sensing challenges. Finally, by exploiting both concepts, namely the cyclostationary concept and the sparsity feature, we proposed efficient entropy based sensing algorithm to deal with the two problems mentioned, and evaluated its performance. The results confirmed its superiority compared to the other traditional approaches.*
In General, the areas which I worked on my master thesis were dealt with compressed sensing techniques in wireless communication and sensor networks for wideband sensing and dimensionality reduction of signal to decrease the number of measurements which is needed for detection. My research activities included MIMO scenarios and also a lot of compressed sensing methods in term of optimization problems for decreasing the cost of complexity. Furthermore, we proposed some methods for detecting signal in low SNR regimes that required a lot of computer programming.

2007 - 2011 Bachelor of Science, Electrical Engineering, Communications (Grade Point Average: 18.58/20.0)
Ranked 1st
UNIVERSITY OF TABRIZ, Tabriz / Iran
Thesis Title: "Practical Physical Layer Network Coding for Two-Way Relay Channels Performance Analysis and Comparison"
Thesis Supervisor: Dr. Javad Musavi Nia

Abstract: *We first considered a network consisting of two source nodes and a single relay node. For this scenario, we investigate transmission over two, three or four time slots. We showed that the two time slot PNC scheme offers a higher maximum sum rate, but a lower sum-bit error rate (BER) than the four time slot transmission scheme for a number of practical scenarios.*

2000 - 2007 High School, Diploma Pre-University Certificate (Grade Point Average: 19.47/20.00)
ALLAMEH HELLI, Tehran / Iran
National Organization for Development of Exceptional Talents (NODET)

Professional and Research Experiences

02 / 16-Present Research Assistant, **Applied Functional Analysis Research Group (AFG)**
Under the Supervision of Prof. Dr. Gitta Kutyniok
TECHNISCHE UNIVERSITÄT BERLIN (TU-Berlin), Berlin / Germany

03 / 15-01/16 Research Assistant to Professor Ngai-man Cheung' Research Group
Visiting Research Assistant Opportunity
SINGAPORE UNIVERSITY OF TECNOLOGY AND DESIGN (SUTD in collaboration with MIT).

***Research Project Topic**: Brain Mapping and Imaging Data (With Focus on **Solving Inverse Problems** in this area such as EEG/MEG Source Localization and also Reconstruction of EEG/MEG signal from reduced number of spatiotemporal samples. We proposed a **framework** which can apply to another practical areas like thermal monitoring.)* Applied Functional Analysis Research Group (AFG)

(In cooperation with Professor Ngai-man Cheung, Dr. Hossein Nejati, Singapore University of Technology and Design and Dr. Mohammad Rostami, University of Pennsylvania)

*We have done a deep study on the brain big data analysis. Actually, since the brain data is high dimensional, In first step, we have developed some new methods based on compresses sensing for analyzing brain mapping and imaging data and an idea to find the suitable basis function, which reduce the dimensionality and decrease the complexity cost. In next step, by merging compressed sensing algorithms with machine learning methods, we have proposed a **"task-based dictionary method"** for classifying brain EEG and MEG signals in a specific applications more efficiently and accurately.*

03/15 – 01/16 Research Assistant to Professor Ngai-man Cheung's Research Group
Visiting Research Assistant Opportunity
SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN (SUTD in collaboration with MIT)
Research Topics:
Compressed Sensing (CS) under partial differential equation (PDE) constraints

- *Studying Compressed Sensing (CS) under Partial Differential Equation (PDE) constraints*

(In cooperation with Professor Ngai-man Cheung, Singapore University of Technology and Design, and Dr. Mohammad Rostami, University of Pennsylvania)
***Abstract**: Investigating Compressed Sensing (CS) under partial differential equation (PDE) constraints. The objective was to take advantage of the instinct property of spatiotemporal sources (multidimensional signals which depend on location and change over the time, e.g. an electromagnetic field) as side information to improve the reconstruction results of classic CS. We have applied our proposed method on the novel applications such as thermal monitoring of multi-core CPU and EEG/MEG signal analysis for demonstrating the superiority of this PDE constrained CS theory compared to other traditional CS algorithms.*

2011- 2014 Research Assistant to Prof. M. Nasiri-Kenari in Wireless Research Laboratory (WRL)
SHARIF UNIVERSITY OF TECHNOLOGY TEHRAN / IRAN, FACULTY OF ELECTRICAL ENGINEERING
Research topic: Compressed Spectrum Sensing in Cognitive Radio Networks

2011- 2014 Research Assistant to Dr. M. Babayi-zadeh in Signal Processing Laboratory (SPL)
SHARIF UNIVERSITY OF TECHNOLOGY TEHRAN / IRAN, FACULTY OF ELECTRICAL ENGINEERING
Research topic: Compressed Spectrum Sensing in Cognitive Radio Networks

09 / 10 – 09 / 11 Research Assistant to Dr. Musavinia in Wireless Communications Research Group
UNIVERSITY OF TABRIZ / IRAN, FACULTY OF ELECTRICAL AND COMPUTER ENGINEERING
Research topic: Practical Physical Layer Network Coding for Two-Way Relay Channels Performance Analysis and Comparison.

07 / 10 – 09 / 10 Internship
TABRIZ URBAN RAILWAY (U-BAHN) ORGANIZATION (TURO); Tabriz / Iran
Topic: Designing of the Tetra Networks for Railway, coverage of base stations and coverage by the effect of fading in outdoor and subway environment.

Teaching Experiences

2013 Teacher Assistant for "Signals and Systems" Course
SHARIF UNIVERSITY OF TECHNOLOGY TEHRAN/ IRAN, Course Instructor: Prof. Nasiri

2011 Teacher Assistant for "Engineering Mathematics" Course
UNIVERSITY OF TABRIZ / IRAN, Course Instructor: Dr. Bemani

2011 Teacher Assistant for "Field and Wave" Course
UNIVERSITY OF TABRIZ / IRAN, Course Instructor: Dr. Bemani

2009 - 2011 Instructor for Master Comprehensive Exam Preparation Course for Electromagnetics and Electronics
UNIVERSITY OF TABRIZ / IRAN

Honors/Awards/Fellowships

2015 Berlin International Graduate School in Model and Simulation based Research (BIMoS) **Fellowship** awarded for 3 years
TECHNISCHE UNIVERSITÄT BERLIN (TU-Berlin), BERLIN / GERMANY

2014 Research **Scholarship** Awarded for 1 year in Professor Ngai-man Cheung's Research Group
SINGAPORE UNIVERSITY OF TECNOLOGY AND DESIGN (SUTD in collaboration with MIT)

2011 Permission to enter the M. Sc. program as an Exceptional Talented Student bypassing the entrance exam
SHARIF UNIVERSITY OF TECHNOLOGY, TEHRAN / IRAN

2011 **Ranked 1st**, highest Grade Point Average among the Electrical & Computer engineering Undergraduate Students
UNIVERSITY OF TABRIZ / IRAN, FACULTY OF ELECTRICAL AND COMPUTER ENGINEERING

2011 Ranked 15th / 30,000
Iranian National Electrical Engineering Olympiad for Undergraduate Students, Iran

2011 Ranked 4th / 1,000
Iranian North West Electrical Engineering Competition Undergraduate Students, Iran

2010 Ranked 10th / 30,000 (And Ranked 1st among all the junior students examinees),
Iranian National Electrical Engineering Olympiad for Undergraduate Students, Iran

2010 Ranked 2nd / 1,000
Iranian North West Electrical Engineering Competition Undergraduate Students, Iran

2009 Ranked 9th / 10,000
Iranian National Electrical Engineering Comprehensive Exam for Junior Students, Iran

2009 Introduced as a Distinguished Student, University of Tabriz, Iran

2008 Introduced as an Exceptional Talent, University of Tabriz, Iran

Research Papers

- **A. Hashemi**, M. Rostami, Ngai-Man Cheung, **"Efficient Compressed Sensing Scheme for Reconstruction of Spatiotemporal Field Arrays"**, submitted to IEEE International Conference on Image Processing (ICIP) 2016.
Diffusive Compressed Sensing for Thermal Monitoring

Abstract:
Diffusion fields are an important subclass of spatiotemporal sources with a wide area of application. Sensor Networks are generally used for sampling and reconstruction of these fields for monitoring, surveillance, and automation purpose. Despite many benefits over traditional devices, sensor networks have their own limits. First, there is a limit on the number of sensing nodes considering the spatial sensing resolution. In addition, restrictions on power consumption of nodes limit the temporal sampling rate. We tackle these problems for the case of diffusion fields by using compressed sensing (CS) to process the collected samples more efficiently. In particular, we propose a Diffusive Compressive Sensing (DCS) framework to benefit from domain knowledge about diffusion fields. Experimental results are provided to demonstrate the effectiveness and efficiency of the proposed algorithm.

- **A. Hashemi**, M. Rostami, Ngai-Man Cheung, **"Efficient Environmental Temperature Monitoring Using Compressed Sensing"**, **accepted** to Data Compression Conference (DCC) 2016, IEEE Signal Processing Society.

Abstract:
Wireless Sensor Networks (WSN) have been used to collect data for environmental monitoring of physical quantities including temperature, humidity, and pressure. A WSN is composed of a network of sensing units which are deployed in the environment to collect local samples of the quantity of interest and then their outputs are fused for monitoring purpose on a planner area. Although WSN's outperform traditional monitoring methods in terms of financial cost, they have their own design and resource constraints. First, although the sensing units are generally inexpensive but there is always a limit on the number of sensing units that can be used which depends on properties of the environment. On the other hand, resource constraints are imposed by power consumption of sensing nodes which limits the time sampling rate of WSN given battery life of sensing nodes. In this paper, we aim to use compressed sensing (CS) in order to tackles these problems for monitoring temperature by processing the collected temperature data more efficiently in a compressed domain. Moreover, we exploit an intrinsic property of diffusion fields as side information to improve the results. Experimental results are provided to demonstrate the effectiveness and usefulness the algorithm.

- **A. Hashemi**, M. Rostami, Ngai-Man Cheung, **"Source Localization in Diffusion Field with Noisy Measurements"**, preparing to submit to 42st IEEE International Conference on Acoustics, Speech and Signal Processing, ICASSP 2017.

  Abstract:
  We study the problem of reconstructing unknown generating point sources of a diffusion field through spatiotemporal samples of the field, collected by a wireless sensor network. Our focus is to tackle this problem in noisy environments where a wireless sensor networks (WSN) is used for collecting samples. A typical problem with WSN is energy consumption of sensor nodes and limits on temporal sampling rate. These issues could increase ill-posedness of the problem. Compressed sensing (CS) is a technique that has been used in the literature to tackle these issues. However, the problem becomes very challenging with noisy measurements. In this paper, we propose to solve an additional inverse problem first before the source localization to reduce the ill-posedness of the localization problem. We take advantage of the signal structure governed by the diffusion field to increase the resolution of the data. To integrate the diffusion field prior, we employ a diffusive compressed sensing (DCS) algorithm in a uniform spatial sampling setting. We show that our proposed approach can significantly reduce the ill-posedness of the problem by decreasing the condition number of sampling operator. Experimental results demonstrate effectiveness and usefulness of our approach, and its competency over previous work in the literature.

- **A. Hashemi**, M. Rostami, Ngai-Man Cheung, "**2D Diffusive Compressed Sensing for Solving Inverse Problems in Noisy Environment**", preparing to submit to IEEE Transaction on Signal Processing.

  Abstract:
  The reconstruction of a diffusion field using samples collected by a sensor network along with estimation the parameters of sources which induce the aforementioned field is a classical inverse problem with applications including temperature monitoring, pollution dispersion, EEG source localization and CPU thermal mapping. A classic work considers source models in noise free setting and use compressed sensing to recover the initial source distribution. While experiments demonstrate usefulness of the approach, it cannot handle noisy situations. Here, we consider uniform spatial sampling in a noisy environment setting and improve the classical approach by employing an extended version of CS which is suitable for this problem. Through experiments we demonstrate effectiveness of our approach.

- **A. Hashemi**, R. Nikbakht "**Reduced-Complexity Compressed Spectrum Sensing in Low SNR Regimes Using Direct 2D Spectral Correlation Function Reconstruction**" preparing to submit to IET Journal of Wireless Communication.

  Abstract:
  In this paper, we explore a reduced-complexity compressive detection method which exploits the sparsity of the two-dimensional spectral correlation function (SCF). Due to the additional sparsity introduced in the SCF with respect to the power spectral density, sparsity pattern of 2D cyclic spectrum are shown to be remain even in low SNR scenarios. Utilizing this feature, we propose a detection method using entropy as the sparsity measure and working quit well in low SNR regimes. Furthermore, in compared to other trivial reconstruction approaches using the kronecker product in order to convert the 2D reconstruction problem in a 1D form, we present an algorithm which directly reconstructs the 2D cyclic spectrum without any vectorize operation. The results show its superiority with respect to tremendous amount of memory and computational cost in other approaches, which reduce the complexity by one order.

- M. Rostami, **A. Hashemi**, Ngai-Man Cheung, Tony Q. S. Quek, "**Efficient Compressed Sensing for Diffusion Fields**", preparing to submit to IEEE Transaction on Image Processing.

Abstract:
Many natural world environmental signals are spatiotemporal sources, where the signal depends on spatial location and changes over the time, e.g. temperature of a piece of land, an electromagnetic field, or reflection of light from a surface. Diffusion fields are an important subclass of such sources, where the source field satisfies diffusion partial differential equation (PDE). Sensor networks have been used as typical type of sampling devices to measure and reconstruct such sources for monitoring or automation purposes. Despite many benefits, sensor networks have their own deficiencies. First, there is a limit on the number of sensing units that can be deployed which limits the spatial sensing resolution. Moreover, battery life of a sensor node limits the power consumption and the temporal sampling rate. In this paper, the above limitations are tackled by means of compressed sensing (CS). We take advantage of the instinct property of such sources, i.e. satisfying a PDE, as side information to increase efficiency, we improve the reconstruction results by incorporating the side information from diffusion PDE into CS recovery. We demonstrate why diffusion compressed sensing (DCS) outperforms classic CS by treating PDE as a second source of knowledge in addition to sparsity. Experimental results are provided to demonstrate the effectiveness and usefulness of the proposed method. It is shown that DCS results in substantial data savings while producing estimates of higher accuracy, as compared to CS-base estimates.

- S. Iravani, **A. Hashemi**, H. Nejati, Ngai-Man Cheung, H. Sosa, C. I.; "**DeepCAPTCHA: An Image CAPTCHA Based on Depth Perception**", preparing to submit to IEEE Transaction on Information Forensics and Security.

Abstract:
In this paper, an adaptive image contrast enhancement algorithm based on an optimization problem in two dimensional histogram domain is presented. To reduce the unwanted effects of the histogram adjustment, through this optimization, similar to other common approach in this literature we find the 2D histogram of enhanced image in close proximity to input image histogram and uniform distribution, simultaneously. In addition, in contrast to other algorithms, by adaptive adjusting the components of a weight matrix, local information is counted. Experimental results on a wide range of images demonstrate the improved performance of the proposed method. Besides, applying the proposed method on variety of images results in 75% and 3% improvement in AMBEN and DEN measurements, respectively comparing to the reference method.

- R. Nikbakht, H. Aghayinia, **A. Hashemi**, M. Kazemi, "**Cyclostationary Features-Based Wideband Compressed Spectrum Sensing for Cognitive Radio Networks" accepted** in 2n International Conference on Electrical, Mechanical, Computer and Mechatronics Engineering-ICE2015.

Abstract:
Robust spectrum sensing is one of the most important parts of cognitive radio networks. The more bandwidth is available, the more spectrum opportunities are provided for secondary users. However, regarding the Nyquist sampling rate, the conventional algorithms for spectrum sensing which has been proposed so far, encounter some fundamental challenges such as expensive and costly computational implementation. In addition, the experiments show that a good portion of the frequency range is idle due to spectrum under-utilization, suggesting that the frequency spectrum of signal is highly sparse in Fourier domain. Therefore, compressed sensing theory can be used for reconstructing wideband spectrum. Since sparse reconstruction methods have poor performance in low SNRs, we cannot utilize the compressed sensing approach directly. In order to solve this problem, direct reconstruction of cyclo-stationary features from compressed measurements has been proposed. In this paper, however, we modify the conventional wideband spectrum sensing to accommodate cyclostationary signals and formulate the problem in a simpler matrix form. Then, we convert the problem to the compressed sensing setting. According to simulations, the proposed scheme demonstrates good results even in low SNR regimes.

- R. Nikbakht, H. Aghaeinia, M. Kazemi, **A. Hashemi,** "**Wideband Compressed Sensing based on 2D Sparse Reconstruction of Asymmetric Cyclic Spectrum**" **accepted** in 2n International Conference on Electrical, Mechanical, Computer and Mechatronics Engineering-ICE2015.

Abstract:
Robust wideband spectrum sensing is one of the most important parts of the cognitive radio networks. Regarding the Nyquist sampling rate challenges at wideband sensing and considering promising sparsity of frequency spectrum due to spectrum under-utilization, wideband spectrum can be reconstructed using compressed sensing methods. However, since sparse reconstruction methods have poor performance in low SNRs due to loss of sparsity property (e.g. due to increase in the noise power), we cannot utilize the compressed sensing approach directly. To address this problem efficiently, we here propose direct 2D sparse reconstruction of cyclostationary features from compressed measurements. In our approach we first reformulate obtaining the cyclic spectrum function in term of matrix form and then present an algorithm which directly reconstructs the 2D cyclic spectrum without any vector operation. This results in computationally efficiency, and significant reduction in the complexity, compared to previous methods that use Kronecker product method. In addition, we use blind detection method using eigenvalues of reconstructed cyclic spectrum. According to simulations, the proposed scheme demonstrates good results in noise uncertainty.

Presentations

Oct 2015	Diffusive Compressed Sensing: Theory and Applications Singapore University of Technology and Design Engineering Department, Singapore
Apr 2015	DeepCAPTCHA: An Image CAPTCHA Based on Depth Perception InnovFest unbound, Singapore
Aug 2013	Compressed Spectrum Sensing in Cognitive Radio Networks Electrical Engineering Department, Sharif University of Technology Tehran / Iran
Jun 2012	Spectrum Sensing in Low SNR Regimes, Electrical Engineering Department, Sharif University of Technology Teheran / Iran
Jan 2012	Beam Forming Approaches to Enhance Secrecy Capacity in Wiretap Channels Electrical Engineering Department, Sharif University of Technology Teheran / Iran
Jul 2011	Practical Physical Layer Network Coding for Two-Way Relay Channels Performance Analysis and Comparison Electrical Engineering Department, Tabriz University

Professional Affiliations

2009 - Present	Member of Tabriz University Electrical Engineering Olympiad Team

Skills

Programming Languages:	**Document Preparation System:**	**Languages:**
MATLAB	LaTeX	Persian - mother language
C/C++	Microsoft Office	English - fluent
Visual Basic		