

# IEEE Statistical Signal Processing Workshop

August 5 – 8, 2012 Ann Arbor, USA www.SSP2012.org



IEEE Signal Processing Society



## **Committees**



## IEEE Statistical Signal Processing Workshop

August 5 – 8, 2012 Ann Arbor, USA www.SSP2012.org

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# Welcome

As Chair of the organizing committee I am delighted to welcome you to SSP 2012 in Ann Arbor, Michigan, USA. The biannual IEEE Statistical Signal Processing Workshop is sponsored by the IEEE Signal Processing Society and has a long history going back more than three decades.

This is the first time ever that SSP 2012 has been held in Michigan and the first time in five years that it has been held in the US. Located 40 miles west of Detroit MI, Ann Arbor is the home of the University of Michigan, a world-class research university established almost 200 years ago. Former students from the University of Michigan that will be familiar to you include: Claude Shannon (father of information theory), Bill Joy (co-founder of Sun Microsystems), and Larry Page (co-founder of Google).

The workshop will be held on central campus of the university and, except for the Opening Reception, all events will be on the second floor of the Michigan League. I am looking forward to seeing you on Sunday evening at the Opening Reception, which will be held at the University of Michigan Museum of Art, at 525 South State Street, within easy walking distance of the Michigan League.

We are proud of our exciting technical program featuring six top flight plenary speakers and over 230 quality papers presented in contributed and invited poster sessions.

I would like to thank all the members of the organizing committee for their tireless work and inspiration in putting together this workshop for you. I give special thanks to Raj Rao Nadakuditi, Local Arrangements Chair, for his inspiration and close involvement with virtually every aspect of workshop planning. I also thank the reviewers who served on our Technical Program Committee. I thank the Signal Processing Theory and Methods Technical Committee of the IEEE Signal Processing Society for sponsoring SSP 2012.

Finally, I thank all of the authors and attendees of SSP 2012 and look forward to seeing you in August.

Alfred Hero, General Chair



# **Welcome from the Technical Program Chairs**

As Technical Co-Chairs of the 2012 IEEE Workshop on Statistical Signal Processing, it is our pleasure to welcome all workshop attendees to Ann Arbor for what promises to be a stimulating three days of presentation and discussion.

The technical program for this year's workshop includes a combination of plenary lectures, special poster sessions, and regular poster sessions. We have six distinguished plenary speakers, two for each day, covering a broad and interesting range of topics. There are 11 special sessions, each devoted to one particular topic of interest and organized by leaders in the field, comprising a total of 66 invited papers. The 28 regular poster sessions cover a wide variety of topics, some traditional and some quite new. In these regular sessions, there are 168 contributed papers selected from 253 submissions (acceptance ratio 66%). In keeping with the international tradition of the SSP Workshop, the technical program includes authors and presenters coming from 34 different countries.

All of the papers in the special and regular sessions went through a rigorous peer review process. Selecting these papers required the considerable efforts of 119 members of the Technical Committee who served as reviewers, writing some 720 reviews. We would especially like to thank them for their valuable work. We would also like to thank the Special Session Chair, Selin Aviyente, and the organizers of the special sessions for all of their efforts.

We see in this program evidence that statistical signal processing continues to play an important role in the technological revolution underway in modern society, in the way that we gather, communicate, and process information. Some of the "traditional" areas for SSP are here, such as array signal processing, estimation and detection theory, time-frequency analysis, and adaptive systems. A major trend that shows no signs of letting up is compressive sensing and the closely related topic of sparse models: our first plenary lecture and no less than six poster sessions are devoted to this area. Two other exciting new areas are signal processing on graphs and networks, and distributed signal processing. Both of these areas become highly relevant with the proliferation of smart mobile devices and the issues of network connectivity and geographical separation that come with them. Of course, the theoretical advances in the field will only have an impact when brought to bear on applications, and here we see some very interesting work in geophysics and petrophysics, biology and biomedicine, communication systems, radar, engineering of materials, speech, and underwater acoustic signal processing.

We very much wish you an enjoyable and productive workshop. Again, welcome!

Best regards,

Daniel Fuhrmann, David Neuhoff, Technical Co-Chairs





**David Neuhoff** 



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# **General Information**

## **Conference Venue**

The workshop will be held on the Central Campus of the University of Michigan and, except for the Opening Reception and the Banquet, all events will be on the second floor of the Michigan League. The Opening Reception will be held on the evening of Sunday, August 5 at the University of Michigan Museum of Art, at 525 South State Street, within easy walking distance of the Michigan League. The banquet will be held on the evening of Tuesday, August 7 at the Michigan Union, at 530 South State Street, in the Rogel Ballroom, which is on the second floor. The Michigan Union is across the street from the Musuem of Art. The back cover of this booklet contains an overview of the schedule and a map marking the venues.

### **Registration and Information**

The registration and information desk is at the concourse level on the 2nd floor of the Michigan League. The desk will be staffed from 8 am to 5 pm on Monday and Tuesday and from 8 am to 1 pm on Wednesday.

## Badges

The name badges may be picked up either at the opening reception on Sunday or at the registration and information desk (see above) during staffed hours. Your badge is also your ticket for the banquet and lunches so please make sure that you wear your badge while on the premises.

## **Social Events**

The Opening Reception will be held at 6 pm on the evening of Sunday, August 5 at the University of Michigan Museum of Art, at 525 South State Street, within easy walking distance of the Michigan League.

The Banquet will be held at 6:30 pm on the evening of Tuesday, August 7 at the Michigan Union, at 530 South State Street, in the Rogel Ballroom. The Michigan Union is across the street from the Musuem of Art. Please wear your name badge and bring your drink tickets to the banquet.

The back cover of this booklet contains an overview of the schedule and a map marking the venues.

## Lunches

Catered lunches will be served on Monday and Tuesday in the Ballroom on the 2nd floor of the Michigan League. Please wear your name badge to lunch.

### **Plenary Talks**

The plenary talks will be held in the Mendelssohn Theatre, which is accessible from the 2nd floor of the Michigan League.

## **Optional Tours**

There is an optional (free) tour of Michigan Stadium starting at 2 pm on Wednesday, August 8 for attendees who have registered for the tour on EDAS. The shuttle bus will pick up attendees at the Michigan League; additional details will be posted on the website.

### **Internet Access**

Free wireless internet access is available in the Michigan League. Please connect to the "Mguest" wireless network, open an internet browser window and follow instructions.

### **Instructions for Poster Installation**

The boards for displaying posters will provide a 46 inch x 46 inch space for displaying each poster. There will be sufficient space that all posters can be displayed for the entire day of the session during which the poster is to be presented. Accordingly, authors are encouraged to put up their posters as early as possible in the day of its presentation and to leave them up until the end of the day.

Each poster space will be labeled with an identifying card number, e.g., MC4-5, for the fifth paper of the 4th poster session of the C time slot on Monday afternoon. The technical program shows the sessions, room assignments, and the order of the papers within each session. Tacks and/or tape will be provided.

# Transportation Between Ann Arbor and Detroit Metro Airport

See workshop website for suggestions.

# **General Information**

### **Public Transport**

Ann Arbor has an extensive bus system. See http://www.theride.org/ for details.

### **Hotel Shuttles**

The workshop has arranged for shuttles to take attendees, who are staying at the Courtyard Marriott, Fairfield Inn by Marriott, Holiday Inn, and Sheraton Inn, to and from the workshop and social events. Details are posted on the workshop website.

### Taxi

Some reliable taxi companies in Ann Arbor are:

Across Town Cab (734) 216-5932	Michigan Green Cab (877) 476-8294
Amazing Blue Taxi (734) 846-0007	University Taxi (734) 368-4800
Ann Arbor Taxi (734) 214-9999	Yellow Cab (734) 663-3355

Blue Cab Co. (734) 547-2222

Have them drop you off at the "Michigan League" if you are using the taxi to attend the conference. If you are having them pick you up from the conference, have them pick you up at the "Michigan League" or even the Campus Inn (see map on last page) if at night.

## The University of Michigan is a No Smoking Campus

### **Safety Instructions**

University buildings are open to the public. Please do not leave any belongings unattended.

## **Useful Telephone Numbers**

Emergency: 911 Non-emergency medical help: 734-764-8320

### Parking

Please see the workshop website for details.

### Weather

August in Ann Arbor is warm with an average daytime high of 81F (27C), a nighttime low of 61F (16C) and occasional thunderstorms.

## Notes:



# Plenary Speakers – Monday – Mendelssohn Theatre



#### Yonina Eldar

Monday 8:30 AM – 9:30 AM, August 6 Room: Mendelssohn Theatre

Title: Xampling at the Rate of Innovation: Correlations, Nonlinearities, and Bounds

**Abstract:** We present a framework for sampling a wide class of wideband analog signals with finite rate of innovation, at rates far below that dictated by the Nyquist rate. We refer to this methodology as Xampling: A combination of compression and sampling, performed simultaneously. Using the Cramer-Rao bound we develop a generic low-rate sampling architecture that is optimal in a mean-squared error sense, and can be applied to a wide variety of wideband inputs. We show that this approach improves upon several alternative sampling mechanisms proposed in the literature. Another advantage of our scheme is that it can be readily implemented in hardware, and is easily modified to incorporate correlations between signals. We consider in detail an application of these ideas to ultrasound imaging and demonstrate recovery of noisy ultrasound images from sub-Nyquist samples while performing beamforming in the compressed domain. Finally, motivated by problems in optics, we extend these principles to nonlinear problems leading to quadratic and more general nonlinear compressed sensing techniques. We demonstrate applications to phase recovery from magnitude measurements and super-resolution imaging.

**Biography:** Yonina C. Eldar received the B.Sc. degree in Physics and the B.Sc. degree in Electrical Engineering both from Tel-Aviv University (TAU), Tel-Aviv, Israel, in 1995 and 1996, respectively, and the Ph.D. degree in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology (MIT), Cambridge, in 2002. She is currently a Professor in the Department of Electrical Engineering at the Technion-Israel Institute of Technology, Haifa. She is also a Research Affiliate with the Research Laboratory of Electronics at MIT and a Visiting Professor at Stanford University, Stanford, CA.

Dr. Eldar was a Horev Fellow of the Leaders in Science and Technology program at the Technion and an Alon Fellow. In 2004, she was awarded the Wolf Foundation Krill Prize for Excellence in Scientific Research, in 2005 the Andre and Bella Meyer Lectureship, in 2007 the Henry Taub Prize for Excellence in Research, in 2008 the Hershel Rich Innovation Award, the Award for Women with Distinguished Contributions, the Muriel & David Jacknow Award for Excellence in Teaching, and the Technion Outstanding Lecture Award, in 2009 the Technion's Award for Excellence in Teaching, in 2010 the Michael Bruno Memorial Award from the Rothschild Foundation, and in 2011 the Weizmann Prize for Exact Sciences.

She is a Signal Processing Society Distinguished Lecturer, a member of the IEEE Bio Imaging Signal Processing technical committee, and an Associate Editor for several IEEE and SIAM journals.



**Robert Ghrist** University of Pennsylvania

Monday 1:00 PM – 2:00 PM, August 6 Room: Mendelssohn Theatre Title: **Topological Signal Processing** 

**Abstract:** This talk will survey some recent advances in a qualitative approach to signal processing using tools from geometric and algebraic topology. Topology — the mathematics of qualitative description and local-to-global inference — is an ideal tool-set for several signal processing applications, especially in settings that are coordinate-free or otherwise minimalist.

**Biography:** After earning an undergraduate degree in Mechanical Engineering from the University of Toledo, Ghrist went on to earn a Ph.D. in Applied Mathematics from Cornell University, writing a thesis on knotted flowlines in 1995. Ghrist has held positions at the University of Texas, Austin; Georgia Institute of Technology; and the University of Illinois, Urbana-Champaign. He is currently the Andrea Mitchell University Professor of Mathematics and Electrical & Systems Engineering at the University of Pennsylvania. Ghrist's work focuses on topological methods in applied mathematics, with applications ranging from fluid dynamics to robotics to sensor networks and more. His work has been honored by *Scientific American* as a "SciAm50 Top Research Innovation" in 2007. He specialized in transferring technology from pure to applied mathematics.

# Plenary Speakers – Tuesday – Mendelssohn Theatre





**Robert Nowak** 

Tuesday 8:30 AM - 9:30 AM, August 7 Room: Mendelssohn Theatre

Title: Adaptive Sensing and Active Learning

Abstract: Progress in science and engineering relies on building good models. Modern applications often involve huge systems of many variables, and researchers have turned to flexible nonparametric and high-dimensional statistical models to capture the complexity of such problems. Most of the work in this direction has focused on non-adaptive measurements. Alternatively, adaptive measurement procedures can improve the accuracy of statistical inference. These procedures automatically adapt the measurements in order to focus and optimize the gathering of new information. Sequential experimental design and testing are classic examples of adaptive approaches. Adaptive measurement procedures for high-dimensional and nonparametric inference are largely unexplored, but researchers in several communities have begun to develop promising new tools. For example, machine learning researchers have devised "active learning" algorithms that can dramatically reduce the number of labeled training examples needed to design good classifiers. In signal processing, new results show that "adaptive sensing" can significantly improve the recovery of sparse signals in noise. This talk takes a modern look at adaptive measurement, highlighting the potential of adaptivity in challenging statistical inference problems.

Biography: Robert Nowak received the B.S., M.S., and Ph.D. degrees in Electrical Engineering from the University of Wisconsin-Madison in 1990, 1992, and 1995, respectively. He was a Postdoctoral Fellow at Rice University in 1995-1996, an Assistant Professor at Michigan State University from 1996-1999, held Assistant and Associate Professor positions at Rice University from 1999-2003, and is now the McFarland-Bascom Professor of Engineering at the University of Wisconsin-Madison. Professor Nowak has held visiting positions at INRIA, Sophia-Antipolis (2001), and Trinity College, Cambridge (2010). He has served as an Associate Editor for the IEEE Transactions on Image Processing and the ACM Transactions on Sensor Networks, and as the Secretary of the SIAM Activity Group on Imaging Science. He was General Chair for the 2007 IEEE Statistical Signal Processing workshop and Technical Program Chair for the 2003 IEEE Statistical Signal Processing Workshop and the 2004 IEEE/ACM International Symposium on Information Processing in Sensor Networks. Professor Nowak received the General Electric Genius of Invention Award (1993), the National Science Foundation CAREER Award (1997), the Army Research Office Young Investigator Program Award (1999), the Office of Naval Research Young Investigator Program Award (2000), the IEEE Signal Processing Society Young Author Best Paper Award (2000), the IEEE Signal Processing Society Best Paper Award (2011), and the ASPRS Talbert Abrams Paper Award (2012). He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE). His research interests include signal processing, machine learning, imaging and network science, and applications in communications, bioimaging, and systems biology. His Google Scholar page contains further information about his research and publications.



Persi Diaconis Stanford University

Tuesday 1:00 PM - 2:00 PM, August 7 Room: Mendelssohn Theatre

Title: Adding Numbers and Determinental Point Processes

Abstract: When a column of digits is added in the usual way, "carries" occur. If the digits are random, the carries form a point process with interesting properties. It is stationary, one-dependent, and determinental. This allows standard theory to answer "any reasonable question." A raft of such processes occur in a variety of applications: random matrix theory, combinatorics, zeros of random functions, and software design. The mathematics involves various parts of algebra, in rare conjunction with probability. All of this is joint work with Alexei Borodin.

Biography: Persi Diaconis is professor of mathematics and statistics at Stanford University. He works in various parts of statistics (graphics, Bayesian statistics, data analysis for large networks), probability (random matrix theory, Markov chain theory), and combinatorics (symmetric functions, combinatorial group theory). An early Macarthur winner and a member of the national academy, he is also well-known for 10 years spent as a professional magician.

# Plenary Speakers – Wednesday – Mendelssohn Theatre



#### Yoram Bresler

University of Illinois, Urbana-Champaign

Wednesday 8:30 – 9:30 AM, August 8 Room: Mendelssohn Theatre

#### Title: The Invention of Compressive Sensing and Recent Results: From Spectrum-Blind Sampling and Image Compression on the Fly to New Solutions With Realistic Performance Guarantees

Abstract: Compressive sensing (CS), also known as compressive sampling, has become widely popular in recent years. In the first part of the talk, we review the little known fact, that the invention of CS preceded the papers that popularized it by almost a decade. Spectrum-blind sampling (SBS), proposed by Bresler and Feng in the mid-90's, and further developed into "image compression on the fly," with Venkataramani, and Gastpar, is the first known compressed sensing technique. This work from the 1990's already included the conceptual breakthrough of sampling at the sparsity level, theoretical guarantees and computationally efficient algorithms, treatment of both finite-length vectors and analog sampling, of the single-vector case and of jointly-sparse recovery (the so-called multiple measurement vector problem), and applications to imaging.

In the second part of the talk, guided by the applications that originally spurred the invention of CS in the 1990's, and which have continued to motivate much of the work on CS to date, we examine the current status of CS theory and algorithms. We find that in spite of deep and seminal contributions in this area, the available results have some limitations. The most powerful performance guarantees for polynomial-time algorithms have been obtained for unstructured random Gaussian or sub-Gaussian sensing matrices. However, in most practical applications, such sensing matrices are infeasible, owing to either the physics of the acquisition system, or computational cost. On the other hand, the performance guarantees for structured sensing matrices that arise in practice are too conservative, or inapplicable. Another weakness of current CS has been the extension to jointly-sparse recovery: algorithms that perform well in practice are computationally expensive, and those that are fast, have inferior performance. We describe new results that address both of these limitations of current theory and algorithms. Expanding on the ideas first proposed for SBS and image compression on the fly, we describe new guaranteed algorithms for jointly-sparse recovery, which provide the best of both worlds: they are fast, and perform at least as well as the best known (but expensive) algorithms. Addressing the broader problem of sensing with structured matrices, we develop new tools for performance guarantees, and new efficient algorithms to which these guarantees are applicable. The new algorithm are not only guaranteed under more lenient conditions that are satisfied in practical compressive sensing systems, but, in numerical experiments, they also perform better than existing algorithms.

Biography: Yoram Bresler (F'99) received the B.Sc. (cum laude) and M.Sc. degrees from the Technion, Israel Institute of Technology, in 1974 and 1981, respectively, and the Ph.D degree from Stanford University, in 1986, all in Electrical Engineering. In 1987, he joined the University of Illinois at Urbana-Champaign, where he is currently a Professor at the Departments of Electrical and Computer Engineering and Bioengineering, and at the Coordinated Science Laboratory. Yoram Bresler is also President and Chief Technology Officer at InstaRecon, Inc., a startup he co-founded to commercialize breakthrough technology for tomographic reconstruction developed in his academic research. His

current research interests include multi-dimensional and statistical signal processing and their applications to inverse problems in imaging, and in particular computed tomography, magnetic resonance imaging, and compressed sensing.

Dr. Bresler has served on the editorial board of a number of journals, and on various committees of the IEEE. Currently, he serves on the editorial board for the SIAM Journal on Imaging Science. Dr. Bresler is a fellow of the IEEE and of the AIMBE. He received two Senior Paper Awards from the IEEE Signal Processing Society, and a paper he coauthored with one of his students received the Young Author Award from the same society in 2002. He is the recipient of a 1991 NSF Presidential Young Investigator Award, the Technion (Israel Inst. of Technology) Fellowship in 1995, and the Xerox Senior Award for Faculty Research in 1998. He was named a University of Illinois Scholar in 1999, appointed as an Associate at the Center for Advanced Study of the University in 2001-2002, and Faculty Fellow at NCSA in 2006.



**Ohio State University** Wednesday 9:45 AM - 10:45 AM, August 8 Room: Mendelssohn Theatre

Title: Radar Signal Processing

Abstract: The steady advance in digital processing hardware and sampling systems are enabling significant new opportunities in radar signal processing. In the same way that increasing processor speed realized a revolution first in digital audio, then in digital video, digital radar is rapidly growing. Digital radar systems are enabling new architectures and new capabilities; examples include 3D imaging, multifunctional systems, and waveform adaptation. This talk will describe some recent advances and highlight emerging opportunities for next-generation digital radar systems.

Biography: Randolph L. Moses received the B.S., M.S., and Ph.D. degrees in Electrical Engineering from Virginia Tech 1979, 1980, and 1984, respectively. Since 1985, he has been on the faculty at The Ohio State University, and holds appointments as Associate Dean for Research in the College of Engineering and Professor in Electrical and Computer Engineering. Professor Moses has also been a visiting researcher with the Air Force Research Laboratory (1983; 2002-03), Eindhoven University of Technology in The Netherlands (1984), Uppsala University in Sweden (1994-95), and Massachusetts Institute of Technology (2003). Professor Moses serves on the ASEE Engineering Research Council, and on the IEEE Sensors Council, and the IEEE Signal Processing Society Sensor Array and Multichannel Technical Committee. He serves on the Board of Directors for the Edison Materials Technology Center (EMTEC) and the Dayton Area Graduate Studies Institute (DAGSI). He is a past associated editor of IEEE Transactions on Image Processing (2008-09) and of IEEE Transactions on Signal Processing (2000-04). He was the founding chairman of the Columbus Ohio Section of the IEEE Signal Processing Society.

Professor Moses' research interests are in statistical signal processing, and include parametric time series analysis, radar signal processing, sensor array processing, and sensor networks. He has published more than 150 technical papers and co-authored two textbooks. He is a Fellow of the IEEE.

# Sunday, August 5



18:00 – 20:00 pm	Opening Reception — Museu	m of Art				
Monday, Aug	gust 6					Day 1
	Hussey Room	Hussey Room	Vandenberg Room	Michigan Room	Vandenberg Room	Michigan Room
08:20 – 08:30 am	Opening Remarks — Room: N	Aendelssohn Theatre				
08:30 – 09:30 am	P1: Yonina Eldar: Xampling	at the Rate of Innovation: Corr	elations, Nonlinearities, and	Bounds — Room: Mendelssohi	n Theatre	
10:00 – 11:30 am	MA1 Special Session: Applica- tions of Statistical Signal Processing to Geophysical/ Petrophysical Data Acquisition and Processing	MA2 Intentionally Blank	MA3 Sparse Models and Applications I	MA4 Estimation Theory I	MA5 Array Signal Processing	MA6 Signal Processing on Graphs
Lunch Break — Michigan Lea	gue Ballroom	^				^ 
13:00 – 14:00 pm	P2: Robert Ghrist: Topologi	cal Signal Processing — Roor	n: Mendelssohn Theatre			
14:30 – 16:00 pm	<b>MB1</b> Special Session: Signal Proc- essing Theory and Method on Graphs and Networks	MB2 Special Session: Value of Information and Distributed Signal Processing I	MB3 Sparse Models and Applications II	<b>MB4</b> Adaptive Systems and Signal Processing I	MB5 Imaging Theory and Methods	MB6 Monte Carlo Methods
16:00 – 17:30 pm	MC1 Special Session: Distributed Synchronization, Localization and Beamforming	MC2 Special Session: Value of Information and Distributed Signal Processing II	MC3 Sparse Models and Applications III	MC4 Adaptive Systems and Signal Processing II	MC5 Speech Signal Processing	MC6 Information Forensics and Security

# Tuesday, August 7



	Hussey Room	Hussey Room	Vandenberg Room	Michigan Room	Vandenberg Room	Michigan Room
<b>08:30 – 09:30 am P3: Robert Nowak:</b> Adaptive Sensing and Active Learning — Room: Mendelssohn Theatre						
10:00 – 11:30 am	<b>TA1</b> Special Session: Challenges in High-Dimensional Learning	TA2 Intentionally Blank	<b>TA3</b> Biological and Biomedical Applications	TA4 Estimation Theory II	TA5 Communication Systems I	<b>TA6</b> Sensor Networks I
Lunch Break — Michigan Leag	ue Ballroom					
13:00 – 14:00 pm	P4: Persi Diaconis: Adding I	lumbers and Determinental Po	int Processes — Room: Mend	elssohn Theatre		
14:30 – 16:00 pm	<b>TB1</b> Special Session: Radar Applications of Compressive Sensing	<b>TB2</b> Special Session: Signal Processing for Complex- Biological Systems and Large-Scale Omics Data I	TB3 Compressive Sensing I	<b>TB4</b> Machine Learning and Pattern Recognition I	TB5 Sensor Networks II	<b>TB6</b> Time-Frequency Analysis
16:00 – 17:30 pm	<b>TC1</b> Special Session: Statistical Signal Processing and the Engineering of Materials	<b>TC2</b> Special Session: Signal Processing for Complex Biological Systems and Large-Scale Omics Data II	TC3 Compressive Sensing II	<b>TC4</b> Machine Learning and Pattern Recognition II	TC5 Radar Signal Processing I	TC6 Computer Systems and Networks
18:30 – 19:00 pm	pm R2: Banquet Reception – Rogel Ballroom at the Michigan Union					
19:00 – 21:00 pm	B1: Banquet – Rogel Ballroom at the Michigan Union					

# Wednesday, August 8



	Hussey Room	Hussey Room	Vandenberg Room	Michigan Room	Vandenberg Room	Michigan Room
08:30 – 09:30 am	<b>P5: Yoram Bresler:</b> The Invention of Compressive Sensing and Recent Results: From Spectrum-Blind Sampling and Image Compression on the Fly to New Solutions With Realistic Performance Guarantees — Room: Mendelssohn Theatre					
09:45 — 10:45 am	P6: Randy Moses: Radar Sig	nal Processing — Room: Men	ndelssohn Theatre			
11:00 – 12:30 pm	WA1 Special Session: Applications of Random Matrix Theory in Underwater Acoustic Signal Processing	WA2 Intentionally Blank	WA3 Communication Systems II	WA4 Radar Signal Processing II	<b>WA5</b> Multivariate Statistical Analysis	WA6 Detection Theory
12:30 – 13:30 pm	<b>Government Panel: Representatives from US DoD agencies will speak</b> <b>Panel Moderator:</b> Randy Moses (Ohio State University), <b>Panel Organizer:</b> Liyi Dai (US Army Research Office) — Room: Michigan League Ballroom					
14:00 pm – 16:30 pm	(Optional) Michigan Stadium Tour. Bus departs from Michigan League.					

### Monday, August 6

**Opening Remarks Room:** Mendelssohn Theatre **Time:** 8:20 – 8:30 am

#### P1: Yonina Eldar: Xampling at the Rate of Innovation: Correlations, Nonlinearities, and Bounds

#### Room: Mendelssohn Theatre Time: 8:30 – 9:30 am

We present a framework for sampling a wide class of wideband analog signals with finite rate of innovation, at rates far below that dictated by the Nyquist rate. We refer to this methodology as Xampling: A combination of compression and sampling, performed simultaneously. Using the Cramer-Rao bound we develop a generic low-rate sampling architecture that is optimal in a mean-squared error sense, and can be applied to a wide variety of wideband inputs. We show that this approach improves upon several alternative sampling mechanisms proposed in the literature. Another advantage of our scheme is that it can be readily implemented in hardware, and is easily modified to incorporate correlations between signals. We consider in detail an application of these ideas to ultrasound imaging and demonstrate recovery of noisy ultrasound images from sub-Nyquist samples while performing beamforming in the compressed domain. Finally, motivated by problems in optics, we extend these principles to nonlinear problems leading to quadratic and more general nonlinear compressed sensing techniques. We demonstrate applications to phase recovery from magnitude measurements and super-resolution imaging.

## MA1: Special Session: Applications of Statistical Signal Processing to Geophysical/Petrophysical Data Acquisition and Processing

Room: Hussey Time: 10:00 – 11:30 am Session Chairs: Shuchin Aeron (Tufts University, USA), Eric L Miller (Tufts University, USA)

*Analysis of Real Vector Fields on the Sphere Using Slepian Functions* A. Plattner, F. Simons, and L. Wei

*Incorporating Spatial Structure Into Hyperspectral Scene Analysis* J. Ash and J. Meola

*A Heuristic Bayesian Design Criterion for Imaging Resolution Enhancement* M. Khodja, M. Prange, and H. Djikpesse

Robust Detection of Weak Acoustic Signals in Noise Using Near Optimal Shrinkage in Radon Domain S. Aeron, S. Bose, and H. P. Valero

A Mixture of Experts Based Discretization Approach for Characterizing Subsurface Contaminant Source Zones B. Ahmed, I. Mendoza-Sanchez, R. Khardon, L. Abriola, and E. Miller

A Localized Ensemble Kalman Smoother M. Butala

Approximate Message Passing Meets Exploration Seismology F. Herrmann

**Reconstruction of Seismic Data Via Tensor Completion** N. Kreimer and M. Sacchi

#### **MA2: Intentionally Blank**

Room: Hussey

#### **MA3: Sparse Models and Applications I**

Room: Vandenberg Time: 10:00 – 11:30 am Session Chairs: Ioannis Schizas (University of Texas at Arlington, USA)

*Maximum Likelihood Based Sparse and Distributed Conjoint Analysis* E. Tsakonas, J. Jaldén, N. Sidiropoulos, and B. Ottersten

**Preprocessing for Classification of Sparse Data: Application to Trajectory Recognition** A. Mayoue, Q. Barthélemy, S. Onis, and A. Larue

**Distributed Informative Sensor Determination Via Sparsity-Cognizant Matrix Decomposition** I. Schizas

*Bayesian Hypothesis Test for Sparse Support Recovery Using Belief Propagation* J. Kang, H. N. Lee, and K. Kim

*Exact Recovery of Low-rank Plus Compressed Sparse Matrices* M. Mardani, G. Mateos, and G. B. Giannakis

**Correlation-Aware Techniques for Sparse Support Recovery** P. Pal and P. P. Vaidyanathan

MA4: Estimation Theory I Room: Michigan Time: 10:00 – 11:30 am Session Chair: Ruixin Niu (Virginia Commonwealth University, USA)

Sequential Bayesian Estimation With Censored Data Y. Zheng, R. Niu, and P. Varshney

*Wiener Filtering of Rotation Processes Using Ordered Exponential* J. Boulanger, N. Le Bihan, and J. Manton

*Reducing the Gap Between Linear Biased Classical and Linear Bayesian Estimation* L. Fu-Mueller, M. LungImayr, and M. Huemer

*Multifractal Analysis of Self-Similar Processes* H. Wendt, S. Jaffard, and P. Abry

*The Relationship Between Transfer Entropy and Directed Information* Y. Liu and S. Aviyente

*An ESPRIT-Based Parameter Estimator for Spectroscopic Data* E. Gudmundson, P. Wirfält, A. Jakobsson, and M. Jansson



MA5: Array Signal Processing

Room: Vandenberg Time: 10:00 – 11:30 am Session Chair: Koby Todros (University of Michigan, USA)

**Robust Prior-based Direction of Arrival Estimation** P. Wirfält and M. Jansson

*Steering Vector Estimation and Beamforming Under Uncertainties* B. Liao, S. C. Chan, K. M. Tsui, and Y. Chu

**Uniform Rectangular Time Reversal Arrays: Joint Azimuth and Elevation Estimation** M. Sajjadieh and A. Asif

**Oblique Projection Beamforming for RFI Mitigation in Radio Astronomy** G. Hellbourg, R. Weber, C. Capdessus, and A. J. Boonstra

An Iterative, Backscatter-Analysis Based Algorithm for Increasing Transmission Through a Highly-Backscattering Random Medium C. Jin, R. R. Nadakuditi, E. Michielssen, and S. Rand

Fast Tests for the Common Causality of Time-Of-Arrival Events From Their Mutual Minkowski Distances S. Howard and S. Sirianunpiboon

#### **MA6: Signal Processing on Graphs**

Room: Michigan Time: 10:00 – 11:30 am Session Chair: Kevin S Xu (University of Michigan, USA)

*Causal Conditioning and Instantaneous Coupling in Causality Graphs* P. O. Amblard and O. Michel

*Graph Entropy Rate Minimization and the Compressibility of Undirected Binary Graphs* M. Bolanos, S. Aviyente, and H. Radha

*Toward Matched Filter Optimization for Subgraph Detection in Dynamic Networks* B. Miller and N. Bliss

*Dynamic Network Summarization Using Convex Optimization* A. Mutlu and S. Aviyente

*Dynamic Network Kriging* K. Rajawat, E. Dall'Anese, and G. B. Giannakis

*Of the Largest Eigenvalue for Modularity-Based Partitioning* Y. T. Chang, D. Pantazis, and L. Richard M.

#### P2: Robert Ghrist: Topological Signal Processing

Room: Mendelssohn Theatre Time: 13:00 – 14:00 pm

This talk will survey some recent advances in a qualitative approach to signal processing using tools from geometric and algebraic topology. Topology — the mathematics of qualitative description and local-to-global inference — is an ideal tool-set for several signal processing applications, especially in settings that are coordinate-free or otherwise minimalist.

#### MB1: Special Session: Signal Processing Theory and Method on Graphs and Networks

Room: Hussey Time: 14:30 – 16:00 pm Session Chairs: Hayder Radha (Michigan State University, USA), Patrick Wolfe (Harvard University, USA)

**On Hard Limits of Eigen-Analysis Based Planted Clique Detection** R. R. Nadakuditi

*A Windowed Graph Fourier Transform* D. Shuman, B. Ricaud, and P. Vandergheynst

*Identifying Online Communities of Interest Using Side Information* C. Leberknight, A. Tajer, M. Chiang, and H. V. Poor

*Graph-Wavelet Filterbanks for Edge-Aware Image Processing* S. Narang, Y. H. Chao, and A. Ortega

*Transitivity Matrix of Social Network Graphs* M. Aghagolzadeh, I. Barjasteh, and H. Radha

#### MB2: Special Session: Value of Information and Distributed Signal Processing I

Room: Hussey Time: 14:30 – 16:00 pm Session Chairs: John W. Fisher III (Massachusetts Institute of Technology, USA), Brian Sadler (Army Research Laboratory, USA)

*A Comparison of Information Theoretic Functions for Tracking Maneuvering Targets* W. Lu, G. Zhang, and S. Ferrari

*Multistage Adaptive Estimation of Sparse Signals* D. Wei and A. Hero III

An Obfuscation Framework for Controlling Value of Information During Sharing S. Chakraborty, K. R. Raghavan, M. Srivastava, C. Bisdikian, and L. Kaplan

Active Learning for Large-Scale Factor Analysis J. Silva and L. Carin

*Diffusion LMS for Source and Process Estimation in Sensor Networks* R. Abdolee, B. Champagne, and A. Sayed

*A Gossip-based Distributed Processing Algorithm for Multiple Transmitter Localization* J. Almodovar and J. Nelson

MB3: Sparse Models and Applications II Room: Vandenberg Time: 14:30 – 16:00 pm Session Chair: Vaughan Clarkson (The University of Queensland, Australia)

*Efficient Block and Time-Recursive Estimation of Sparse Volterra Systems* S. Adalbjörnsson, G. O. Glentis, and A. Jakobsson

*Equivalence of Synthesis and Atomic Formulations of Sparse Recovery* M. Fatemi, S. Dashmiz, M. H. Shafinia, and V. Cevher

*Discriminative Sparse Image Representation for Classification Based on a Greedy Algorithm* S. Cardona-Romero and S. Aviyente

*Matrix ALPS: Accelerated Low Rank and Sparse Matrix Reconstruction* A. Kyrillidis and V. Cevher

*Fast OMP: Reformulating OMP Via Iteratively Refining L2-Norm Solutions* S. H. Hsieh, C. S. Lu, and S. C. Pei

*Estimating Period From Sparse, Noisy Timing Data* B. Quinn, R. McKilliam, and V. Clarkson

MB4: Adaptive Systems and Signal Processing I Room: Michigan Time: 14:30 – 16:00 pm Session Chair: Stéphanie Bidon (ISAE, France)

**Bayesian Estimation of Forgetting Factor in Adaptive Filtering and Change Detection** V. Šmídl and F. Gustafsson

Subband Adaptive Convex Combination of Two NLMS Based Filters for Sparse Impulse Response Systems S. W. Sohn, J. Lee, K. Lee, H. Choi, and H. D. Bae

Adaptive Filtering in the Presence of Outliers O. Besson and S. Bidon

*LMS in Prominent System Subspace for Fast System Identification* R. Yu, Y. Song, and S. Rahardja

Adaptive Filtering for Lightning Electric Field (LEF) Signals in Fractional Fourier Domain H. Rojas and C. Cortes

**Boosting Quantization for Lp Norm Distortion Measure** L. Wang, N. Piotto, and D. Schonfeld

MB5: Imaging Theory and Methods Room: Vandenberg Time: 14:30 – 16:00 pm Session Chair: Sathish Ramani (University of Michigan, USA)

Accelerated Parallel Magnetic Resonance Imaging Reconstruction Using Joint Estimation With a Sparse Signal Model D. Weller, J. Polimeni, L. Grady, L. Wald, E. Adalsteinsson, and V. Goyal *Alternating Minimization Approach for Multi-frame Image Reconstruction* J. H. Cho, S. Ramani, and J. Fessler

*Regularized Hyperalignment of Multi-set fMRI Data* H. Xu, A. Lorbert, P. Ramadge, S. Guntupalli, and J. Haxby

*fMRI Activation Detection Using a Variant of Akaike Information Criterion* A. K. Seghouane

*The Value of Multispectral Observations in Photon-Limited Quantitative Tissue Analysis* Z. Harmany, X. Jiang, and R. Willett

*Nonparametric Methods for Full-Waveform Ladar Images* E. Buschelman and R. Martin

MB6: Monte Carlo Methods Room: Michigan Time: 14:30 – 16:00 pm Session Chair: Mark Coates (McGill University, Canada)

**Bayesian Model Comparison Via Path-Sampling Sequential Monte Carlo** Y. Zhou, A. Johansen, and J. Aston

Distributed State Estimation for Large-scale Nonlinear Systems: A Reduced Order Particle Filter Implementation A. Mohammadi and A. Asif

*Joint Bayesian Decomposition of a Spectroscopic Signal Sequence with RJMCMC* V. Mazet, S. Faisan, A. Masson, M. A. Gaveau, L. Poisson, and J. M. Mestdagh

*Implementation of the Daum-Huang Exact-Flow Particle Filter* T. Ding and M. Coates

Estimation of Posterior Distributions With Population Monte Carlo Sampling and Graphical Modeling P. Djurić and Ç. Taşdemir

MC1: Special Session: Distributed Synchronization, Localization and Beamforming Room: Hussey Time: 16:30 – 17:30 pm Session Chairs: Patrick Bidigare (Raytheon BBN Technologies, USA), Raghuraman Mudumbai (University of Iowa, USA), Troy Stevens (SRI, USA)

**Reference-Aided Distributed Transmit Beamforming With Mobile Radios** T. Stevens and K. Kastella

*Receiver-Coordinated Zero-Forcing Distributed Transmit Nullforming* D. Brown, P. Bidigare, S. Dasgupta, and U. Madhow

Initial Over-the-Air Performance Assessment of Ranging and Clock Synchronization Using Radio Frequency Signal Exchange

P. Bidigare, D. Raeman, S. Pruessing, D. Scherber, U. Madhow, and R. Mudumbai

#### Frequency Estimation in the Presence of Cycle Slips: Filter Banks and Error Bounds for Phase Unwrapping

K. Kastella, R. Mudumbai, and T. Stevens

*A Distributed Consensus Approach to Synchronization of RF Signals* M. M. U. Rahman, S. Dasgupta, and R. Mudumbai

Loss Characterization of Distributed Space-Time Transmit Beamforming With Embedded Channel Probing A. Margetts, E. Torkildson, and D. Bliss

#### MC2: Special Session: Value of Information and Distributed Signal Processing II

Room: Hussey Time: 14:30 – 16:00 pm Session Chairs: John W. Fisher III (Massachusetts Institute of Technology, USA), Brian Sadler (Army Research Laboratory, USA)

Sensor Selection in Adversarial Setting E. Ertin

*The Value of Information in Constrained Parametric Models* T. Moore and B. Sadler

*Maximum-entropy Surrogation in Network Signal Detection* D. Cochran, S. Howard, B. Moran, and H. Schmitt

**Theoretical Guarantees on Penalized Information Gathering** G. Papachristoudis and J. Fisher III

**On-Line Gossip-Based Distributed Expectation Maximization Algorithm** G. Morral, P. Bianchi, and J. Jakubowicz

**Correlated Observations in Distributed Detection Systems** H. Ahmadi and A. Vosoughi

*Diffusion Networks Outperform Consenus Networks* S. Y. Tu and A. Sayed

MC3: Sparse Models and Applications III Room: Vandenberg Time: 14:30 – 16:00 pm Session Chair: Zhi Tian (Michigan Technological University, USA)

*Non-Line-of-Sight Localization Using Low-rank + Sparse Matrix Decomposition* V. Ekambaram and K. Ramchandran

Sparse FIR Estimation of Low-Order Systems Q. Ling, W. Shi, G. Wu, and Z. Tian

*A Generalized Framework for Learning and Recovery of Structured Sparse Signals* J. Ziniel, S. Rangan, and P. Schniter

Sample Complexity of Salient Feature Identification for Sparse Signal Processing C. Aksoylar, G. Atia, and V. Saligrama *Localization and Bearing Estimation Via Structured Sparsity Models* M. Duarte

**Beyond L1-Norm Minimization for Sparse Signal Recovery** H. Mansour

#### MC4: Adaptive Systems and Signal Processing II

Room: Michigan Time: 14:30 – 16:00 pm Session Chair: Yuriy S. Shmaliy (Universidad de Guanajuato, Mexico)

*Theoretical Discussion of the Filtered-X LMS Algorithm Based on Statistical Mechanical Analysis* S. Miyoshi and Y. Kajikawa

*Extended UFIR Filtering of Nonlinear Models Corrupted by White Gaussian Noise* O. Ibarra-Manzano, F. Ramirez-Echeverria, and Y. Shmaliy

*Studies of Optimal Memory for Discrete-Time FIR Filters in State-Space* F. Ramirez-Echeverria, A. Sarr, O. Ibarra-Manzano, and Y. Shmaliy

*Lag-Recursive Estimation of the Average Autocorrelation of an Arbitrarily Time-Variant System Response* L. Peng and H. Lev-Ari

MC5: Speech Signal Processing Room: Vandenberg Time: 14:30 – 16:00 pm Session Chair: Hafiz Malik (University of Michigan - Dearborn, USA)

Speech Enhancement Combined With Dereverberation and Acoustic Echo Reduction for Time Varying Systems M. Togami and Y. Kawaguchi

A New Regularized TVAR-based Algorithm for Recursive Detection of Nonstationarity and Its Application to Speech Signals Y. Chu, S. C. Chan, Z. Zhang, and K. M. Tsui

*Phase Difference of Filter-stable Part-tones as Acoustic Feature* Z. Tüske, F. Drepper, and R. Schlüter

**BaNa: A Hybrid Approach for Noise Resilient Pitch Detection** He Ba, Na Yang, I. Demirkol, and W. Heinzelman

**Audio Forensics Using Acoustic Environment Traces** H. Zhao and H. Malik

MC6: Information Forensics and Security Room: Michigan Time: 14:30 – 16:00 pm

Session Chair: Kevin M. Carter (MIT Lincoln Laboratory, USA)

**Probabilistic Reasoning for Streaming Anomaly Detection** K. Carter and W. Streilein

*Relay Selection and Scaling Law in Destination Assisted Physical Layer Secrecy Systems* Y. Liu and A. Petropulu

*System State Estimation in the Presence of False Information Injection* R. Niu and L. Huie

**Outage Constrained Secrecy Rate Maximization Using Cooperative Jamming** S. Luo, J. Li, and A. Petropulu

*New Statistic in \$p\$-value Estimation for Anomaly Detection* J. Qian and V. Saligrama

### Tuesday, August 7

#### P3: Robert Nowak: Adaptive Sensing and Active Learning

Room: Mendelssohn Theatre Time: 8:30 – 9:30 am

Progress in science and engineering relies on building good models. Modern applications often involve huge systems of many variables, and researchers have turned to flexible nonparametric and high-dimensional statistical models to capture the complexity of such problems. Most of the work in this direction has focused on non-adaptive measurements. Alternatively, adaptive measurement procedures can improve the accuracy of statistical inference. These procedures automatically adapt the measurements in order to focus and optimize the gathering of new information. Sequential experimental design and testing are classic examples of adaptive approaches. Adaptive measurement procedures for high-dimensional and nonparametric inference are largely unexplored, but researchers in several communities have begun to develop promising new tools. For example, machine learning researchers have devised "active learning" algorithms that can dramatically reduce the number of labeled training examples needed to design good classifiers. In signal processing, new results show that "adaptive sensing" can significantly improve the recovery of sparse signals in noise. This talk takes a modern look at adaptive measurement, highlighting the potential of adaptivity in challenging statistical inference problems.

#### TA1: Special Session: Challenges in High-Dimensional Learning

Room: Hussey Time: 10:00 – 11:30 am Session Chairs: Prakash Ishwar (Boston University, USA), William Karl (Boston University, USA), Venkatesh Saligrama (Boston University, USA)

The Performance of Deterministic Matched Subspace Detectors When Using Subspaces Estimated From Noisy, Missing Data

N. Asendorf, R. T. Suryaprakash, and R. R. Nadakuditi

#### Sequentially Designed Compressed Sensing

J. Haupt, R. Baraniuk, R. Castro, and R. Nowak

Sensing Aware Dimensionality Reduction for Nearest Neighbor Classification of High Dimensional Signals Z. Sun, W. Karl, P. Ishwar, and V. Saligrama

*Fast Global Convergence of Gradient Methods for Solving Regularized \$M\$-estimation* A. Agarwal, S. Negahban, and M. Wainwright

*Simple Algorithms for Sparse Linear Regression with Noisy and Missing Data* Y. Chen and C. Caramanis

**Greedy Dirty Models: A New Algorithm for Multiple Sparse Regression** A. Jalali and S. Sanghavi

TA2: Intentionally Blank Room: Hussev

#### **TA3: Biological and Biomedical Applications**

Room: Vandenberg Time: 10:00 – 11:30 am Session Chair: Alessio Medda (Georgia Tech Research Institute & Georgia Institute of Technology, USA)

*Muscle Activity Detection From Myoelectric Signals Based on the AR-GARCH Model* G. Rasool, N. Bouaynaya, and K. Iqbal

A Wavelet Clustering Technique for the Identification of Functionally Connected Regions in the Rat Brain Using Resting State fMRI A. Medda, L. Hoffmann, M. Willis, M. Magnuson, and S. Keilholz

**Comparison of Gaussian Process Models for Single-Trial Event-Related Potentials** M. R. Mestre and W. Fitzgerald

Accelerated Time-of-Flight Mass Spectrometry M. Ibrahimi, A. Montanari, and G. Moore

Describing the Structure of a Macro Molecular Complex as a Random Signal in Noise and a Maximum Likelihood Reconstruction Q. Wang and P. Doerschuk

**EEG Signal Classification With Super-Dirichlet Mixture Model** Z. Ma, Z. H. Tan, and S. Prasad

*Classification of EEG Recordings Without Perfectly Time-Locked Events* J. Meng, L. Merino, K. A. Robbins, and Y. Huang



TA4: Estimation Theory II

Room: Michigan Time: 10:00 – 11:30 am Session Chair: Rebecca Willett (Duke University, USA)

*Charrelation-Based Estimation of the Parameters of Non-Gaussian Autoregressive Processes* A. Slapak and A. Yeredor

*SURE-based Blind Gaussian Deconvolution* F. Xue and T. Blu

A Statistical Inference Method for a Subset of Long-range Dependent FARIMA Processes M. Mossberg

*Linearity Conditions for Optimal Estimation From Multiple Noisy Measurements* E. Akyol, K. Viswanatha, and K. Rose

*A Two-Stage Denoising Filter: The Preprocessed Yaroslavsky Filter* J. Salmon, R. Willett, and E. Arias-Castro

Analytical Precision Limits in Slitless Spectroscopy F. Oktem and F. Kamalabadi

#### **TA5: Communication Systems I**

Room: Vandenberg Time: 10:00 – 11:30 am Session Chair: Bill Correll, Jr. (General Dynamics, USA)

**Bayesian Sparse Channel Estimation and Tracking** C. Chen and M. Zoltowski

Parameter Estimation Techniques for Polynomial Phase and Phase Coded Waveforms in Multi-Channel Systems

S. Sirianunpiboon, S. Howard, and S. Elton

*Power Allocation for Distributed Detection in a Multiple-Ring Cluster* S. Laitrakun and E. Coyle

**Particle Filtering Based Data Detection in a Flat-Fading Relay-Based Communication System** T. Ghirmai

*MIMO Broadcast DFE Transceiver Design With Bit Allocation Under QoS Constraints* C. H. Liu and P. P. Vaidyanathan

*The Density of Costas Arrays and Three-Free Permutations* B. Correll

**Random Jitter Beamforming for Point-and-Link Communications** B. J. Kwak

*On the Distribution of Valid Pages With Greedy Garbage Collection for NAND Flash* B. Peleato, R. Agarwal, and J. Cioffi

#### **TA6: Sensor Networks I**

Room: Michigan Time: 10:00 – 11:30 am Session Chairs: Richard K. Martin (Air Force Institute of Technology, USA) **Resolving a Variable Number of Hypotheses With Multiple Sensors** J. Gubner and L. Scharf

*Radio Frequency Tomography in Mobile Networks* B. Hamilton, X. Ma, R. Baxley, and S. Matechik

Temporally Staggered Sensing for Field Estimation With Quantized Data in Wireless Sensor Networks S. Liu, E. Masazade, and P. Varshney

Least Favorable Distributions for the Design of Sensor Detection Systems in Non-Circular Regions of Interest B. Fonseca Jr. and J. Gubner

How Valid is the Regularly-Spaced Grid Assumption in RSS Source Localization Sensor Networks? R. Martin

*Full Order Distributed Particle Filters for Intermittent Connections: Feedback From Fusion Filters to Local Filters Improves Performance* A. Mohammadi and A. Asif

**Continuous-time Distributed Estimation With Asymmetric Mixing** V. Nascimento and A. Sayed

#### P4: Persi Diaconis: Adding Numbers and Determinental Point Processes

Room: Mendelssohn Theatre Time: 13:00 – 14:00 pm

When a column of digits is added in the usual way, "carries" occur. If the digits are random, the carries form a point process with interesting properties. It is stationary, one-dependent, and determinental. This allows standard theory to answer "any reasonable question." A raft of such processes occur in a variety of applications: random matrix theory, combinatorics, zeros of random functions, and software design. The mathematics involves various parts of algebra, in rare conjunction with probability. All of this is joint work with Alexdi Borodin.

#### TB1: Special Session: Radar Applications of Compressive Sensing

Room: Hussey Time: 14:30 – 16:00 pm Session Chair: Christopher Kreucher (Integrity Applications Incorporated, USA)

*Multistatic RADAR Change Detection Using Sparse Imaging Methods* M. Brennan, C. Kreucher, and B. Shapo

*Reusable Low-Error Compressive Sampling Schemes Through Privacy* A. Gilbert, B. Hemenway, M. Strauss, D. Woodruff, and M. Wootters

*Compressive Sensing and 3-D Radar Imaging* M. Stuff, B. Thelen, J. Garbarino, and N. Subotic

*Minimum L1 Norm SAR Image Formation* C. Coleman, S. Connell, E. Gabl, and J. Walter

*Compressed Sensing for MIMO RADAR: A Stochastic Perspective* Z. Tian and E. Blasch

## TB2: Special Session: Signal Processing for Complex Biological Systems and Large-Scale Omics Data I

Room: Hussey Time: 14:30 – 16:00 pm Session Chairs: Xiaoning Qian (University of South Florida, USA), Byung-Jun Yoon (Texas A&M, USA)

Analyzing Pathway Design From Drug Perturbation Experiments N. Berlow, R. Pal, L. Davis, and C. Keller

*A Non-parametric Bayesian Clustering for Gene Expression Data* L. Wang and X. Wang

Inference of Genetic Regulatory Networks Using Regularized Likelihood With Covariance Estimation G. Rasool, N. Bouaynaya, H. Fathallah-Shaykh, and D. Schonfeld

**Optimal Classifiers Within a Bayesian Framework** L. Dalton and E. Dougherty

*Optimal Cancer Therapy Based on a Tumor Growth Inhibition Model* M. R. Yousefi, A. Datta, and E. Dougherty

Gene Deletion Data Based Genomic Regulatory Network Inference L. Wang and X. Wang

TB3: Compressive Sensing I Room: Vandenberg Time: 14:30 – 16:00 pm Session Chair: Yao C Xie (Duke University, USA)

*Compressive Subspace Fitting for Multiple Measurement Vectors* J. Kim, O. Lee, and J. C. Ye

*The Restricted Isometry Property for Echo State Networks with Applications to Sequence Memory Capacity* H. L. Yap, A. Charles, and C. Rozell

**Online Search Orthogonal Matching Pursuit** A. Weinstein and M. Wakin

**Optimal Estimation With Arbitrary Error Metrics in Compressed Sensing** J. Tan, D. Carmon, and D. Baron

*Null Space Tuning Based Algorithms for Sparse Representation and Compressed Sensing* T. Mi, S. Li, and Y. Liu

*Compressive Demodulation of Mutually Interfering Signals* Y. Xie, Y. Chi, L. Applebaum, and R. Calderbank

**TB4: Machine Learning and Pattern Recognition I Room:** Michigan **Time:** 14:30 – 16:00 pm **Session Chairs:** Dennis Wei (University of Michigan, USA)

*Efficient Batch-Mode Active Learning of Random Forest* H. Nguyen, J. Yadegar, B. Kong, and H. Wei **One-class Machines Based on the Coherence Criterion** Z. Noumir, P. Honeine, and C. Richard

*Dictionary Adaptation for Online Prediction of Time Series Data With Kernels* C. Saidé, R. Lengellé, P. Honeine, C. Richard, and R. Achkar

*Hierarchical Clustering Using Randomly Selected Measurements* B. Eriksson

*k-Subspaces With Missing Data* L. Balzano, A. Szlam, B. Recht, and R. Nowak

A Combined Approach to Multi-label Multi-task Learning D. Motamedvaziri, V. Saligrama, and D. Castanon

*Multiscale Online Tracking of Manifolds* Y. Xie, J. Huang, and R. Willett

#### **TB5: Sensor Networks II**

Room: Vandenberg Time: 14:30 – 16:00 pm Session Chair: Michael Rabbat (McGill University, Canada)

*Multi-sensor Networked State Estimation With Delayed and Irregularly-spaced Observations* B. Yan, H. Lev-Ari, and A. Stanković

*Almost Sure Convergence of Consensus Algorithms by Relaxed Projection Mappings* O. Sluciak and M. Rupp

Bounded Confidence Opinion Dynamics With Network Constraints and Localized Distributed Averaging M. Rabbat

**Energy-Efficient Quickest Change Detection in Sensor Networks** T. Banerjee and V. Veeravalli

**Collaborative Sensor Scheduling for Space Situational Awareness** T. Hobson and V. Clarkson

*Channel-aware M-ary Distributed Detection: Optimal and Suboptimal Fusion Rules* N. Maleki and A. Vosoughi

*Distributed Pareto-Optimal Solutions Via Diffusion Adaptation* J. Chen and A. Sayed

TB6: Time-Frequency Analysis Room: Michigan Time: 14:30 – 16:00 pm Session Chair: Jia Meng (Massachusetts Institute of Technology, USA)

*A New Non-redundant Complex Hilbert Wavelet Transforms* L. Wei and T. Blu

Some Comments on Multitaper Estimates of Autocorrelation D. Thomson

*Multicomponent Signal Denoising With Synchrosqueezing* S. Meignen, T. Oberlin, and S. McLaughlin

**Reverberant Speech Separation Based on Audio-visual Dictionary Learning and Binaural Cues** Q. Liu, W. Wang, P. Jackson, and M. Barnard

**Exploiting Correlated Discriminant Features in Time Frequency and Space for Characterization and Robust Classification of Image RSVP Events with EEG Data** J. Meng, L. Merino, K. A. Robbins, and Y. Huang

#### TC1: Special Session: Statistical Signal Processing and the Engineering of Materials

Room: Hussey Time: 16:00 – 17:30 pm Session Chairs: Charles Bouman (Purdue University, USA), William Karl (Boston University, USA), Jeff Simmons (AFRL, Wright-Patterson Air Force Base, USA)

#### Application of FIB/SEM/EDXS Tomographic Spectral Imaging and Multivariate Statistical Analysis to the Analysis of Localized Corrosion P. Kotula, M. Van Benthem, and N. Sorensen

**Bayesian Image Segmentation of Transmission Electron Tomography 3D Reconstructions** L. Drummy

Bayesian Tomographic Reconstruction for High Angle Annular Dark Field (HAADF) Scanning Transmission Electron Microscopy (STEM)

S. Venkatakrishnan, L. Drummy, M. Jackson, M. De Graef, J. Simmons, and C. Bouman

*Discrete Image Reconstruction for Material Quantification* A. Tuysuzoglu, W. Karl, D. Castanon, and M. S. Ünlü

*Joint Deconvolution/Segmentation of Microscope Images of Materials* D. W. Kim and M. Comer

## TC2: Special Session: Signal Processing for Complex Biological Systems and Large-Scale Omics Data II

Room: Hussey Time: 16:00 – 17:30 pm Session Chairs: Xiaoning Qian (University of South Florida, USA), Byung-Jun Yoon (Texas A&M, USA)

**Base Calling Error Rates in Next-Generation DNA Sequencing** S. Manohar and H. Vikalo

*Causal Compressive Sensing for Gene Network Inference* Mo Deng, A. Emad, and O. Milenkovic

*Basis-Expansion Factor Models for Uncovering Transcription Factor Regulatory Network* M. Sanchez-Castillo, J. Meng, I. T. Luna, and Y. Huang

Joint State and Parameter Estimation for Boolean Dynamical Systems U. Braga-Neto

Statistical Assessment of Gene Fusion Detection Algorithms Using RNA Sequencing Data V. Varadan, A. Janevski, S. Kamalakaran, N. Banerjee, L. Harris, and N. Dimitrova *Adaptive Experimental Design for Drug Combinations* M. Park, M. Nassar, B. Evans, and H. Vikalo

TC3: Compressive Sensing II Room: Vandenberg Time: 16:00 – 17:30 pm Session Chair: Ervin Sejdić (University of Pittsburgh, USA)

*Restricted Isometry Property in Coded Aperture Compressive Spectral Imaging* H. Arguello and G. Arce

*Compressive LADAR in Realistic Environments* D. Sale, C. Rozell, J. Romberg, and A. Lanterman

Subspace Detection of High-Dimensional Vectors Using Compressive Sampling M. Azizyan and A. Singh

*Near-Isometric Linear Embeddings of Manifolds* C. Hegde, A. Sankaranarayanan, and R. Baraniuk

*Grouped Incoherent Measurements for Compressive Sensing* A. Polak, M. Duarte, and D. Goeckel

**Compressive Asynchronous Decomposition of Heart Sounds** A. Can, E. Sejdić, O. Alkishriwo, and L. Chaparro

#### TC4: Machine Learning and Pattern Recognition II Room: Michigan Time: 16:00 – 17:30 pm

Session Chairs: Raviv Raich (Oregon State University, USA)

**Regularized Joint Density Estimation for Multi-instance Learning** B. Behmardi, F. Briggs, X. Fern, and R. Raich

An Asymptotically Convex Approach to Discriminative Coding R. Raj

*A Bootstrap Interval Estimator for Bayes' Classification Error* C. Hawes and C. Priebe

*Learning Kernel Combination From Noisy Pairwise Constraints* T. Yang, R. Jin, and A. Jain

*Real Adaboost for Content Identification* R. Naini and P. Moulin

*Estimating Intrinsic Dimension Via Clustering* B. Eriksson and M. Crovella

TC5: Radar Signal Processing I Room: Vandenberg Time: 16:00 – 17:30 pm Session Chair: Alexander Ihler (UC Irvine, USA)

*Maneuvering Target Tracking Based on SDE Driven by GARCH Volatility* M. Hajiramezanali and H. Amindavar

# Agenda – Wednesday, August 8

*A Graphical Model Representation of the Track-Oriented Multiple Hypothesis Tracker* A. Frank, P. Smyth, and A. Ihler

*A Track-Before-Detect Procedure for Sparse Data* E. Grossi, M. Lops, and L. Venturino

*MIMO Radar Detection With Heterogeneous Propagation Losses* X. Song, P. Willett, S. Zhou, and J. Glaz

*Theoretical Multidimensional Resolution Limit for MIMO Radar Based on the Chernoff Distance* D. Tran, R. Boyer, A. Renaux, S. Marcos, and P. Larzaba

#### **TC6: Computer Systems and Networks**

Room: Michigan Time: 16:00 – 17:30 pm Session Chairs: Ali Pezeshki (Colorado State University, USA)

*Mapping Equivalence Under Iterative Dynamics for Symbolic Sequences* L. Wang and D. Schonfeld

**Probabilistic Graphical Model for Flash Memory Programming** B. Peleato, R. Agarwal, and J. Cioffi

Detection Performance of M-ary Relay Trees With Non-binary Message Alphabets Z. Zhang, E. Chong, A. Pezeshki, B. Moran, and S. Howard

*Estimation of Flow Distributions Tails From Sampled Traffic* N. Antunes and V. Pipiras

### Wednesday, August 8

#### P5: Yoram Bresler: The Invention of Compressive Sensing and Recent Results: From Spectrum-Blind Sampling and Image Compression on the Fly to New Solutions With Realistic Performance Guarantees

Room: Mendelssohn Theatre Time: 08:30 – 09:30 am

Compressive sensing (CS), also known as compressive sampling, has become widely popular in recent years. In the first part of the talk, we review the little known fact, that the invention of CS preceded the papers that popularized it by almost a decade. Spectrum-blind sampling (SBS), proposed by Bresler and Feng in the mid-90's, and further developed into "image compression on the fly," with Venkataramani, and Gastpar, is the first known compressed sensing technique. This work from the 1990's already included the conceptual breakthrough of sampling at the sparsity level, theoretical guarantees and computationally efficient algorithms, treatment of both finitelength vectors and analog sampling, of the single-vector case and of jointly-sparse recovery (the so-called multiple measurement vector problem), and applications to imaging. In the second part of the talk, guided by the applications that originally spurred the invention of CS in the 1990's, and which have continued to motivate much of the work on CS to date, we examine the current status of CS theory and algorithms. We find that in spite of deep and seminal contributions in this area, the available results have some limitations. The most powerful performance guarantees for polynomial-time algorithms have been obtained for unstructured random Gaussian or sub-Gaussian sensing matrices. However, in most practical applications, such sensing matrices are infeasible, owing to either the physics of the acquisition system, or computational cost. On the other hand, the performance guarantees for structured sensing

matrices that arise in practice are too conservative, or inapplicable. Another weakness of current CS has been the extension to jointly-sparse recovery: algorithms that perform well in practice are computationally expensive, and those that are fast, have inferior performance. We describe new results that address both of these limitations of current theory and algorithms. Expanding on the ideas first proposed for SBS and image compression on the fly, we describe new guaranteed algorithms for jointly-sparse recovery, which provide the best of both worlds: they are fast, and perform at least as well as the best known (but expensive) algorithms. Addressing the broader problem of sensing with structured matrices, we develop new tools for performance guarantees, and new efficient algorithms to which these guarantees are applicable. The new algorithm are not only guaranteed under more lenient conditions that are satisfied in practical compressive sensing systems, but, in numerical experiments, they also perform better than existing algorithms.

#### P6: Randy Moses: Radar Signal Processing

Room: Mendelssohn Theatre Time: 09:45 – 10:45 am

The steady advance in digital processing hardware and sampling systems are enabling significant new opportunities in radar signal processing. In the same way that increasing processor speed realized a revolution first in digital audio, then in digital video, digital radar is rapidly growing. Digital radar systems are enabling new architectures and new capabilities; examples include 3D imaging, multifunctional systems, and waveform adaptation. This talk will describe some recent advances and highlight emerging opportunities for next-generation digital radar systems.

#### WA1: Special Session: Applications of Random Matrix Theory in Underwater Acoustic Signal Processing

Room: Hussey Time: 11:00 – 12:30 pm Session Chairs: John Buck (University of Massachusetts Dartmouth, USA), James Preisig (Woods Hole Oceanographic Institution, USA)

#### The Performance of MUSIC-based DOA in White Noise With Missing Data

R. T. Suryaprakash and R. R. Nadakuditi

*Passive Acoustic Monitoring Using Random Matrix Theory* R. Menon, P. Gerstoft, and W. Hodgkiss

Analytical Characterization of the MPDR-based Power Estimators in Snapshot Scarce Regime M. Pajovic, J. Preisig, and A. Baggeroer

Mean Squared Error Performance of Adaptive Matched Field Localization Under Environmental Uncertainty N. Lee, C. Richmond, and V. Kmelnitsky

Experimental Validation of a Random Matrix Theory Model for Dominant Mode Rejection Beamformer Notch Depth

K. Wage, J. Buck, M. Dzieciuch, and P. Worcester

*A Random Matrix Theory Model for the Dominant Mode Rejection Beamformer Notch Depth* J. Buck and K. Wage

Approximate Eigenvalue Distribution of a Cylindrically Isotropic Noise Sample Covariance Matrix

S. Tuladhar, J. Buck, and K. Wage

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# Agenda

WA2: Intentionally Blank Room: Hussey

#### WA3: Communication Systems II

Room: Vandenberg Time: 11:00 – 12:30 pm Session Chairs: Daniel Sebald (USA)

*Quantized Network Coding for Sparse Messages* M. Nabaee and F. Labeau

**On the Design of Fractional Frequency Reuse in Cellular Wireless Systems** M. Alghoniemy, A. Badawi, and H. Elgebaly

*Time-Domain Impulse Injection Method for Crest Factor Reduction of OFDM Signals* Z. Yu, R. Baxley, and G. T. Zhou

**Robust Interference Channel Transmission Using Sparsity Enhanced Mismatch Model** C. Y. Chang and C. Fung

**Optimal SIMO MLSE Receivers for the Detection of Linear Modulation Corrupted by Noncircular Interference** S. Sallem, J. P. Delmas, and P. Chevalier

**Branch and Bound Algorithm for Code Spread OFDM** A. Elghariani and M. Zoltowski

Fast Adaptive Decision-Selection Equalizer Convergence Using a Tree-Structured Algorithm D. Sebald

WA4: Radar Signal Processing II Room: Michigan Time: 11:00 – 12:30 pm Session Chairs: Pawan Setlur (University of Illinois at Chicago, USA)

*Improved Variational Inference for Tracking in Clutter* J. Pacheco and E. Sudderth

*Test Statistics for Synthetic Aperture Radar Coherent Change Detection* M. Cha, R. Phillips, and P. Wolfe

*Time Reversal MIMO Radar for Angle-Doppler Estimation* F. Foroozan and A. Asif

*Waveform Scheduling Via Directed Information in Cognitive Radar* P. Setlur, N. Devroye, and Z. Cheng

*Performance Comparison of Airborne Phased-Array and MIMO Radar With Subarrays* Y. Li, Z. S. He, J. Li, and H. Liu

Coordinating Complementary Waveforms Across Time and Frequency W. Dang, A. Pezeshki, S. Howard, and B. Moran

#### **WA5: Multivariate Statistical Analysis**

Room: Vandenberg Time: 11:00 – 12:30 pm Session Chairs: Ami Wiesel (Hebrew University in Jerusalem, Israel)

**Optimal Linear Correction in LMMSE Estimation Using Moments of the Complex Inverse Wishart Distribution** J. Serra and M. Nájar

*Nonparametric Low-rank Tensor Imputation* J. A. Bazerque, G. Mateos, and G. B. Giannakis

**On the Convexity in Kronecker Structured Covariance Estimation** A. Wiesel

*Kronecker Graphical Lasso* T. Tsiligkaridis, A. Hero III, and S. Zhou

*Hyperspherical Phase Synchrony for Quantifying Multivariate Phase Synchronization* A. Mutlu and S. Aviyente

**Overcoming Noise, Avoiding Curvature: Optimal Scale Selection for Tangent Plane Recovery** D. Kaslovsky and F. Meyer

*Non-Parametric Prediction of the Mid-Price Dynamics in a Limit Order Book* D. Palguna and I. Pollak

WA6: Detection Theory Room: Michigan Time: 11:00 – 12:30 pm Session Chairs: Kush Varshnev (IBM Thomas J. Watson Research Center, USA)

Signal Classification by Power Spectral Density: An Approach Via Riemannian Geometry K. M. Wong and Y. Li

*Decision Trees for Heterogeneous Dose-Response Signal Analysis* K. Varshney, M. Singh, and J. Wang

A Selection Criterion for Piecewise Stationary Long-Memory Models Li Song and P. Bondon

*Statistical Detection of LSB Matching in the Presence of Nuisance Parameters* R. Cogranne, C. Zitzmann, F. Retraint, I. Nikiforov, L. Fillatre, and P. Cornu

*Detection of Gaussian Signals in Unknown Time-Varying Channels* D. Romero, J. Vía, R. López-Valcarce, and I. Santamaria

*Two Stage Decision System* K. Trapeznikov, V. Saligrama, and D. Castanon

#### **Government Panel: Representatives from US DoD agencies will speak**

Room: Michigan League Ballroom Time: 12:30 – 13:30 pm Panel Moderator: Randy Moses (Ohio State), Panel Organizer: Liyi Dai (US Army Research Office) Statistical signal processing plays a critical role in many important defense applications. The purpose of this special session is to provide an opportunity for representatives from DoD funding agencies and laboratories to discuss defense research needs, areas of research emphases, and challenging issues relevant to statistical signal processing.

# **Acknowledgements**

#### Reviewers

Patrice Abry, Ecole Normale Superieure, Lyon, France Shuchin Aeron, Tufts University, USA Mohammad Aghagolzadeh, Michigan State University, USA Ali Al-Matouq, Colorado School of Mines, USA Moeness G. Amin, Villanova University, USA Joshua Ash, Ohio State University, USA Kenneth Barner, University of Delaware, USA Francesca Bassi, LSS-CNRS-Supelec, France Patrick Bidigare, Raytheon BBN Technologies, USA José Bioucas Dias, J.S.T. - Technical U. Lisbon / J.T. Lisbon, Portugal Chatschik Bisdikian, IBM Research, USA Thierry Blu, Chinese University of Hong Kong, Hong Kong Nidhal Bouaynaya, University of Arkansas at Little Rock, USA Charles Bouman, Purdue University, USA Donald R. Brown, Worcester Polytechnic Institute, USA James Browning, Air Force Research Laboratory, USA Xiaodong Cai, University of Miami, USA Constantine Caramanis, The University of Texas at Austin, USA Kevin M Carter, MIT Lincoln Laboratory, USA A. Enis Cetin, Bilkent University, Turkey Müjdat Cetin, Sabanci University, Turkey Volkan Cevher, Ecole Polytechnique Federale de Lausanne, Switzerland Pierre Chainais, INRIA Lille-Nord Europe, France Shantanu Chakrabartty, Michigan State University, USA Jonathon A. Chambers, Loughborough University, United Kingdom Chong-Yung Chi, National Tsing Hua University, Taiwan Symeon Chouvardas, University of Athens, Greece Pei-Jung Chung, University of Edinburgh, United Kingdom Mark Coates, McGill University, Canada Douglas Cochran, Arizona State University, USA Pierre Comon, Université de Nice Sophia-Antipolis, France Bill Correll, Jr., General Dynamics, USA Samarjit Das, Carnegie Mellon University, USA Mark Davenport, Stanford University, USA John Deller, Michigan State University, USA Paulo Diniz, Universidade Federal do Rio de Janeiro, Brazil Petar M. Djurić, Stony Brook University, USA Kutluyıl Doğançay, University of South Australia, Australia Aleksandar Dogandžić, Iowa State University, USA Lawrence Drummy, Air Force Research Laboratory, USA Armin Eftekhari, Colorado School of Mines, USA Alper T. Erdogan, Koc University, Turkey Deniz Erdogmus, Northeastern University, USA Emre Ertin, The Ohio State University, USA Silvia Ferrari, Duke University, USA Mário A. T. Figueiredo, Instituto Superior Técnico, Portugal John Fisher, MIT AI Lab, USA

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#### **Workshop Logistics**

Graphic Designer: Rose Anderson Administrative Support: Beth Lawson Michelle Feldkamp Ann Pace

# Map of the Ann Arbor Area



#### **Directions to the Michigan League**

#### Via I-94 (Ford Freeway) From Detroit (heading West)

Take State Street Exit 177. Turn right (north). Continue on State Street approximately 2 miles to the main campus area. Turn right onto North University, which is one block past the Michigan Union. The Michigan League is on your left at the corner of North University and Fletcher Street.

#### From Chicago (heading East)

Take State Street Exit 177. Turn left (north). Continue on State Street approximately 2 miles to the main campus area. Turn right onto North University, which is one block past the Michigan Union. The Michigan League is on your left at the corner of North University and Fletcher Street.

#### Via US-23

#### From Ohio (heading North)

Take Washtenaw-Ann Arbor Exit 37B and turn right (west) onto Washtenaw. Where Stadium Blvd and Washtenaw split (approximately 2-3 miles), stay to the right on Washtenaw following the "Hospital" signs. Turn left at Hill Street (you'll see "The Rock"). Continue down Hill Street (campus buildings will be on your right). Turn right on State Street. Go three blocks. Turn right on North University. The Michigan League is on your left at the corner of North University Street and Fletcher Street.

#### From Northern MI (heading South)

Take US-23 South to M-14 West. Take Exit #3, "Downtown Ann Arbor," which will become Main Street. Follow Main Street to Huron Street. Turn left at Huron Street. Continue down Huron to State Street. Turn right on State Street. Turn left on North University. The Michigan League is on your left at the corner of North University Street and Fletcher Street.

#### Via I-696 (W. P. Ruether Freeway) From Northwest Suburbs

Take I-696 to I-275 South to M-14 West. Follow M-14 West signs closely. Take Exit #3, "Downtown Ann Arbor," which turns into Main Street. Follow Main Street to Huron Street. Turn left onto Huron Street. Continue on Huron until State Street intersects. Turn right on State Street. Turn left on North University Street. The Michigan League is on your left at the corner of North University Street and Fletcher Street.

#### I-96 (also called the Jeffries Freeway) From Parts of Detroit, Redford, M-14, Plymouth, and Canton

Take I-96 to M-14 West. Follow M-14 West signs closely. Take Exit #3, "Downtown Ann Arbor," which turns into Main Street. Follow Main Street to Huron Street. Turn left on Huron Street until State Street intersects. Turn right on State Street. Turn left on North University Street. The Michigan League is on your left at the corner of North University Street and Fletcher Street.

#### Via I-96

#### From Lansing

Take I-96 to US-23 South. Drive on US-23 South to M-14 West (Downtown Ann Arbor) Exit. Take Exit and drive about a mile to Exit 3, also marked "Downtown." Take exit ramp, which turns into Main Street. Follow Main Street to Huron Street. Turn left on Huron Street until State Street intersects. Turn right on State Street. Turn left on North University. The Michigan League is on your left at the corner of North University and Fletcher Street.

# **Map of Ann Arbor Area Restaurants**



# Ann Arbor Area Restaurants

### Inexpensive (quick bites)

- **Comet** Terrific coffee, cappucino and espresso for serious coffee drinkers
- 2 Jerusalem Garden Fast, cheap, and good middle eastern food
- **3** Amer's Deli Deli style sandwiches. A favorite of students
- 4 Cottage Inn The first, and still one of the best, pizza restaurants in Ann Arbor
- 5 Grizzly Peak a brew pub with good burgers and better-than-mostbrewpub food
- **Frita Batidos** Cuban-inspired burgers and milkshakes
- 7 Red Hawk Sandwiches and beer
- 3 Jamaican Jerk Pit Right next to Michigan League

### Medium Cost (casual good dining)

- **2 Zingerman's Deli** Gourmet sandwiches NY deli style. A must visit.
- 10 Seva's Zesty vegetarian food
- **Sava's** Large, airy dining space with local products
- 12 Madras Masala Good south Indian food (but generic atmosphere)



### Higher Cost (white tablecloths, candleight dining)

- **Gratzi** Upsscale Italian and continental style with great pasta and fish dishes
- 20 Mercy's French-Asian cuisine
- **The Grange** "Locavore" food focusing on Michigan ingredients
- 22 Vinology Wine bar focusing on Michigan ingredients.
- **Pacific Rim** Pan-asian cuisine with great seafood options
- 24 Shalimar Good north Indian food
- 25 The Earle Country French and Italian, very large selection of wine by the glass
- West End Grill Very good and fairly expensive

## University of Michigan Central Campus



#### Day 0: Sunday, August 5

17:30 – 18:00 pm	Registration @ Museum of Art
18:00 – 20:00 pm	Opening Reception @ Museum of Art
	Cocktails and Opening Remarks

#### Day 1: Monday, August 6

08:00 – 08:20 am	Registration @ Michigan League
08:20 – 08:30 am	Opening Remarks @ Mendelssohn Theatre
08:30 – 09:30 am	Yonina Eldar Plenary @ Mendelssohn Theatre
09:30 – 10:00 am	Break
10:00 – 11:30 am	MA Poster Sessions
11:30 – 13:00 pm	Catered Lunch @ Michigan League Ballroom
13:00 – 14:00 pm	Robert Ghrist Plenary @ Mendelssohn Theatre
14:00 – 14:30 pm	Break
14:30 – 16:00 pm	MB Poster Sessions
16:00 – 17:30 pm	MC Poster Sessions

#### Day 2: Tuesday, August 7

08:30 – 09:30 am	Rob Nowak Plenary @ Mendelssohn Theatre
09:30 – 10:00 am	Break
10:00 – 11:30 am	TA Poster Sessions
11:30 – 13:00 pm	Catered Lunch @ Michigan League Ballroom
13:00 – 14:00 pm	Persi Diaconis Plenary @ Mendelssohn Theatre
14:00 – 14:30 pm	Break
14:30 – 16:00 pm	TB Poster Sessions
16:00 – 17:30 pm	TC Poster Sessions
18:30 – 19:00 pm	Banquet Reception @ Michigan Union Rogel Ballroom
19:00 – 21:00 pm	Banquet @ Michigan Union Rogel Ballroom

#### Day 3: Wednesday, August 8

08:30 – 09:30 am	Yoram Bresler Plenary @ Mendelssohn Theatre
09:45 – 10:45 am	Randy Moses Plenary @ Mendelssohn Theatre
11:00 – 12:30 pm	WA Poster Sessions
12:30 – 13:30 pm	Government Panel Session @ Michigan League Ballroom
14:00 pm	(Optional) Michigan Stadium Tour
	Shuttle Pick Up @ Michigan League