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Minnepolis, MN 55455 -2070

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14. ABSTRACT

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Georgios Giannakis
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RPPR Final Report
as of 26-Apr-2018

Agency Code:

Proposal Number: 65697NS **Agreement Number: W911NF-15-1-0492**
INVESTIGATOR(S):

Name: Georgios Giannakis
Email: georgios@umn.edu
Phone Number: 6126267781
Principal: Y

Organization: **University of Minnesota - Minneapolis**
Address: 450 McNamara Alumni Center, Minnepolis, MN 554552070
Country: USA
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Report Date: 30-Nov-2017 Date Received: 16-Apr-2018
Final Report for Period Beginning 01-Sep-2015 and Ending 31-Aug-2017
Title: Comprehensive Tactical Network State Inference from Incomplete Data
Begin Performance Period: 01-Sep-2015 **End Performance Period:** 31-Aug-2017
Report Term: 0-Other
Submitted By: Georgios Giannakis Email: georgios@umn.edu
Phone: (612) 626-7781

STEM Degrees: 3 **STEM Participants:** 6

Major Goals: The objective of this project is to capitalize on contemporary advances in statistical learning to develop tools for cognitive radio network state acquisition, tracking, and prediction, even under dynamic battlefield operation. The vision is to construct a comprehensive ognition infrastructure, capable to cope with dynamic operating conditions of tactical ad hoc wireless networks, as well as incomplete, corrupt and sporadic data, which reflect the cost and restrictions in acquiring relevant state measurements.

The research agenda is centered around three intertwined thrusts, which broadly aim at:

* Gaining comprehensive cognition of the RF propagation environment in the theatre of operations;

* Real-time MAC and networking state prediction from incomplete sets of observations; jointly with

* Tactical network threat protection through alarms upon occurrence of intrusions or cyber-attacks.

Intrinsic structural traits of propagation ambiance and network data will be exploited to impute and extrapolate unobserved state variables, even in a (semi-)blind and non- parametric fashion, by leveraging recent advances in compressive sampling, kernel-based learning techniques, and nuclear norm minimization.

The impact of this project's tactical network analytics is huge: Enhanced tactical network state cognition will enable proactive routing and congestion control, link failure prevention, capacity provisioning, as well as real-time jamming and hacking detection, thus leading to drastic improvements of end-to-end communication robustness and quality-of-service. Comprehensive cognition of topologies, warfighther-to-warfighther information flows, and similarity traits of malicious attacks will allow for better understanding of adversarial networks with limited data, as well as the effects of both human and communication networks on mission-critical decisions.

Overall, this research project will complement the Army efforts in the areas of Communication and Human Networks, Intelligent Networks, as well as Multi-Agent Network Control and Decision, to realize the network-centric Army vision. At a broader scale, advances in the foundations of kernel-based learning, kernel matrix completion, and inference on graphs, will benefit a gamut of research areas including social analytics (with the prime goal to track social structures from heterogeneous data), bio-informatics, and surveillance using sensor networks.

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Accomplishments: Major activities:
In par with the project goals, we pursued A1) State cognition at the PHY; A2) State interference at the network layer; and A3) Cognition of anomalies to flag cyberattacks.

Specific objectives:

A1) Using a set of linearly compressed and possibly quantized power measurements collected by distributed sensors, we targeted power spectral density (PSD) estimators to map the RF interference ambiance. In addition, using channel measurement collected by pairs of allied radios, we pursued channel gain maps to effect inference of channel gains at any transmit-receive points in the battlefield. Both PSD maps as well as channel gain maps are instrumental for various sensing, surveillance, and resource allocation tasks essential for the operation of tactical cognitive radio networks.

A2) Postulating a structural equation model (SEM) with dynamics, we targeted an approach to identify the topology of the underlying network graph, and track the evolution of dynamic networks from information cascades even when topologies arbitrarily switch between discrete states.

A3) Tapping on recent advances in low-rank and sparse recovery, we targeted maps of nominal and anomalous traffic, to yield a valuable input for network management and proactive cyber security measures. We further investigated novel approaches to jointly track communities in time-varying network settings, and identify anomalous members.

Significant results and key outcomes

A1) We developed a family of nonparametric and semiparametric PSD estimators using quantized sensor data. To capture different degrees of prior information without sacrificing flexibility, we leveraged kernel-based learning. We generalized semiparametric regression techniques to vector-valued function estimation and showed they subsume thin plate spline regression as a special case. We further accommodated multiple measurements per sensor, non-uniform quantization as well as non-negativity constraints, and developed batch and online approaches while delineating the emergent performance-complexity trade-off. To derive channel gain maps, we modeled them as tomographic accumulations of an underlying spatial loss field (SLF), which captures the attenuation in the signal strength due to obstacles in the propagation path. In order to estimate the map accurately with a relatively small number of measurements, we leveraged the low-rank structure of SLFs possibly with sparse deviations to derive efficient batch and online algorithms for map reconstruction. This became possible using a bi-factor characterization of the matrix nuclear norm. The resultant algorithms enjoy low computational complexity and a reduced memory requirement, without sacrificing the optimality, with provable convergence properties. Comprehensive tests with both synthetic and real data sets corroborate that our approaches can accurately reveal the structure of the RF propagation medium needed produce the desired channel gain maps.

A2) For unveiling the topology of (e.g., social or terrorist networks) from information cascades, we established that presence of exogenous influences is critical to guarantee model identifiability, and one can even identify the underlying network topologies with fewer cascade measurements by leveraging edge sparsity. Recognizing that identification of the unknown network states and the switching sequence is computationally challenging, we discretized the states whose number can become available, and developed an exponentially weighted least-squares estimator regularized by edge sparsity. To solver the resultant optimization task, we adapted a recursive two-step topology tracking algorithm leveraging advances in proximal gradient optimization was developed. Per interval, the first step estimates the active state by minimizing the a priori prediction error, while the second step recursively updates only the matrices corresponding to the estimated state. Experiments on synthetically-generated cascades demonstrated the effectiveness of the advocated approach in jointly tracking the switching sequence, while identifying the state-dependent network topologies. Numerical tests were also conducted on real cascades of popular news over the web, collected over one year. The goal was to identify the underlying topological structure of causal influences between news websites and blogs. Interestingly, websites exhibiting the highest influence (as measured by the out-degree) turned out to be recognizable news outlets and popular news aggregators.

A3) We developed a tomographic framework that subsumes critical network monitoring and inference tasks including traffic estimation, anomaly identification, and traffic interpolation. We relied on link loads and small subsets of flow counts as our available data, and leveraged the low intrinsic-dimensionality of nominal traffic as well as the sparsity of anomalies, to formulate a convex program with l1-norm and nuclear-norm regularizers. We derived sufficient conditions to guarantee accurate estimation of the traffic. For tactical networks that these

conditions are violated, we capitalized on additional knowledge about inherent traffic patterns that we incorporated through correlations by adopting a Bayesian approach and taking advantage of the bilinear characterization of the l1- and nuclear-norm. We further devised a systematic approach to learn the correlations using (cyclo)stationary historical traffic data. Our with synthetic and real Internet data confirm the efficacy of the novel estimators. With regards to identifying communities, we leveraged advances in overlapping community discovery to pioneer a temporal outlier-aware edge generation model. We postulated that the anomaly matrix is sparse, while the outlier-free, noiseless factor model is low rank, and the network evolves slowly. Based on these conditions, we developed a sparsity-promoting, rank-regularized estimators to jointly track communities and identify anomalous nodes. We further devised a first-order sequential tracker based on alternating minimization and recent advances in accelerated proximal-splitting optimization. We attained real-time operation by developing a fast online tracking algorithm, based on stochastic gradient iterations. For settings involving distributed acquisition and storage of network data, we also devised a decentralized tracker that capitalizes on the separability of ADMM iterations. Simulations on synthetic stochastic block model networks successfully unveiled the underlying communities, and flagged off artificially-induced anomalies. Experiments conducted on a sequence of networks extracted from historical global trade flows between nations revealed interesting results concerning globalization of trade, and unusual trading behavior exhibited by certain countries during the early post-world war era.

Training Opportunities: The research has provided the graduate students and postdocs working on this project numerous opportunities to develop a better understanding of key research tools, including optimization, complexity theory, estimation theory, and machine learning.

Weekly research and conference presentations improved the graduate student delivery and teaching skills. Testing and extensive simulations on monitoring and resource allocation of wireless mobile ad hod networks familiarized them with industry standards.

Giannakis' designs of of RF spectrum maps and estimators/trackers of comprehensive network states provided the postdocs and graduate students working on this project with deep understanding of sparsity-aware, online, and decentralized estimation algorithms, as well as the fundamentals on stochastic optimization theory. They further gained hands-on experience with shadow fading models, real data processing, and simulations of the entire protocol stack.
Two of the PhD students that worked on this project during the last couple of years (B. Baingana, M. Mardani) were trained and are now researchers at WindLogic and Stanford, respectively. In addition to foreign visitors, several PhD students (T. Chen, Y. Shen, V. Ioannidis) and two postdocs were trained (Drs. S.-J. Kim, and Dr. D. Romero) are now asst. professors at UMBC, and Adger U. in Norway, respectively, while Dr. E. Dall'Anese joined the National Renewable Energy Labs (NREL) at Denver, Colorado, as a Senior Researcher; from where he was recently hired as an asst. prof. at U. of Colorado, Boulder.

Four graduate students defended their Theses (two MSc and two PhDs); two are now in the job market, and two have accepted and begun full-time positions in industry. One of the PhD graduates (B. Baingana) is a minority graduate with outstanding research performance in social networks.

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Results Dissemination: In addition to conference and journal publications that have been our main dissemination channels, throughout this project, PI Giannakis was invited and delivered tutorials at:

T1) EUSIPCO, Lisbon, Portugal, Sept. 1-5, 2014;
T2) Intl. Conf. on Acoust. Speech and Signal Proc., Gold Coast, Australia, April 19-24, 2015;
T3) EUSIPCO, Nice, France, Aug. 31-Sept. 4, 2015.
T4) Center for Telecommunications Tech. Catalunia, Barcelona, Spain, Oct. 26-27, 2015;
T5) Signal Processing for Wireless Comm. (SPAWC), Edinburg, Scotland, July 3-6, 2016.
T6) IEEE-SPS Winter School on Distributed Signal Proc. for Secure Cyber Physical Systems, Montreal, Canada, Nov. 2, 2016;
T7) BigDat2017, Bari, Italy, Feb. 16-17, 2017; and
T8) CAMSAP Workshop, Curacao, Dutch Antilles, December 10-13, 2017.

Giannakis also delivered keynote plenary addresses at:

P1) Signal Proc. Algorithms and Applications (SPA), Poznan, Poland, Sept. 22-24, 2014;
P2) Intl. Conf. on Wireless Comm. and Signal Processing, Hefei, China, Oct. 23-25, 2014;
P3) Asilomar Conf. on Signals, Systems, and Computers, Pacific Grove, CA, Nov. 2-5, 2014;
P4) GlobalSIP, Atlanta, GA, Dec. 3-5, 2014;
P5) Conf. on Info. Sciences and Sys., John Hopkins Univ., Baltimore, March 18-20, 2015; and
P6)Center for Adv. Signal and Image Sciences, Lawrence Livermore Ntl. Lab, May 13, 2015.
P7) Ntl. Renewable Energy Lab (NREL), Golden, CO, Jan. 26-28, 2016;
P8) Intl. Conf. on Comp., Networking and Comm. (ICNC), Kauai, Hawaii, Feb. 15-18, 2016;
P9) Intl. Workshop on Signal, Array, and Comm. (IWSAC), Xi'an, China, March 2016;
P10) SPAWC, Edinburg, Scotland, July 3-6, 2016;
P11) STATOS, Budapest, Hungary, Sept. 2, 2016; and
P12) Global Signal and Information Proc. (Globalsip) Conf., Washington DC, Dec. 7-9, 2016.
P13) UF Informatics Institute Symposium, Gainesville, FL, March 16, 2017;
P14) ACCESS Data Analytics Worshop, Stockholm, Sweden, May 15, 2017;
P15) Workshop on Compressive Sensing and Apps., Budva, Montenegro, May 26, 2017;
P16) 1st Intl. Balkan Conf. on Comms. and Networking, Tirana, Albania, June 1, 2017; and
P17) Trans-Atl. Symp. on Tech. and Policy for a Smart Society, Minneapolis, June 19, 2017;
P18) Ntl. Renewable Energy Lab., Golden CO, Sept. 13, 2017; and
P19) 17th Intl. Symp. on Comm. and Infor. Tech. (ISCIT), Cairns, Australia, Sept. 25-27, 2017.

In most of these addresses, he presented parts of the monitoring, and optimization for cognitive communication and social networks, the main theme of this project; as well as broader impact themes on statistical tools for Big Data analytics.

He further co-organized and co-chaired (with G. Mateos) a Special Session on "Estimation, Statistical Learning, and Optimization for Analysis and Modeling of Social Networks," at the Intl. Conf. on Acoust., Speech and Signal Proc., Florence, Italy, May 2014. He also served as co-organizer and Lead Guest Co-Editor of a Special Issue in the IEEE Signal Processing Magazine, on "Big Data," Sept. 2014; and As a co-organizer and Lead Guest Co-Editor of a Special Issue in the IEEE Journal on Special Topics in Signal Processing, on "Signal Processing for Big Data," that appeared June 2015.

Finally, Giannakis delivered colloquium speeches in Electrical and Computer Engineering Departments at the following academic and research institutions

C1) Dept. of ECE, UCLA, Los Angeles, October 2014.
C2) Dept. ECE, Fudan Univ., Shanghai, P. R. China, October 2014.
C3) Dept. ECE, Shanghai Tech, P. R. China, October 2014.
C4) Dept. ECE, USTC, Hefei, P. R. China, October 2014.
C5) Dept. ECE, SouthEast Univ., Nanjing, P. R. China, October 2014.
C6) Dept. of EE-Systems, USC, Los Angeles, March 2015.
C7) School of Science & Engr., Harvard University, Boston, April 2015.
C8) Dept. of ECE, UIUC, Illinois, October 2015
C9) Dept. of ECE, UCI, Irvine, October 2015

C10)Dept. of ECE, UT San Antonio, TX, Nov. 2015.
C11) Dept. of EE-Systems, USC, Los Angeles, Nov. 2015
C12) Dept. ECE, Shanghai Tech, P. R. China, Dec. 2015.
C13) Dept. of Control Engr., Zhejiang Univ., Hangzhou, P. R. China, Dec. 2015.
C14) Dept. of EE, Delft Univ., Netherlands, January 2016.
C15) AFOSR, Annual Review Meeting, Washington, DC, January 2016.
C16) Dept. of ECE, U. of Maryland, March 2016
C17) Dept. of ECE, George Mason Univ., Washington, DC, April 2016;
C18) Dept. of ECE, UT Dallas, TX, May 2016;
C19) Dept. of ECE, Ntl. Tech. Univ. of Athens, Greece, May 2016.
C20) Dept. of ECE, McGill Univ., Montreal, Canada, Nov. 1, 2016.
C21) Dept. of VaTech, Balcksburg, VA, Jan. 27, 2017;
C22) Dept. of ECE, NC State Univ., Raleigh, NC, April 21, 2017;
C23) Distinguished Lecture Series, KTH, Sweden, May 16, 2017;
C24) Dept. of ECE, Boston Univ., Boston, MA, Oct. 9, 2017; and
C25) Dept. of EECS, Northwestern Univ., Evanston, IL, Nov. 8, 2017.

Co-PI Giannakis further disseminated research results from this project to the Industry affiliates of the Digital Technology Center that he serves as its Director. These affiliates include 3M, ADC, Brocade, DuPont, Emerson, IBM, Intel, Los Alamos, LSI, Rockwell-Collins, Seagate, SGI, Sun, Symantec, Thomson, and Unisys. This broad network of commercial partners offers unique opportunities for graduate students to intern with industry and government laboratories. In addition, DTC facilitates technology transfer through its UMN partner, the Office of Technology Commercialization (OTC) -- the venue that promotes patents and funds/assists start-ups based on UMN-generated IP. In the Robotics summer camp with K-12 participants (hosted at DTC in August 2015), the PI presented a high-level description of his research on wireless communications and networking which touched upon issues related to this project.

Honors and Awards: PI G. B. Giannakis received the following honors during the course of this progject:

1) Top H-index of 130 (Among the top 18 researchers in ECE and CS worlwide)

2) Honorary Doctorates from the Dept. of Computer Engr. & Informatics, and the Dept. of ECE, Polytechnic School, University of Patras, Greece (2018).

3) Received the presitous University-wide McKnight Presidential Chair, University of Minnesota (2016)

4) Received the Technical Field Award - IEEE Fourier Award, (2015); Inaugural recipient worldwide. This award recognizes an outstanding contribution to the advancement of signal processing, other than in the areas of speech and audio processing—sponsored by IEEE Signal Processing Society and the IEEE Circuits and Systems Society. The award includes a bronze medal, an honorarium ($10K), and a certificate with the citation “For contributions to the theory and practice of statistical signal processing and its applications to wireless communications.”

5) PhD student M. Mardani received IEEE Signal Processing Society’s Young Authos Best Paper Award, 2018, for the paper published in the May 2015 issue of the IEEE Trans. on Signal Processing.

6) PhD student B. Baingana received the Best Conf. Paper Award for his paper:
B. Baingana and G. B. Giannakis, "Switched Dynamic Structural Equation Models for Tracking Social Network Topologies," Proc. of Globalsip Conf., Orlando, FL, Dec. 14-16, 2015.

Protocol Activity Status:

Technology Transfer: Technology transfer has been effected through the provisional patents filed as a result of this project's research.

Insights gained from this project will permeate benefits to various applications as diverse as data centers, smart grid, and intelligent transportation networks, as well as medical telemetry, geo-monitoring, and surveillance systems. Advances in the foundations of kernel-based learning, kernel matrix completion, inference on graphs, and sampling-based scenario optimization, will benefit a gamut of research areas including social analytics, bio-informatics, medical imaging, and surveillance using sensor networks.

PARTICIPANTS:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)
Participant: Daniel Romero
Person Months Worked: 4.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: PD/PI
Participant: Georgios B. Giannakis
Person Months Worked: 2.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Vassilios N. Ioannidis
Person Months Worked: 2.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Brian Baingana
Person Months Worked: 12.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Meng Ma
Person Months Worked: 4.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Morteza Mardani
Person Months Worked: 4.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Donghoon Lee
Person Months Worked: 6.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Dimitrios Berberidis
Person Months Worked: 4.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)
Participant: Seung-Jun Kim
Person Months Worked: 2.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Swayambhoo Jain
Person Months Worked: 2.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Swayambhoo Jain
Person Months Worked: 2.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N

Other Collaborators:

ARTICLES:

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Journal: IEEE Transactions on Cognitive Communications and Networking
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Volume: Issue: First Page #:
Date Submitted: 4/16/18 12:00AM Date Published:
Publication Location:
Article Title: Blind Spectrum Sensing for Cognitive Radios using Dictionary Learning
Authors: S.-J. Kim, N. Jain, G. B. Giannakis
Keywords: Spectrum sensing, dictionary learning, online and distributed algorithms, finite-alphabet constraint
Abstract: Novel cooperative spectrum sensing algorithms for cognitive radios (CRs) are developed, which can blindly learn the channel gains between CRs and licensed primary users (PUs), while jointly detecting active PU transmitters at each time instant. A dictionary learning approach is adopted to decompose the signal energy vectors, collected by a network of CRs, to linear combinations of channel gains and PU transmit-powers, up to scaling ambiguity. In addition to a batch baseline algorithm, an efficient online implementation that can track slow variation of channel gains is developed. A distributed version, which requires only local message passing among neighbors in the CR network, is also proposed. When the PU transmitters employ a finite number of transmit-power levels, the scaling ambiguity can be resolved as well. Numerical tests verify the effectiveness of the proposed design.
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CONFERENCE PAPERS:

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: IEEE GlobalSIP Conference
Date Received: 04-Aug-2016 Conference Date: 14-Dec-2015 Date Published: 14-Dec-2015
Conference Location: Orlando
Paper Title: Switched Dynamic Structural Equation Models for Tracking Social Network Topologies
Authors: B. Baingana, G. B. Giannakis
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: Asilomar Conf. on Signals, Systems, and Computers
Date Received: 04-Aug-2016 Conference Date: 08-Nov-2015 Date Published: 08-Nov-2015
Conference Location: Pacific Grove, CA
Paper Title: Robust Kriged Kalman Filtering
Authors: B. Baingana, E. Dall'Anese, G. Mateos, G. B. Giannakis
Acknowledged Federal Support: **Y**

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Conference Name: International Workshop on Emerging Cognitive Radio Applications and Algorithms (CORAL)
Date Received: 04-Aug-2016 Conference Date: 15-Jun-2015 Date Published: 15-Jun-2015
Conference Location: Boston, MA
Paper Title: Underlay Multi-Hop Cognitive Networks with Orthogonal Access
Authors: A. G. Marqués, S. Molinero, G. B. Giannakis
Acknowledged Federal Support: **N**

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Conference Name: Intl. Conf. on Acoust., Speech, and Signal Processing (ICASSP)
Date Received: 16-Apr-2018 Conference Date: 19-Apr-2015 Date Published: 19-Apr-2015
Conference Location: Brisbane, Australia
Paper Title: Spectrum Cartography Using Quantized Observations
Authors: D. Romero, S.-J. Kim, R. Lopez-Valcarce, and G. B. Giannakis
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: 6th Intl. Workshop on Computational Advances in Multi-Sensor Adaptive Processing
Date Received: 16-Apr-2018 Conference Date: 13-Dec-2015 Date Published: 13-Dec-2015
Conference Location: Cancoun, Mexico
Paper Title: Stochastic Nonparametric Regression over Dynamic Networks
Authors: D. Romero, S.-J. Kim, G. B. Giannakis
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: 6th Intl. Workshop on Computational Advances in Multi-Sensor Adaptive Processing
Date Received: 16-Apr-2018 Conference Date: 13-Dec-2015 Date Published: 13-Dec-2015
Conference Location: Cancoun, Mexico
Paper Title: Dynamic and Decentralized Learning of Overlapping Communities
Authors: B. Baingana, G. B. Giannakis
Acknowledged Federal Support: **Y**

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Conference Name: Globalsip Conf.
Date Received: 16-Apr-2018 Conference Date: 14-Dec-2015 Date Published: 14-Dec-2015
Conference Location: Orlando, FL
Paper Title: Switched Dynamic Structural Equation Models for Tracking Social Network Topologies
Authors: B. Baingana, G. B. Giannakis
Acknowledged Federal Support: **Y**

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Conference Name: Conf. on Info. Sciences and Systems
Date Received: 16-Apr-2018 Conference Date: 16-Mar-2016 Date Published: 16-Mar-2016
Conference Location: Princeton, NJ
Paper Title: Nonlinear Structural Equation Models for Network Topology Inference
Authors: Y. Shen, B. Baingana, G. B. Giannakis
Acknowledged Federal Support: **Y**

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Conference Location: Shanghai, China
Paper Title: Data Sketching for Large-Scale Kalman Filtering
Authors: D. K. Berberidis, G. B. Giannakis
Acknowledged Federal Support: **Y**

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Conference Location: Palma de Mallorca, Spain
Paper Title: Estimating Signals over Graphs via Multi-kernel Learning
Authors: D. Romero, M. Ma, G. B. Giannakis
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Conference Location: Budapest, Hungary
Paper Title: Online Dictionary Learning for Large-Scale Binary Data
Authors: Y. Shen, G. B. Giannakis
Acknowledged Federal Support: **Y**

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Conference Name: Asilomar Conf.
Date Received: 16-Apr-2018 Conference Date: 06-Nov-2016 Date Published: 06-Nov-2016
Conference Location: Pacific Grove, CA
Paper Title: Semiparametric Reconstruction of Signals over Graphs
Authors: V. N. Ioannidis, D. Romero, and G. B. Giannakis, "," Proc. of ., , Nov. 6-9, 2016.
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: Asilomar Conf.
Date Received: 16-Apr-2018 Conference Date: 06-Nov-2016 Date Published: 06-Nov-2016
Conference Location: Pacific Grove, CA
Paper Title: Inferring Directed Network Topologies via Tensor Factorization
Authors: Y. Shen, B. Baingana, G. B. Giannakis
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
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Date Received: 16-Apr-2018 Conference Date: 07-Dec-2016 Date Published: 07-Dec-2016
Conference Location: Washington, DC
Paper Title: Blind Channel Gain Cartography
Authors: D. Romero, D. Lee, G. B. Giannakis
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: Globalsip Conf.
Date Received: 16-Apr-2018 Conference Date: 07-Dec-2016 Date Published: 07-Dec-2016
Conference Location: Washington, DC
Paper Title: Tracking dynamic piecewise-constant network topologies via adaptive tensor factorization
Authors: Y. Shen, B. Baingana, and G. B. Giannakis, "," Proc. of , , Dec. 7-9, 2016.
Acknowledged Federal Support: **Y**

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Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: Intl. Conf. on Acoust., Speech, and Signal Processing
Date Received: 16-Apr-2018 Conference Date: 05-Mar-2017 Date Published: 05-Mar-2017
Conference Location: New Orleans, USA
Paper Title: Topology Inference of Directed Graphs using Nonlinear Structural Vector Autoregressive Models
Authors: Y. Shen, B. Baingana, G. B. Giannakis, "," Proc. of ,, March 5-9, 2017
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: EUSIPCO
Date Received: 16-Apr-2018 Conference Date: 28-Aug-2017 Date Published: 28-Aug-2017
Conference Location: Kos Island, Greece
Paper Title: Inference of Spatiotemporal Processes over Dynamic Graphs via Kernel Kriged Kalman Filters
Authors: V. N. Ioannidis, D. Romero, G. B. Giannakis, "," Proc. of ,, Aug. 28 - Sept. 3, 2017.
Acknowledged Federal Support: **Y**

DISSERTATIONS:

Publication Type: Thesis or Dissertation
Institution: University of Minnesota
Date Received: 04-Aug-2016 Completion Date: 2/6/16 12:10AM
Title: Dynamic Learning from Time-Varying Social Networks
Authors: Brian Baingana
Acknowledged Federal Support: **N**

Publication Type: Thesis or Dissertation
Institution: University of Minnesota
Date Received: 15-Apr-2018 Completion Date: 7/16/17 5:48AM
Title: Kernel-based Reconstruction of Dynamic Functions over Dynamic Graphs
Authors: V. N. Ioannidis
Acknowledged Federal Support: **Y**

WEBSITES:

URL: www.spincom.umn.edu
Date Received: 04-Aug-2016
Title: Research group
Description: Contains updated information on publications, students, and honors/awards

PATENTS:

Intellectual Property Type: Patent Date Received: **15-Apr-2018**
Patent Title: Robust Parametric Power Spectrum Density Map Construction
Patent Abstract: This disclosure describes techniques for constructing power spectral density (PSD) maps repres
Patent Number: 9,363,679
Patent Country: USA
Application Date: 31-Jul-2014 Application Status: 3
Date Issued: 07-Jun-2016

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"Nothing to report in the uploaded pdf (see accomplishments)"