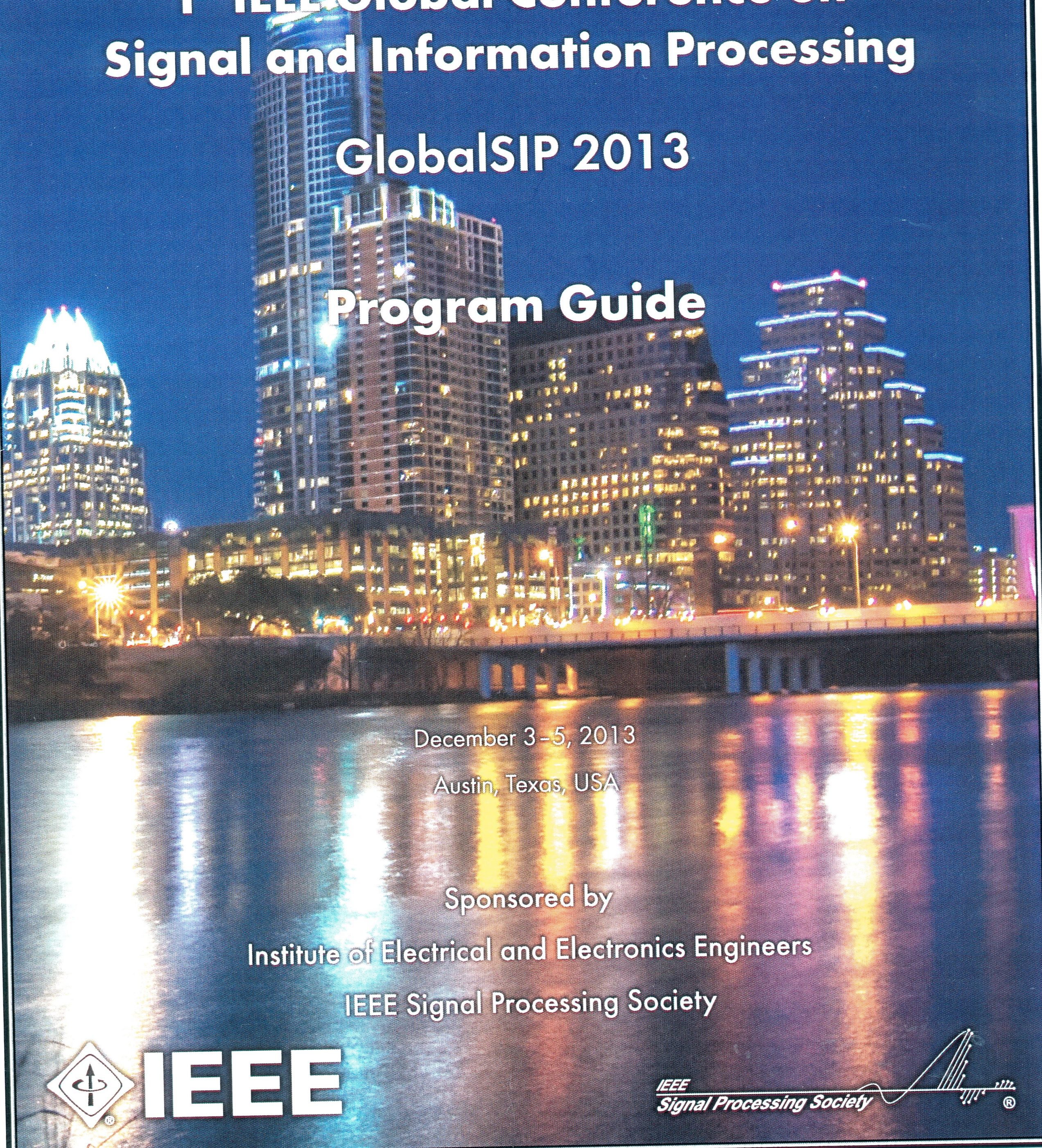
IEEE GlobalSIP

1st IEEE Global Conference on Signal and Information Processing

GlobalSIP 2013

Program Guide



December 3–5, 2013

Austin, Texas, USA

Sponsored by

Institute of Electrical and Electronics Engineers

IEEE Signal Processing Society

IEEE

IEEE Signal Processing Society

Wednesday, December 4 | 10:00 - 12:00
Poster Session | LDMOSPa.PB | Poster Area B

Low-Dimensional Models and Optimization in Signal Processing I

LDMOSPa.PB.1 RANDOM TRANSMITTANCE BASED FILTER ARRAY SPECTROMETERS: SPARSE SPECTRUM RECOVERY AND RESOLUTION IMPROVEMENT
Oliver James, Woong-Bi Lee, Heung-No Lee, Gwangju Institute of Science and Technology, Republic of Korea

LDMOSPa.PB.2 GENERALIZED SHRINKAGE AND PENALTY FUNCTIONS
Rick Chartrand, Los Alamos National Laboratory, United States

LDMOSPa.PB.3 NONLINEAR COMPRESSED SENSING WITH APPLICATION TO PHASE RETRIEVAL
Amir Beck, Yonina C. Eldar, Yoav Shechtman, Technion - Israel Institute of Technology, Israel

LDMOSPa.PB.4 SPARSE EXPANDER-LIKE REAL-VALUED PROJECTION (SERP) MATRICES FOR COMPRESSED SENSING
Abdolreza Abdolhosseini Moghadam, Hayder Radha, Michigan State University, United States

LDMOSPa.PB.5 OBJECT DETECTION AND RECOGNITION USING STRUCTURED DIMENSIONALITY REDUCTION
Ran Sharon, Joseph Francos, Rami Hagege, Ben Gurion University, Israel

LDMOSPa.PB.6 A SPARSE RANDOMIZED KACZMARZ ALGORITHM
Hassan Mansour, Mitsubishi Electric Research Laboratories, United States; Ozgur Yilmaz, University of British Columbia, Canada

LDMOSPa.PB.7 LOW-RANK MATRIX RECOVERY WITH POISSON NOISE
Yao Xie, Duke University, United States; Yuejie Chi, Ohio State University, United States; Robert Calderbank, Duke University, United States

LDMOSPa.PB.8 PROJECTIONS ONTO CONVEX SETS (POCS) BASED OPTIMIZATION BY LIFTING
A. Enis Cetin, Alican Bozkurt, Osman Gunay, Y. Hakan Habiboglu, Bilkent University, Turkey; Kivanc Kose, Memorial Sloan Kettering Cancer Center, United States; Ibrahim Onaran, R. Akin Sevimli, Mohammad Tofighi, Bilkent University, Turkey

LDMOSPa.PB.9 COMPRESSIVE TIME DELAY ESTIMATION USING INTERPOLATION
Karsten Fyhn, Aalborg University, Denmark; Marco F. Duarte, University of Massachusetts Amherst, United States; Søren Holdt Jensen, Aalborg University, Denmark

Wednesday, December 4 | 16:00 - 18:00
Poster Session | LDMOSPb.PB | Poster Area B

Low-Dimensional Models and Optimization in Signal Processing II

LDMOSPb.PB.1 EMBEDDING-BASED REPRESENTATION OF SIGNAL DISTANCES
Petros Boufounos, Shantanu Rane, Mitsubishi Electric Research Laboratories, United States

LDMOSPb.PB.2 DICTIONARY LEARNING VIA PROJECTED MAXIMAL EXPLORATION
Boris Mailhé, Mark D. Plumbley, Queen Mary, University of London, United Kingdom

LDMOSPb.PB.3 A TIGHTEST CONVEX ENVELOPE HEURISTIC TO ROW SPARSE AND RANK ONE MATRICES
Alireza Aghasi, Sohail Bahmani, Justin Romberg, Georgia Institute of Technology, United States

LDMOSPb.PB.4 RECONSTRUCTION OF GAUSSIAN MIXTURE MODELS FROM COMPRESSIVE MEASUREMENTS: A PHASE TRANSITION VIEW
Francesco Renna, Universidade do Porto, Portugal; Robert Calderbank, Lawrence Carin, Duke University, United States; Miguel R. D. Rodrigues, University College London, United Kingdom

LDMOSPb.PB.5 DISTRIBUTED COMPRESSED SENSING ALGORITHMS: COMPLETING THE PUZZLE
João Mota, Instituto Superior Tecnico / Carnegie Mellon University, Portugal; João Xavier, Pedro Aguiar, Institute of Systems and Robotics, Instituto Superior Tecnico, Technical University of Lisbon, Portugal; Markus Püschel, ETH Zurich, Switzerland

LDMOSPb.PB.6 USING THE COEFFICIENT OF VARIATION TO IMPROVE THE SPARSITY OF SEISMIC DATA
Hasan Al-Marzouqi, Ghassan AlRegib, Georgia Institute of Technology, United States

LDMOSPb.PB.7 GREED IS SUPER: A NEW ITERATIVE METHOD FOR SUPER-RESOLUTION
Armin Eftekhari, Michael Wakin, Colorado School of Mines, United States

LDMOSPb.PB.8 TRACTABILITY OF INTERPRETABILITY VIA SELECTION OF GROUP-SPARSE MODELS
Nirav Bhan, Luca Baldassarre, Volkan Cevher, École Polytechnique Fédérale de Lausanne, Switzerland

LDMOSPb.PB.9 A MATLAB TOOLBOX FOR VISUALIZATION OF IMAGE MANIFOLDS
Kevin Eykholt, Marco F. Duarte, University of Massachusetts Amherst, United States

Random Transmittance Based Filter Array Spectrometers: Sparse Spectrum Recovery and Resolution Improvement

Oliver James, Woong-Bi Lee, and Heung-No Lee
Gwangju Institute of Science and Technology, South Korea. Email:{oliver,wblee,heungno}@gist.ac.kr

***Abstract*—In this paper, we introduce filters with random transmittance to improve the resolution of miniature spectrometers. We show that a sparse signal spectrum sensed by such filters when processed by an L_1 algorithm aids in improving the resolution. We also show a way to design the filters with random transmittance using optical thin-film technology. We demonstrate that a resolution of 0.99nm, which is 7-fold compared to using filters in [3], can be achieved with only 40 random filters.**

***Index Terms*—Compressive sensing, L_1 norm minimization, random transmittance, resolution, spectrometers.**

I. Introduction and Motivation

Modern miniature spectrometers are equipped with digital signal processing (DSP) algorithms [1]. These algorithms process the raw spectrum obtained from a spectrometer to improve the resolution. In filter array based spectrometers, the resolution is limited by the number of filters and the shapes of the transmittance functions (TF) of the filters. Rather than increasing the number of filters (and the CCD elements), we design the TFs in order to improve the recovery performance of the DSP algorithms and hence the resolution.

In this paper, we assume to use the L_1-norm minimization based DSP algorithm in [2] and aim to address the following relevant questions: Is it possible to enhance the resolution by shaping the TFs in a particular way? Namely, is there a certain shape of the TF that is suitable with the L_1 norm minimization algorithm we use at the back end? If yes, what is the shape and how to design and implement such a TF? From our study, we observe that TFs whose auto-covariance functions resemble that of a Dirac delta function acquire fine details of a signal spectrum. Filters with random TFs possess such auto-covariance. We show that it is possible to design filters with random TFs using thin-film technology and can improve the resolution up to 7-fold when compared to the filters with non-ideal TFs in [3].

II. System Description and Design Approach

We consider a filter array spectrometer with M filters each of which is specified in terms of a TF, $T_i(\lambda), i = 1, 2, \cdots, M$. Each filter is attached to a CCD element whose output (after sampling) denotes a sample of the raw spectrum modeled as $y_i = \int T_i(\lambda)\boldsymbol{x}(\lambda)\, d\lambda + w_i$, where $\boldsymbol{x}(\lambda)$ is a signal spectrum and w_i is a Gaussian noise sample. The model for the raw spectrum is $\boldsymbol{y} = DG\boldsymbol{s} + \boldsymbol{w},\ \boldsymbol{s} \geq 0$, where D is an $M \times N$ TF matrix with $M < N$. The i-th row of D contains the samples of $T_i(\lambda)$, G is an $N \times N$ Gaussian kernel matrix and $\boldsymbol{s}$ is an $N \times 1$ K-*sparse spectrum* with $K \ll N$ non-zero components. Since $\boldsymbol{s}$ is K-sparse we use the L_1 norm minimization algorithm derived in [2] to estimate $\boldsymbol{s}$ from $\boldsymbol{y}$, given D and G. The matrix G is fixed depending on applications. Thus, it is important to design a good TF matrix D for the L_1 algorithm to recover the sparse spectrum. Designing a good TF matrix D resembles that of designing a sensing matrix in compressive sensing (CS). In CS, random sensing matrices are shown to be good for sensing and reconstruction of sparse signals. Thus, in this paper, we propose random TFs for improving resolution. We note that TFs are analog functions and the central question now is how to design and implement filters with random TFs optically?

Filters with random TFs can be designed by using thin-film optical filter technology [4]. The usual quarter wavelength thicknesses of thin film filter layers provide band-pass like transmittance. We randomly vary the thicknesses of the thin film layers in each filter and generate M number of filters with random TFs. We found that these random TFs are white and uncorrelated with each other. Currently, the implementation of these random TFs is underway in our lab.

III. Results and Conclusions

We consider a mercury lamp with 7 spectral lines (Fig. 1(a)). The least separation among these lines is 2.106nm (between the pair 576.959nm and 579.065nm). It is apparent from Fig. 1(c) that the random TFs clearly resolve these two closely spaced spectral lines. In fact, we found that random TFs are capable of resolving any two spectral lines which are more than 0.99nm apart. In contrast, the TFs in [3] cannot resolve the two closely spaced spectral lines (Fig. 1(b)) and we found that these TFs resolve spectral lines that are 6.5nm apart. Based on these results we conclude that random TFs outperform the TFs in [3] and improve the resolution by 7-fold.

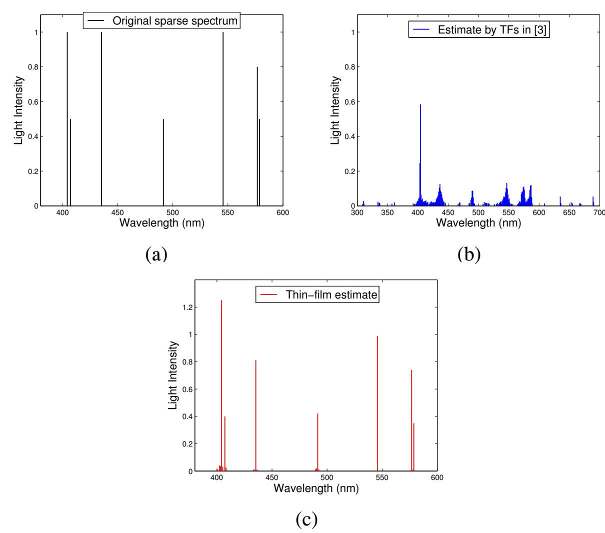


Fig. 1: (a) Original sparse spectrum (b) Estimate by TFs in [3] (c) Estimate by thin film based random TFs

Acknowledgement: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MEST) (Do-Yak research program. No. 2013-035295)

References

[1] D. J. Brady, *Optical Imaging and Spectroscopy*, John Wiley, 2009.
[2] S. Park et al., "Designing an algorithm to solve basis pursuit denoising with a nonnegative constraint," submitted to IEEE Sig. Pro. Letters.
[3] J. Oliver et al., "Improving resolution of miniature spectrometers by exploiting sparse nature of signals," Opt. Exp., vol. 20, no.3, 2012.
[4] J. R. Barry et al., "Link design for non-directed infrared wireless communications," App. Opt., vol. 34, no. 19, pp. 3764-3776, 1995.