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INFORMATION ACQUISITION, ANALYSIS AND INTEGRATION

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This report briefly describes the accomplishments under the NSSEFF project on the area of integration of signal acquisition and processing. As detailed in the report, contributions range from new theories to new applications, new camera designs, and numerous DoD and industrial technology transfers.

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NSSEFF- INFORMATION ACQUISITION, ANALYSIS AND INTEGRATION

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1 OVERVIEW OF ACCOMPLISHMENTS

As detailed in the next sections, we have accomplished all the challenges in the original proposal and beyond. We have advanced science in all directions we targeted, we have received some of the most prestigious awards in our discipline, graduate numerous students thereby enhancing the US work force, and contributed to science dissemination in multiple directions. Particulars are given in the next sections, and is virtually impossible to enumerate all the results that were made possible by this NSSEFF award. At the science level we can exemplify just a few:

1. Developed some of the more advanced theoretical and computational results in the important topic of graph matching.

2. Developed new cameras and computational reconstruction frameworks for advanced video and image acquisition with unique integrations of sensing and processing.

3. Developed advanced computational techniques for some of the most critical tools in signal processing, from sparse modeling to matrix factorization.

4. Developed theoretical foundations for successful algorithms such as deep learning.

5. Solved elegantly old problems like image and video debluring, introducing new revolutionary approaches.

6. Introduced new fundamental signal representations, ranging from new aspects of the Weyl transform to active selection of signal representatives.

7. Combined fundamental tools such as random forest, hashing, and subspace learning to produce state-of-the-art results in numerous classification tasks at a fraction of the computational and memory cost of competing approaches.

8. Introduced new concepts of sparse modeling and compressed sensing into shape analysis and representation.

9. Demonstrated how fundamental problems like gaze analysis can be solved with cameras that cost about 5 orders of magnitude less than current technology.

10. Connected sparse modeling and compressed sensing with the fundamental theories of universal modeling and minimal description length.

11. Provided unique theoretical foundations for multimodal signal processing.

12. Developed fundamental theoretical and practical results on Gaussian mixture models and its connections with compressed sensing and sparse modeling.

13. Developed novel hierarchical and collaborative tools for sparse modeling and compressed sensing.

14. Made contributions in applications covering health, consumers, and defense.

These are just examples of the contributions, which resulted in also numerous technology transfers to the Department of Defense (ONR, ARO, NGA), to the NIH, and to industry (Adobe, LSS, etc). As mentioned above, these also resulted in numerous awards and become the core education of a large number of PhD, MSc, and post-docs.

The next sections provides list of publications, honors, and other activities showing the accomplishments.

2 HONORS AND AWARDS

2010: Plenary Speaker, *The Learning Workshop*, Snowbird, April 2010.

2010: Plenary Speaker, *SIAM Image Science Conference*, Chicago, April 2010.

2011: Success story from the *National Geospatial-Intelligence Agency* Basic Research Program (NURI).

2011: Helmholtz Test-of-Time Award, *International Conference Computer Vision*, "Geodesic Active Contours" ICCV '95 paper.

2012: Best Poster Award, P. Sprechmann, A. Bronstein, and G. Sapiro, "Real-time online singing voice separation from monaural recordings using robust low-rank modeling," *International Society for Music Information Retrieval Conference*, Porto, October 2012.

2013 SIAM Fellow.

2013 Best Paper Award, P. Llull, X. Liao, X. Yuan, J. Yang, D. Kittle, L. Carin, G. Sapiro, and D. J. Brady, "Compressive sensing for video using a passive coding element," *Imaging and Applied Optics Congress*, Arlington, VA, June 2013.

2013 International Society in Magnetic Resonance in Medicine Recognition, Top 5 cited articles in *Magnetic Resonance in Medicine* 10, I. Aganj, C. Lenglet, G. Sapiro, E. Yacoub, K. Ugurbil, and N. Harel, "Reconstruction of the orientation distribution function in single and multiple shell q-ball imaging within constant solid angle" *Magnetic Resonance in Medicine* **64:2**, pp. 554-566, 2010.

2013 IEEE Fellow.

2013 Science Advisory Board, Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University.

2014 Plenary Speaker, *European Signal Processing Conference (EUSIPCO)*, September 2014.

2014-2017 Member, National Academies Board on Mathematical Sciences and their Applications (BMSA).

2015 Plenary Speaker, *CIARP*, December 2015.

2015-2016 Distinguished Israel Pollack Lecturer, Technion, Haifa.

3 PUBLICATIONS

Journals and Book Chapters

1. R. Giryes, A. Bronstein, and G. Sapiro, "Deep neural networks with random Gaussian weights: A universal classification strategy?," *IEEE Trans. Signal Processing*, 2016, to appear.

2. M. Tepper and G. Sapiro, "Compressed nonnegative matrix factorization is fast and accurate," *IEEE Trans. Signal Processing*, 2016, to appear.

3. E. Elhamifar, G. Sapiro, and S. Sastry, "Dissimilarity-based sparse subset selection," *IEEE Trans. Pattern Analysis Machine Intelligence*, 2015, to appear.

4. A. Thompson, Q. Qiu, R. Calderbank, and G. Sapiro, "Data representation using the Weyl transform," *IEEE Trans. Signal Processing* **64:7**, pp. 1844-1853, 2016.

5. M. Delbracio and G. Sapiro, "Hand-held video deblurring via efficient Fourier aggregation," *IEEE Transactions on Computational Imaging* **1:4**, pp. 270-283, 2015.

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7. G. Sapiro, "Mathematical Image Processing," in *The Princeton Companion to Applied Mathematics*, N. J. Higham, Ed., Princeton University Press, 2015.

8. M. Delbracio and G. Sapiro, "Removing camera shake via weighted Fourier burst," *IEEE Trans. Image Processing* **24:11**, pp. 3293-3307, 2015.

9. V. Lyzinski, D. Fishkind, M. Fiori, J. T. Vogelstein, C. E. Priebe, and G. Sapiro, "Graph matching: Relax at your own risk," *IEEE Trans. Pattern Analysis Machine Intelligence* **38:1**, pp. 60-73, 2015.

10. P. Sprechmann, A. Bronstein, and G. Sapiro, "Learning efficient sparse and low rank models," *IEEE Trans. Pattern Analysis Machine Intelligence* **37:9**, pp. 1821-1833, 2015.

11. M. Fiori and G. Sapiro, "On spectral properties for graph matching and graph isomorphism problems," *Information and Inference: A Journal of the IMA* **4:1**, pp. 63-76, 2015

12. J. Lucas and G. Sapiro, "Cancer: What's luck got to do with it?," *Significance - statistics making sense* **12:2**, pp. 40-42, April 2015.

13. I. Aganj, G. Sapiro, and N. Harel, "Q-space modeling in diffusion-weighted MRI," *Brain Mapping-An Encyclopedic Reference*, pp. 257263, Academic Press, 2015.

14. Q. Qiu and G. Sapiro, "Learning transformations for clustering and classification," *Journal of Machine Learning Research* **16**, pp. 187-225, 2015.

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16. M. Tepper and G. Sapiro, "A bi-clustering framework for consensus problems," *SIAM Journal on Imaging Sciences* **7:4**, pp. 2488-2525, 2014.

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18. M. Fiori, P. Muse, and G. Sapiro, "A complete system for candidate polyps detection in virtual colonoscopy," *International Journal of Pattern Recognition and Artificial Intelligence* **28:7**, November 2014.

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85. J. Hashemi, Q. Qiu, and G. Sapiro, "Cross-modality pose-invariant facial expression," *IEEE International Conference Image Processing*, Quebec City, Canada, September 2015.

86. M. Tepper, A. Newson, P. Sprechmann, and G. Sapiro, "Multi-temporal foreground detection in videos," *IEEE International Conference Image Processing*, Quebec City, Canada, September 2015.

87. M. Delbracio and G. Sapiro, "Burst deblurring: Removing camera shake through Fourier burst accumulation," *IEEE Computer Vision Pattern Recognition (CVPR)* Boston, June 2015.

88. Q. Qiu, A. Thompson, R. Calderbank, G. Sapiro, "Representation using the Weyl Transform," *International Conference on Learning Representations*, 2015.

89. J. Kim, Y. Duchin, J. Vitek, N. Harel, and G. Sapiro "Clinical subthalamic nucleus prediction from high-field MRI," *International Symposium on Biomedical Imaging: From Nano to Macro*, New York, April 2015.

90. J. Huang, Q. Qiu, R. Calderbank, M. Rodrigues, and G. Sapiro, "Alignment with intra-class structure can improve classification," *ICASSP 2015*, Australia, April 2015.

91. Q. Qiu and G. Sapiro, "Learning transformations," *IEEE International Conference Image Processing*, Paris, November 2014.

92. Q. Qiu and G. Sapiro, "Learning compressed image classification features," *IEEE International Conference Image Processing*, Paris, November 2014.

93. M. Tepper and G. Sapiro, "Intersecting 2D lines: A simple method for detecting vanishing points," *IEEE International Conference Image Processing*, Paris, November 2014.

94. P. Llull, X. Yuan, X. Liao, J. Yang, L. Carin, G. Sapiro, and D. J. Brady, "Compressive extended depth of field using image space coding," *Classical Optics Congress - Computational Optical Sensing and Imaging*, Hawaii, June 2014.

95. X. Yuan, P. Llull, X. Liao, J. Yang, G. Sapiro, D. J. Brady, and L, Carin, "Low-cost compressive sensing for color video and depth," *IEEE Computer Vision Pattern Recognition (CVPR)*, June 2014.

96. P. Sprechmann, A. Bronstein, and G. Sapiro, "Supervised non-Euclidean sparse NMF via bilevel optimization with applications to speech enhancement," *Joint Workshop on Hands-free Speech Communication and Microphone Arrays (HSCMA 2014)*, Nice, France, May 2014.

97. Q. Qiu and G. Sapiro, "Learning transformations for classification forests," *International Conference on Learning Representations*, May 2014.

98. J. Masci, P. Sprechmann, M. Bronstein, A. Bronstein, and G. Sapiro, "Sparse similarity-preserving hashing," *International Conference on Learning Representations*, May 2014.

99. K. Carpenter, P. Sprechmann, M. Fiori, R. Calderbank, H. Egger, and G. Sapiro, "Questionnaire simplification for fast risk analysis of children's mental health," *ICASSP 2014*, Florence, May 2014.

100. M. Tepper and G. Sapiro, "All for one, one for all: Consensus community detection in networks," *ICASSP 2014*, Florence, May 2014.

101. M. Fiori, P. Sprechmann, J. Vogelstein, P. Muse, and G. Sapiro, "Robust multimodal graph matching: Sparse coding meets graph matching," *Neural and Information Processing Systems (NIPS)*, 2013.

102. P. Sprechmann, R. Litman, T. Ben Yakar, A. Bronstein, and G. Sapiro, "Efficient supervised sparse analysis and synthesis operators," *Neural and Information Processing Systems (NIPS)*, 2013.

103. E. Elhamifar, G. Sapiro, A. Yang, and S. Sastry, "Active learning via convex programming," *International Conference Computer Vision*, Australia, December 2013.

104. M. Tepper and G. Sapiro, "Ants crawling to discover the community structure in networks," *18th Iberoamerican Congress on Pattern Recognition*, Cuba, November 2013.

105. M. Fiori, P. Muse, and G. Sapiro, "Polyps flagging in virtual colonoscopy," *18th Iberoamerican Congress on Pattern Recognition*, Cuba, November 2013.

106. T. Ben Yakar, P. Sprechmann, R. Litman, A. Bronstein, and G. Sapiro, "Bilevel sparse models for polyphonic music transcription," *International Society for Music Information Retrieval Conference*, Curitiba, Brazil, November 2013.

107. N. Walczak, J. Fasching Λ, W. D. Toczyski, V. Morellas Λ, G. Sapiro, and N. Papanikolopoulos, "Locating occupants in pre-school class-

rooms using a multiple RGB-D sensor system," *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Tokyo, November 2013.

108. J. Fasching, N. Walczak, W. Toczyski, K. Cullen, G. Sapiro, V. Morellas, and N. Papanikolopoulos, "Computer-assisted labeling of motor stereotypes in video," *American Academy of Child and Adolescent Psychiatry Annual Meeting*, Florida, October 2013.

109. E. L. Dennis, L. Zhan, N. Jahanshad, B. A. Mueller, Y. Jin, C. Lenglet, E. Yacoub, G. Sapiro, K. Ugurbil, N. Harel, A. W. Toga, K. O. Lim, and P. M. Thompson, "Rich club analysis of structural brain connectivity at 7 Tesla versus 3 Tesla," *MICCAI MMBC Workshop 2013*, Nagoya, Japan, Sept. 22-26, 2013

110. Z. Tang, M. Tepper, and G. Sapiro, "Reflective symmetry detection by rectifying randomized correspondences," *British Machine Vision Conference*, Bristol, September 2013.

111. H. Cetingul, L. Dumont, M. Nadar, P. Thompson, G. Sapiro, and C. Lenglet, "Importance sampling spherical harmonics to improve filtered probabilistic tractography," *3rd International Workshop on Pattern Recognition in NeuroImaging*, Philadelphia, June 2013.

112. J. Yang, X. Yuan, X. Liao, P. Llull, G. Sapiro, D. Brady, and L. Carin, "Gaussian mixture models for video compressive sensing," *IEEE International Conference Image Processing*, Melbourne, Australia, 2013.

113. X. Yuan, J. Yang, P. Llull, X. Liao, G. Sapiro, D. Brady, and L. Carin, "Adaptive temporal compressive sensing for video," *IEEE International Conference Image Processing*, Melbourne, Australia, 2013.

114. M. Tepper and G. Sapiro, "Fast L1 smoothing splines with an application to Kinect depth data," *IEEE International Conference Image Processing*, Melbourne, Australia, 2013.

115. P. Llull, X. Liao, X. Yuan, J. Yang, D. Kittle, L. Carin, G. Sapiro, and D. J. Brady, "Compressive sensing for video using a passive coding element," *Imaging and Applied Optics Congress*, Arlington, VA, June 2013.

116. P. Sprechmann, A. Bronstein, J-M. Morel, and G. Sapiro, "Audio restoration from multiple copies," *ICASSP 2013*, Vancouver, May 2013.

117. P. Sprechmann, A. Bronstein, M. Bronstein, and G. Sapiro, "Learnable low rank sparse models for speech denoising," *ICASSP 2013*, Vancouver, May 2013.

118. E. Elhamifar, R. Vidal, and G. Sapiro, "Finding exemplars from pairwise dissimilarities via simultaneous sparse recovery," *Neural and Information Processing Systems (NIPS)*, 2012.

119. M. Fiori, P. Muse, and G. Sapiro, "Topology constraints in graphical models," *Neural and Information Processing Systems (NIPS)*, 2012.

120. A. Taheri, M. Tepper, A. Banerjee, and G. Sapiro,"If you are happy and know it ... Tweet," *ACM Conference on Information and Knowledge Management*, Maui, November 2012.

121. J. Hashemi, T. Vallin Spina, M. Tepper, A. Esler, V. Morellas, N. Papanikolopoulos, and G. Sapiro, "A computer vision approach for the assessment of autism-related behavioral markers," *IEEE Conference on Development and Learning*, San Diego, November 2012.

122. J. Fasching, N. Walczak, R. Sivalingam, K. Cullen, B. Murphy, G. Sapiro, V. MorellasΛ, and N. Papanikolopoulos, "Detecting risk-markers in children in a preschool classroom," *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Vilamoura, Algarve (Portugal), October 2012.

123. P. Sprechmann, A. Bronstein, and G. Sapiro, "Real-time online singing voice separation from monaural recordings using robust low-rank modeling," *International Society for Music Information Retrieval Conference*, Porto, October 2012.

124. J. M. Duarte-Carvajalino, C. Lenglet, K. Ugurbil, S. Moeller, L. Carin, and G. Sapiro, "A framework for multi-task Bayesian compressive sensing of DW-MRI," *MICCAI 2012 Workshop on Computational Diffusion MRI*, October 2012.

125. A. Kamath, I. Aganj, J. Xu, E. Yacoub, Kamil Ugurbil, G. Sapiro, and C. Lenglet, "Generalized constant solid angle ODF and optimal acqui-

sition protocol for fiber orientation mapping," *MICCAI 2012 Workshop on Computational Diffusion MRI*, October 2012.

126. H. Ertan, L. Dumont, M. Nadar, P. Thompson, G. Sapiro, and C. Lenglet, "Simultaneous ODF estimation and robust probabilistic tractography from HARDI," *MICCAI 2012 Workshop on Computational Diffusion MRI*, October 2012.

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128. M. Tepper and G. Sapiro, "Decoupled coarse-to-fine matching and nonlinear regularization for efficient motion estimation," *IEEE International Conference Image Processing*, Orlando, Florida, September 2012.

129. A. Castrodad, T. Khuon, R. Band, and G. Sapiro, "Sparse modeling for hyperspectral imagery and LIDAR data fusion for subpixel mapping," *IEEE International Geoscience and Remote Sensing Symposium*, July 2012.

130. A. Bronstein, P. Sprechmann, and G. Sapiro, "Learning efficient structured sparse models," *International Conference Machine Learning*, Edinburgh, June 2012.

131. E. Elhamifar, R. Vidal, and G. Sapiro, "See all by looking at a few: Sparse modeling for finding representative objects," *IEEE Computer Vision Pattern Recognition (CVPR)*, Providence, June 2012.

132. M. Tong, Y. Kim, L. Zhan, G. Sapiro, C. Lenglet, B. Mueller, P. Thompson, and L. Vese, "A variational model for denoising high angular resolution diffusion imaging," *IEEE International Symposium on Biomedical Imaging*, 2012.

133. R. Sivalingam, A. Cherian, J. Fasching, N. Walczak, N. Bird, V. Morellas, N. Papanikolopoulos, G. Sapiro, and K. Lim, "A multi-sensor visual tracking system for behavior monitoring of at-risk children," *IEEE Int. Conference on Robotics and Automation*, Minneapolis, May 2012.

134. T. Zhou, H. Shan, A. Banerjee, and G. Sapiro, "Kernelized probabilistic matrix factorization: Exploiting graphs and side information," *SIAM Data Mining (SDM) 2012*, Anaheim, CA, April 2012.

135. T. Michaeli, Y. Eldar, and G. Sapiro, "Semi-supervised multi-domain regression with distinct training sets," *ICASSP 2012*, Kyoto, March 2012.

136. I. Ramirez and G. Sapiro, "Low-rank data modeling via the minimum description length principle," *ICASSP 2012*, Kyoto, March 2012.

137. J. M. Duarte-Carvajalino, G. Yu, L. Carin, and G. Sapiro, "Adaptive statistical compressive sensing: Learning to sense Gaussian mixture models," *ICASSP 2012*, Kyoto, March 2012.

138. P. Sprechmann, P. Cancela, and G. Sapiro, "Gaussian mixture models for score-informed instrument separation," *ICASSP 2012*, Kyoto, March 2012.

139. N. Walczak, J. Fasching, W. Toczyski, R. Sivalingam, N. Bird, K. Cullen, V. Morellas, B. Murphy, G. Sapiro, and N. Papanikolopoulos, "A nonintrusive system for behavioral analysis of children using multiple RGB+depth sensors," *Workshop on Applications in Computer Vision*, Colorado, 2012.

140. L. Bar and G. Sapiro, "Hierarchical invariant sparse modeling for image analysis," *IEEE International Conference Image Processing*, Brussels, Belgium, September 2011.

141. B. Chen, G. Sapiro, G. Polatkan, D. B. Dunson, and L. Carin, "The hierarchical beta process for convolutional factor analysis and deep learning," *International Conference Machine Learning*, Washington, June 2011.

142. L. Li. M. Zhou, G. Sapiro, and L. Carin, "On the integration of topic modeling and dictionary learning," *International Conference Machine Learning*, Washington, June 2011.

143. M. Zhou, H. Yang, G. Sapiro, D. Dunson, and L. Carin, "Dependent hierarchical beta process for image interpolation and denoising," *Proceedings of the 14th International Conference on Artificial Intelligence and Statistics (AISTATS)*, Fort Lauderdale, FL, 2011.

144. P. Sprechmann, I. Ramirez, P. Cancela, and G. Sapiro, "Collaborative sources identification in mixed signals via hierarchical sparse modeling," *IEEE ICASSP 2011*, Prague, May 2011.

145. F. Leger, G. Yu, and G. Sapiro, "Efficient matrix completion with Gaussian models," *IEEE ICASSP 2011*, Prague, May 2011.

146. G. Yu and G. Sapiro, "Statistical compressive sensing of Gaussian mixture models," *IEEE ICASSP 2011*, Prague, May 2011.

147. I. Ramirez and G. Sapiro, "Sparse coding and dictionary learning based on the MDL principle," *IEEE ICASSP 2011*, Prague, May 2011.

148. M. Zhou, H. Yang, G. Sapiro, D. Dunson, and L. Carin, "Covariate-dependent dictionary learning and sparse coding," *IEEE ICASSP 2011*, Prague, May 2011.

149. N. Jahanshad, I. Aganj, C. Lenglet, A. Joshi, Y. Jin, M. Barysheva, K. McMahon, G. de Zubicaray, N. Martin, M. Wright, A. Toga, G. Sapiro, and P. Thompson, "Sex differences in the human connectome: 4-Tesla high angular resolution diffusion imaging (HARDI) tractography in 234 young adult twins," *IEEE International Symposium on Biomedical Imaging*, Chicago, March-April 2011.

150. E. Caruyer, I. Aganj, C. Lenglet, G. Sapiro, and R. Deriche, "Online motion detection in high angular resolution diffusion imaging," *IEEE International Symposium on Biomedical Imaging*, Chicago, March-April 2011.

151. L. Zhan, A. D. Leow, I. Aganj, C. Lenglet, G. Sapiro, E. Yacoub, N. Harel, A. W. Toga, and P. M. Thompson, "Differential information content in staggered multiple shell HARDI measured by the tensor distribution function," *IEEE International Symposium on Biomedical Imaging*, Chicago, March-April 2011.

152. G. Prasad, N. Jahanshad, I. Aganj, C. Lenglet, G. Sapiro, A. Toga, and P. Thompson, "Atlas-based fiber clustering for multi-subject analysis of high angular resolution diffusion imaging tractography," *IEEE International Symposium on Biomedical Imaging*, Chicago, March-April 2011.

153. Y. Jin, Y. Shi, N. Jahanshad, I. Aganj, G. Sapiro, A. Toga, and P. Thompson, "3D elastic registration improves HARDI-derived fiber alignment and automated tract clustering," *IEEE International Symposium on Biomedical Imaging*, Chicago, March-April 2011.

154. X. Bai, J. Wang, and G. Sapiro, "Dynamic color flow: A motion-adaptive color model for object segmentation in video," *Proc. ECCV*, September 2010.

155. G. Yu, G. Sapiro, and S. Mallat, "Image modeling and enhancement via structured sparse model selection," *IEEE International Conference Image Processing*, Hong Kong, September 2010.

156. A. Castrodad, Z. Xing, J. Greer, E. Bosch, L. Carin, and G. Sapiro, "Discriminative sparse representations in hyperspectral imagery," *IEEE International Conference Image Processing*, Hong Kong, September 2010.

157. J. Paisley, M. Zhou, G. Sapiro, and L. Carin, "Nonparametric image interpolation and dictionary learning using spatially-dependent Dirichlet and beta process priors," *IEEE International Conference Image Processing*, Hong Kong, September 2010.

158. I. Aganj, C. Lenglet, and G. Sapiro, "ODF maxima extraction in spherical harmonic representation via analytical search space reduction," *Medical Image Computing and Computer Assisted Intervention (MICCAI2010)*, Beijing, September 2010.

159. M. Fiori, P. Muse, S. Aguirre, and G. Sapiro, "Automatic colon polyp flagging via geometric and texture features," *IEEE EMBC*, Buenos Aires, August-September, 2010.

160. I. Ramirez, P. Sprechmann, and G. Sapiro, "Classification and clustering via dictionary learning with structured incoherence," *IEEE Computer Vision Pattern Recognition (CVPR)*, San Francisco, June 2010.

161. D. Raviv, A. Bronstein, M. Bronstein, R. Kimmel, and G. Sapiro, "Diffusion symmetries of non-rigid shapes," *Proc. 3D Data Processing, Visualization and Transmission (3DPVT)*, Paris, May 2010.

4 SELECTED ADDITIONAL INVITED ORAL PRESENTATIONS

1. Plenary Speaker, *CIARP*, Montevideo, December 2015.

2. Plenary Speaker, *European Signal Processing Conference (EUSIPCO)*, Lisbon, September 2014.

3. Plenary Speaker, *Signal Processing and Machine Learning*, Haifa, 2014.

4. Plenary Speaker, *MATHEON Workshop on Compressed Sensing and its Applications*, Berlin, 2013.

5. Plenary Speaker, *Workshop on Learning Data Representation: Hierarchies and Invariance*, MIT, November 2013.

6. Plenary Speaker, *Methodological Aspects of Hyperspectral Imaging*, Nice, October 2013.

7. *February Fourier Talks (FFT) at the Norbert Wiener Center*, University of Maryland, February 2012.

8. *Foundations of Computational Mathematics*, Budapest, July 2011.

9. Plenary Speaker, *1st Technion Computer Engineering (TCE) Conference*, June 2011.

5 SELECTED CONFERENCE ORGANIZATIONS & JOURNAL ACTIVITIES

1. Associate Editor, "Computer Image Analysis," *Frontiers*.

2. Program Committee, *Symmetries of Differential Equations: Frames, Invariants and Applications*, May 2012.

3. Program Committee, *Advances in Scientific Computing, Imaging Science and Optimization*, IPAM, UCLA, April 2012.

4. Program Committee, *International Conference on Scale Space and Variational Methods in Computer Vision*, 2011.

6 STUDENTS

GRADUATED

1. X. Bai, PhD, '10 (currently at Adobe)

2. M. Mahmoudi, PhD, '10
3. I. Aganj, PhD, '10 (joint with Prof. C. Lenglet, currently at MIT/MGH)
4. M. Fiori, MSc '11
5. I. Ramirez, PhD '11 (currently Professor, Universidad de la Republica, Uruguay)
6. F. Lecumberry, PhD '12 (currently Professor, Universidad de la Republica, Uruguay)
7. P. Sprechmann, PhD '12 (currently postdoctoral associate, NYU)
8. L. Yatziv, PhD '12 (currently at Google)
9. A. Castrodad, PhD '12 (currently at the National Geospatial-Intelligence Agency)
10. J. Hashemi, MSc, May '13 (currently PhD student at Duke University)
11. M. Fiori, PhD '15 (currently Professor, Universidad de la Republica, Uruguay)
12. Zhuoqing Chang, MSc '15 (currently PhD student, Duke University)
13. Kim Jinyoung, PhD '15 (currently postdoctoral associate, Duke University)

POST-DOCTORAL ASSOCIATES

1. Christophe Lenglet (joint with Prof. K. Ugurbil, currently Assistant Professor, Radiology, University of Minnesota)
2. Guoshen Yu (currently in a Hedge Fund, Geneva).
3. Oleg Kuybeda (currently at NIH).
4. Julio M. Duarte-Carvajalino
5. Zhongwei Tang
6. Raja Giryes (currently at Tel Aviv University)
7. P. Sprechmann (currently at NYU)

8. Mariano Tepper (current).
9. Mauricio Delbracio (current)
10. Alasdair Newson (current)
11. Cecilia Aguerebere (current)

UNDERGRADUATE RESEARCH ASSISTANTS

1. Flavien Leger, 2010
2. Karl Otness, 2011 (high school student)

1.

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Final Report

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Guillermo Sapiro

Program Manager

The AFOSR Program Manager currently assigned to the award

Dohme, Evelyn

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Abstract

This report briefly describes the accomplishments under the NSSEFF project on the area of integration of signal acquisition and processing. As detailed in the report, contributions range from new theories to new applications, new camera designs, and numerous DoD and industrial technology transfers.

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Extensions granted or milestones slipped, if any:

None.

AFOSR LRIR Number

LRIR Title

Reporting Period

Laboratory Task Manager

Program Officer

Research Objectives

Technical Summary

Funding Summary by Cost Category (by FY, $K)

	Starting FY	FY+1	FY+2
Salary			
Equipment/Facilities			
Supplies			
Total			

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Appendix Documents

2. Thank You

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