OMB No. 0925-0001 and 0925-0002 (Rev. 10/15 Approved Through 10/31/2018)

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.

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| --- |
| NAME: Hero, Alfred |
| eRA COMMONS USER NAME (credential, e.g., agency login):  |
| POSITION TITLE: John H Holland Distinguished University Professor of Electrical Engineering and Computer Science |

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

|  |  |  |  |
| --- | --- | --- | --- |
| INSTITUTION AND LOCATION | DEGREE(if applicable) | Completion Date MM/YYYY | FIELD OF STUDY |
| Boston University, Boston, MA | BS | 05/1980 | Electrical Engineering |
| Princeton University, Princeton, NJ | MS | 05/1982 | Electrical Engineering and Computer Science |
| Princeton University, Princeton, NJ | PHD | 12/1984 | Electrical Engineering and Computer Science |

### A. Personal Statement

My multi-disciplinary interests are reflected by my faculty appointments in three different colleges at the University of Michigan: the College of Engineering (Depts. of EECS and BME), the College of Literature, Sciences and the Arts (Dept. of Statistics), and the College of Medicine (Dept. of BME). In addition, I am affiliated with the Graduate Programs in Applied and Interdisciplinary Mathematics (AIM) in LS&A, Computational Medicine and Bioinformatics (CMB) in the Medical School, and Applied Physics in LS&A. In my career in the data sciences, I have trained over 50 PhD students in the general areas of modeling, computation, and inference for large scale time varying data arising from networks and graphs in the biosciences. These included analysis of data whose provenance includes: electrocardiology, materials science, medical imaging, biomolecular assays, health surveillance, communications/surveillance networks, and dynamic social media. Many of these students have written PhD theses on cross-cutting area of data science applied to health. In particular, some of my students have written their theses on the problem of data-driven prediction of health and disease in a human host and across a population based on a combination of genetic, metabolic, and social network data. Others have developed image registration methods that are capable of compensating for patient motion and multimodality distortions in order to combine data from different populations, phenotypes or sites.

1. Liu TY, Burke T, Park LP, Woods CW, Zaas AK, Ginsburg GS, Hero AO. An individualized predictor of health and disease using paired reference and target samples. BMC Bioinformatics. 2016 Jan 22;17:47. PubMed PMID: [26801061](http://www.ncbi.nlm.nih.gov/pubmed/26801061/); PubMed Central PMCID: [PMC4722633](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4722633/).
2. Bazot C, Dobigeon N, Tourneret JY, Zaas AK, Ginsburg GS, Hero AO 3rd. Unsupervised Bayesian linear unmixing of gene expression microarrays. BMC Bioinformatics. 2013 Mar 19;14:99. PubMed PMID: [23506672](http://www.ncbi.nlm.nih.gov/pubmed/23506672/); PubMed Central PMCID: [PMC3681645](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3681645/).
3. Finn WG, Harrington AM, Carter KM, Raich R, Kroft SH, Hero AO 3rd. Immunophenotypic signatures of benign and dysplastic granulopoiesis by cytomic profiling. Cytometry B Clin Cytom. 2011 Sep;80(5):282-90. PubMed PMID: [21462309](http://www.ncbi.nlm.nih.gov/pubmed/21462309/).
4. Huang Y, Zaas AK, Rao A, Dobigeon N, Woolf PJ, Veldman T, Øien NC, McClain MT, Varkey JB, Nicholson B, Carin L, Kingsmore S, Woods CW, Ginsburg GS, Hero AO 3rd. Temporal dynamics of host molecular responses differentiate symptomatic and asymptomatic influenza a infection. PLoS Genet. 2011 Aug;7(8):e1002234. PubMed PMID: [21901105](http://www.ncbi.nlm.nih.gov/pubmed/21901105/); PubMed Central PMCID: [PMC3161909](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3161909/).

### B. Positions and Honors

Positions and Employment

|  |  |
| --- | --- |
| 1984 - 1990 | Assistant Professor of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI |
| 1990 - 1996 | Associate Professor of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI |
| 1996 -  | Professor of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI |
| 1996 -  | Professor of Biomedical Engineering, University of Michigan |
| 2000 -  | Professor of Statistics, University of Michigan |
| 2009 -  | R. Jamison and Betty Williams Professor of Engineering, University of Michigan, Ann Arbor, MI |
| 2015 -  | Co-Director Michigan Institute for Data Science, University of Michigan , Ann Arbor, MI |
| 2016 -  | John H Holland Distinguished University Professor of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI |

Other Experience and Professional Memberships

|  |  |
| --- | --- |
| 1978 -  | Member, IEEE |
| 1994 -  | Member, American Statistical Association (ASA) |
| 1994 - 1998 | Associate Editor, IEEE Transaction on Information Theory |
| 1998 -  | Member, Society for Industrial and Applied Mathematics (SIAM) |
| 1999 - 2002 | Chair, US National Commission C, International Union of Radio Sciences |
| 2000 -  | Member, American Association for the Advancement of Science (AAAS) |
| 2003 - 2008 | Associate Editor, IEEE/ACM Transactions on Computational Biology and Bioinformatics |
| 2004 - 2006 | Member, Army Research Laboratory Technical Activities Board |
| 2005 - 2006 | President, IEEE Signal Processing Society |
| 2010 - 2011 | Director, Division IX (Signals and Applications), IEEE Board of Directors |
| 2011 -  | Member, US National Research Council, Committee on Applied and Theoretical Statistics |
| 2011 -  | Member, Committee on Applied and Theoretical Statistics, US National Academies |
| 2017 -  | Chair, Committee on Applied and Theoretical Statistics, US National Academies |

Honors

|  |  |
| --- | --- |
| 1996 | Best Paper Award, IEEE Signal Processing Society |
| 1997 | Fellow, IEEE |
| 2000 | Third Millenium Medal, IEEE |
| 2009 | Best Original Research Paper Award, J. of Cytometry - Part B - Clinical Cytometry |
| 2009 | R. Jamison and Betty Williams Endowed Chair in Engineering, University of Michigan |
| 2010 | Best Paper Award, IEEE Signal Processing Magazine |
| 2011 | Best Student Paper Award, SPIE Defense, Security and Sensing Conference |
| 2011 | Best Student Paper Award, IEEE Conference on Acoust, Speech, and Signal Processing (ICASSP) |
| 2011 | Rackham Distinguished Faculty Achievement Award, University of Michigan |
| 2013 | Notable Paper Award, Conference on Artificial Intelligence and Statistics (AISTAT) |
| 2013 | Best Paper Award, IEEE Conf on Image Processing |
| 2013 | Technical Achievement Award, IEEE Signal Processing Society |
| 2013 | Best Student Paper Award, IEEE workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP) |
| 2015 | Society Award, IEEE Signal Processing Society  |

### C. Contribution to Science

1. Data in motion and self localizing sensor networks.

Hero and Patwari published the first maximum likelihood estimators for relative node localization in wireless networks ((a), (b) and (d) - best paper awardee). The distributed weighted multidimensional scaling (dwMDS) algorithm (c) improved upon the previous parametric node localization methods by using a local distributed optimization to learn the propagation characteristics of the medium. As shown by several citations to this work, the dwMDS algorithm can be applied to more general problems as a distributed non-linear manifold learning technique. These four papers are collectively cited over 5000 times according to Google Scholar.

* 1. Patwari Neal, Hero AO, Perkins M, Correal NS, O'Dea RJ. Relative location estimation in wireless sensor networks. IEEE transactions on signal processing : a publication of the IEEE Signal Processing Society. 2003 August; 51(8):2137-2148.
	2. Patwari Neal, Hero AO. Using proximity and quantized RSS for sensor localization in wireless networks. Proceedings of the 2nd ACM international conference on Wireless sensor networks and applications. 2003 September; :20-29.
	3. Costa JoseA, Patwari Neal, Hero AO. Distributed weighted-multidimensional scaling for node localization in sensor networks. ACM transactions on sensor networks. 2006 February; 2(1):39-64.
	4. Patwari Neal, Ash JoshN, Kyperountas S, Hero AO, Moses RL, Correal NealS. Locating the nodes: cooperative localization in wireless sensor networks. IEEE Signal Processing Magazine. 2007 July; 22(4):54-69.
1. Development of fast statistical estimation algorithms.

Hero and Fessler introduced the space alternating generalized EM (SAGE) algorithm for maximum likelihood parameter estimation (a) and its application to tomography (b). In different work, a widely cited SIAM Journal on Optimization paper by Hero (d) and his former student Blatt introduced a convergent version of the incremental gradient algorithm (called stochastic gradient in machine learning) that resulted in collaborations with Fessler that produced the fastest known iterative PET/CT image reconstruction algorithm (c) at the time. Remarkably, many of the over 920 citations of the SAGE paper (a) are in the area of wireless communications, and in particular, for channel equalization for cellular networks. SAGE is the primary basis for US patent 7340257 (2008), owned by Intel Mobile, which is cited in recent patents for OFDMA (US 8095076 B2 (2012) Qualcomm) and multi-antenna communications (US 8238471 B2 (2012) Qualcomm). The papers (a) and (b) have been collectively cited over 1500 times according to Google Scholar.

* 1. Hero AO, Fessler JA. Space-alternating generalized expectation-maximization algorithm. IEEE transactions on signal processing : a publication of the IEEE Signal Processing Society. 1994 October; 42(10):2664-2677.
	2. Fessler JA, Hero AO. Penalized maximum-likelihood image reconstruction using space-alternating generalized EM algorithms. IEEE Trans Image Process. 1995;4(10):1417-29. PubMed PMID: [18291973](http://www.ncbi.nlm.nih.gov/pubmed/18291973/).
	3. Ahn S, Fessler JA, Blatt D, Hero AO. Convergent incremental optimization transfer algorithms: application to tomography. IEEE Trans Med Imaging. 2006 Mar;25(3):283-96. PubMed PMID: [16524085](http://www.ncbi.nlm.nih.gov/pubmed/16524085/).
	4. Blatt D, Hero AO, Gauchman H. A convergent incremental gradient algorithm with a constant stepsize. SIAM Journal on Optimization. 2007 February; 18(1):29-51.
1. Performance benchmarking.

Hero and his students have introduced several widely used information theoretic tools for benchmarking the fundamental limits governing statistical communication, estimation, classification, and detection algorithms. These include the constrained Cramer-Rao lower bound (CRLB) for parameter estimation with constraints (a), the uniform CRLB on estimators with smooth bias functions (b) (Best Paper awardee), simultaneous detection and estimation bounds under false alarm constraints (c), and error exponents bounding the best achievable error rates in secure space time communication (d). These four papers have been collectively cited over 750 times according to Google Scholar.

* 1. Gorman JohnD, Hero AO. Lower bounds for parametric estimation with constraints. IEEE transactions on information theory / Professional Technical Group on Information Theory. 1990 June; 36(6):1285-1301.
	2. Baygun B, Hero AO. Optimal simultaneous detection and estimation under a false alarm constraint. IEEE transactions on information theory / Professional Technical Group on Information Theory. 1995 March; 41(3):688-703.
	3. Hero AO, Fessler JA, Usman M. Exploring estimator bias-variance tradeoffs using the uniform CR bound. IEEE transactions on signal processing : a publication of the IEEE Signal Processing Society. 1996 August; 44(8): 2026-2041.
	4. Hero AO. Secure space-time communication. IEEE transactions on information theory / Professional Technical Group on Information Theory. 2003 December; 49(12):3235-3249.
1. Statistical signal processing for Medicine.

Hero has made sustained contributions to biomedical signal and image processing. His early work on iterative tomographic reconstruction for PET/CT were mentioned above. He has also worked in the area of biomedical data analysis using machine learning approaches. Hero's Fisher-information non-linear embedding (FINE) method of manifold learning was applied to flow cytometry in (c). This latter paper received the Best Original Paper Award in 2010 by the editors of the journal Cytometry, the leading journal in clinical flow cytometry. His papers on applications of factor analysis to gene expression and sequence analysis are published in some of the top scientific journals including: PLoS Genetics (d), Human Molecular Genetics (a), Proceedings of the National Academy of Science (b), Blood, Cell Host and Microbe, and Science Translational Medicine. The four papers below have been collectively cited over 500 times. Also of note is that in 2002 Hero co-organized (with Krim and Zhou) GENSIPS (Genomic Signal Processing and Statistics Symposium), the first-ever signal processing workshop on genomics.

* 1. Akimoto M, Cheng H, Zhu D, Brzezinski JA, Khanna R, Filippova E, Oh EC, Jing Y, Linares JL, Brooks M, Zareparsi S, Mears AJ, Hero A, Glaser T, Swaroop A. Targeting of GFP to newborn rods by Nrl promoter and temporal expression profiling of flow-sorted photoreceptors. Proc Natl Acad Sci U S A. 2006 Mar 7;103(10):3890-5. PubMed PMID: [16505381](http://www.ncbi.nlm.nih.gov/pubmed/16505381/); PubMed Central PMCID: [PMC1383502](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1383502/).
	2. Finn WG, Carter KM, Raich R, Stoolman LM, Hero AO. Analysis of clinical flow cytometric immunophenotyping data by clustering on statistical manifolds: treating flow cytometry data as high-dimensional objects. Cytometry B Clin Cytom. 2009 Jan;76(1):1-7. PubMed PMID: [18642311](http://www.ncbi.nlm.nih.gov/pubmed/18642311/).
	3. Huang Y, Zaas AK, Rao A, Dobigeon N, Woolf PJ, Veldman T, Øien NC, McClain MT, Varkey JB, Nicholson B, Carin L, Kingsmore S, Woods CW, Ginsburg GS, Hero AO 3rd. Temporal dynamics of host molecular responses differentiate symptomatic and asymptomatic influenza a infection. PLoS Genet. 2011 Aug;7(8):e1002234. PubMed PMID: [21901105](http://www.ncbi.nlm.nih.gov/pubmed/21901105/); PubMed Central PMCID: [PMC3161909](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3161909/).
	4. Yoshida S, Mears AJ, Friedman JS, Carter T, He S, Oh E, Jing Y, Farjo R, Fleury G, Barlow C, Hero AO, Swaroop A. Expression profiling of the developing and mature Nrl-/- mouse retina: identification of retinal disease candidates and transcriptional regulatory targets of Nrl. Hum Mol Genet. 2004 Jul 15;13(14):1487-503. PubMed PMID: [15163632](http://www.ncbi.nlm.nih.gov/pubmed/15163632/).
1. Data mining for correlations in high dimensional data.

Several contributions were made in correlation analysis and graphical models in high dimension. Correlation screening (a) and hub screening (b) are methods that extract a a dependency graph from observational data with guaranteed familywise error control and have been applied by us to gene expression network discovery (a,b,d), brain connectomics, financial time series networks, spatio-temporal earth climate (windspeed) (c) and solar climate (sunspots, flares and CMEs). Our screening methods operate in the purely high dimensional regime appropriate to Big Data where the number of samples (time snapshots, replicates) are fixed while the number of variables (biomarkers, electrode locations) is large.

* 1. Hero AO, Rajaratnam Bala. Large Scale Correlation Screening. Journal of the American Statistical Association. 2011 December; 106(496):1540-1552.
	2. Hero AO, Rajaratnam Bala. Hub discovery in partial correlation graphs. IEEE transactions on information theory / Professional Technical Group on Information Theory. 2012 September; 58(9): 6064-6078.
	3. Tsiligkaridis T. Covariance Estimation in High Dimensions via Kronecker Product Expansions. IEEE transactions on signal processing : a publication of the IEEE Signal Processing Society. 2013 November; 61(21):5347 - 5360.
	4. Hero AO, Rajaratnam Bala. ``Correlation mining for biomolecular network discovery," in Big Data over Networks . Cui S, Hero AO, Luo Z, Moura Jose, editors. Cambridge UK: Cambridge University Press; 2015. (ISBN: 9781107099005 https://statistics.stanford.edu/sites/default/files/2015-02.pdf)

### D. Additional Information: Research Support and/or Scholastic Performance

Ongoing Research Support

DE-NA0002534, Department of Energy National Nuclear Security Administration

Sara Pozzi (PI)

09/01/14-08/31/19

Consortium for Verification Technology

Role: CPI

W911NF-15-1-0479, Army Research Office

Hero, Alfred (PI)

08/17/15-08/16/19

Adaptive exploitation of non-commutative multimodal information structure

Role: CPI

Completed Research Support

W911NF-11-1-0391, Army Research Office

Alfred Hero (PI)

08/01/11-07/31/16

Value-Centered Information Theory For Adaptive Learning, Inference, Tracking and Exploitation

Role: PI

W911NF-12-1-0443, Army Research Office

Alfred Hero (PI)

08/23/12-07/22/16

Social Informatics Program: Emergent spatio-temporal behavior in social networks

Role: PI

FA9550-13-1-0043, Air Force Office of Scientific Research

Alfred Hero (PI)

02/01/13-01/31/16

Sample-starved large scale network analysis

Role: PI

CCF-1217880, National Science Foundation

Clayton Scott (PI)

09/01/12-12/31/15

Distribution-Adaptive Prediction and Classification

Role: CPI