

GEORGE LEE, Ph.D.
Department of Biomedical Engineering
Case Western Reserve University

Research Assistant Professor, Center for Computational Imaging and Personalized
Diagnostics (CCIPD), Case Western Reserve University

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A. EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE <i>(if applicable)</i>	YEAR(s)	FIELD OF STUDY
Rutgers University, Piscataway, NJ	B.S.	09/2004-05/2008	Biomedical EnG
Rutgers University/UMDNJ, Piscataway, NJ	Ph.D.	09/2008-01/2014	Biomedical EnG

B. PROFESSIONAL EXPERIENCE

B.1. Academic

Case Western Reserve University (CWRU), Department of Biomedical Engineering (BME)

2015-Present Research Assistant Professor

Case Western Reserve University (CWRU), Department of Biomedical Engineering (BME)

2014-2015 Research Associate

Rutgers, the State University of New Jersey (RU), Department of Biomedical Engineering (BME)

2012-2014 Graduate Fellow

Rutgers, the State University of New Jersey (RU), Department of Biomedical Engineering (BME)

2008-2012 Graduate Research Assistant

B.2. Industry

Colgate-Palmolive Company, Product Development

2007 Engineering Intern

C. HONORS, AWARDS AND RECOGNITION

- 3-year \$246,000 NIH-K01 Big Data to Knowledge (BD2K) Career Development Award, 2015
- The Data Incubator Scholars Program, 2015
- National Science Foundation (NSF) Scholarship for presentation at International Symposium on Biomedical Imaging (ISBI), 2013

LEE, GEORGE
October 5, 2015

- 2-year \$64,000 Pre-doctoral Health Disparity Training Award - CDMRP Department of Defense (DoD) Prostate Cancer Research Program (PCRP), 2011
- Rutgers Biomedical Engineering Department Travel Award, 2011
- James J. Slade Scholar, 2008
- Aresty Research Award, 2007
- Edward J. Bloustein Scholarship, 2004
- Outstanding Scholar Award, 2004

Media Recognition

- “Proscia Introduces First Cloud-Based Software Platform for Digital Pathology”
 - Prweb.com , March 13th, 2015
- “Medical Image Informatics for Personalized Medicine”
 - Madabhushi, A., Viswanath, S, Lee, G, Tiwari P. “Medical Image Informatics for Personalized Medicine.” American Society for Clinical Pathology (ASCP) Critical Values - Pathology Informatics p. 30-32. July 2013
- “George Lee awarded a \$64K, two year pre-doctoral training grant from the Department of Defense”
 - Rutgers Biomedical Engineering Spring Newsletter, 2012

D. PROFESSIONAL/EDITORIAL ACTIVITIES/INSTITUTIONAL SERVICE

CHAIRING, MEMBERSHIP PROGRAM COMMITTEES OF CONFERENCES, WORKSHOPS, SPECIAL ISSUES

- Technical Committee Member, International Association for Pattern Recognition (IAPR) TC20 Technical Committee Pattern Recognition for Bioinformatics, 2013-Present
- Session Chair for “Learning Methods for Gene Expression and Mass Spectrometry Data” at Pattern Recognition in Bioinformatics (PRIB), Nijmegen, Netherlands, Sept. 2010

REVIEWING ACTIVITIES

Grant Proposals

- SOURCE Summer Undergraduate Research Applications at CWRU, 2015

Technical Journal Papers

- ACM/IEEE Transactions on Computational Biology and Bioinformatics
- Advanced Science Letters
- Bioinformatics
- Computers in Biology and Medicine
- Information Sciences
- IEEE Journal of Biomedical and Health Informatics

Conference and Workshop Papers

- Medical Image Computing and Computer Assisted Intervention (MICCAI), 2013-Present

PROFESSIONAL SOCIETIES

- Student Member, Institute of Electrical and Electronics Engineers (IEEE) 2007-2013
- Member, Graduate Biomedical Engineering Student Society (BESS), 2008-2014
- Treasurer, Member, Biomedical Engineering Society, (BMES), 2007-2008.

DEPARTMENTAL SERVICE

- Undergraduate Mentor, CWRU (2014-2015)
- Undergraduate Mentor, Rutgers University (2008-2012)
- Volunteer, Biomedical Engineering Open House, Rutgers University (2007-2012)

INSTITUTIONAL SERVICE

- Volunteer, School of Engineering Open House, Rutgers University (2007-2012)

E. PATENTS

Issued Patents

1. "Quantitatively Characterizing Disease Morphology With Co-Occurring Gland Tensors In Localized Subgraphs", by Anant Madabhushi, **George Lee**, Sahirzeeshan Ali, Rachel Sparks. USSN: US 14/226,083.
2. "Quantitatively Characterizing Disease Morphology With Cell Orientation Entropy", by Anant Madabhushi, **George Lee**, Sahirzeeshan Ali, Rachel Sparks, United States Serial Number (USSN): US 14/226,226.

Invention Disclosures

3. "Co-occurring Gland Tensors in Localized Cluster Graphs for Quantitative Histomorphometry", Anant Madabhushi, **George Lee**, Sahir Ali, Rachel Sparks, Case 2013-2369.
4. "Co-occurring Nuclear Tensors in Localized Cluster Graphs for Quantitative Histomorphometry", Anant Madabhushi, **George Lee**, Sahir Ali, Rachel Sparks, Case No. 2013-2452.
5. "Tumor + Adjacent Benign Signature (TABS) for Quantitative Histomorphometry", Anant Madabhushi, **George Lee**, Sahirzeeshan Ali, 2014, Case No. 2014-2654

F. PUBLICATIONS

Citation Indices (from Google Scholar) as of 10/1/2015

Citations: 249

h-index: 8

i0-index: 7

*Note: * denotes joint first authorship*

Book Chapters

BC1. Veltri, RW, Zhu, G, Lee, G, Ali, S, Madabhushi, A, "Histomorphometry of Digital Pathology: Case Study in Prostate Cancer", *Frontiers in Medical Imaging*, 2014.

Peer Reviewed Journal Papers

- J1. Ginsberg, S, Lee, G, Ali, S, Madahubshi, A. Feature Importance in Nonlinear Embeddings (FINE): Applications in Digital Pathology. *IEEE Transactions in Biomedical Imaging*, 2015.
- J2. Lee, G, Singanamali, A, Wang, H, Feldman, MD, Master SR, Shih, N, Spangler, E, Rebbeck, T, Tomaszewski, JE, Madabhushi, A. Supervised Multi-View Canonical Correlation Analysis (sMVCCA): Integrating histologic and proteomic features for predicting recurrent prostate cancer," *IEEE Trans Med Imaging*, Jan;34(1):284-97, 2015.
- J3. Lee, G, Sparks, R, Ali, S, Madabhushi, A, Feldman, MD, Shih, N, Spangler, E, Rebbeck, T, Tomaszewski, JE, Madabhushi A. "Co-occurring Gland Angularity in Localized Subgraphs: Predicting Biochemical Recurrence in Intermediate-risk Prostate Cancer Patients". *PLOS ONE*, 9:5, e97954, 2014
- J4. Golugula, A, Lee, G, Madabhushi, A. "Supervised Regularized Canonical Correlation Analysis: Integrating Histologic and Proteomic Measurements for Predicting Biochemical Failures Following Prostate Surgery" *BMC Bioinformatics*, 12:483, 2011.
- J5. Madabhushi, A, Agner, S, Basavanhally, A, Doyle, S, Lee, G, "Computer-aided prognosis: Predicting patient and disease outcome via quantitative fusion of multi-scale, multi-modal data", *Computerized Medical Imaging and Graphics*. 35(7-8):506-514, 2011.
- J6. Madabhushi, A, Doyle, S, Lee, G, Basavanhally, A, Monaco, J, Master, S, Tomaszewski, J, and Feldman, M, "Review: Integrated diagnostics: a conceptual framework with examples," *Clinical Chemistry and Laboratory Medicine*, vol. 48(7), pp. 989-998, 2010.
- J7. Lee, G, Madabhushi, A., "Investigating the Efficacy of Nonlinear Dimensionality Reduction Schemes for High-dimensional Gene and Protein Expression Cancer Studies". *IEEE/ACM Transactions on Computational Biology and Bioinformatics*, 5(3), pp. 368-384, July-September 2008

Peer-reviewed Conference Papers

- C1. Leo, P, Lee, G, Madabhushi, A. Evaluating Stability of Histomorphometric Features Across Scanner and Staining Variations: Predicting Biochemical Recurrence From Prostate Cancer Whole Slide Images. *SPIE: Medical Imaging*, 2016
- C2. Singanamalli, A, Wang, H, Lee, G, Shih, N, Ziober, A, Rosen, M, Master, S, Tomaszewski, J, Feldman, M, Madabhushi, A. Supervised multi-view canonical correlation analysis: fused multimodal prediction of disease prognosis. *SPIE: Medical Imaging*, 2014
- C3. Lee, G, Ali, S, Veltri, R, Epstein, J, Christudass, C, Madabhushi, A. Cell Orientation Entropy (COre): Predicting Biochemical Recurrence from Prostate Cancer Tissue Microarrays. K. Mori et al. (Eds.): *MICCAI 2013, Part III, LNCS 8151*, pp. 396-403. Springer, Heidelberg, 2013
- C4. Ginsberg, S, Ali, S, Basavanhally, A, Lee, G, Madabhushi, A. Variable Ranking in Kernel PCA: Applications to Cancer Characterization on Digitalized Histopathology. *MICCAI 2013*.

- C5. Lee, G, Sparks, R, Ali, S, Feldman, MD, Master, SR, Shih, N, Tomaszewski, JE, Madabhushi, A. Co-occurring Gland Tensors in Localized Cluster Graphs: Quantitative Histomorphometry for Predicting Biochemical Recurrence for Intermediate Grade Prostate Cancer. International Symposium on Biomedical Imaging (ISBI) 2013.
- C6. Golugula A, Lee G, Master SR, Feldman MD, Tomaszewski JE, Madabhushi A. Supervised Regularized Canonical Correlation Analysis: Integrating Histologic and Proteomic Data for Predicting Biochemical Failures. IEEE International Conference of Engineering in Medicine and Biology Society (EMBS). 6434-6437, 2011
- C7. Golugula A, Lee G, Madabhushi A. Evaluating Feature Selection Strategies for High Dimensional, Small Sample Size Datasets. IEEE International Conference of Engineering in Medicine and Biology Society (EMBS). pp. 949-952, 2011
- C8. Tiwari, P*, Viswanath, S*, Lee, G*, Madabhushi, A. "Multi-modal Data Fusion Schemes for Integrated Classification of Imaging and Non-Imaging Biomedical Data." International Symposium for Biomedical Imaging (ISBI) 2011 *(Joint first authors)
- C9. Madabhushi, A, Basavanhally, A, Doyle, S, Agner, S, Lee, G Computer-Aided Prognosis: Predicting Patient and Disease Outcome via Multi-Modal Image Analysis. International Symposium for Biomedical Imaging (ISBI) 2011
- C10. Lee, G, Madabhushi A., "Semi-Supervised Graph Embedding Scheme with Active Learning (SSGEAL): Classifying High Dimensional Biomedical Data", in Pattern Recognition in Bioinformatics (PRIB), LNCS 6282, 207-218, 2010.
- C11. Madabhushi, A, Basavanhally, A, Doyle, S, Agner, S, Janowczyk, A, Lee, G, Computer-Aided Prognosis: Predicting Patient and Disease Outcome via Multi-Modal Image Analysis," International Symposium for Biomedical Imaging (ISBI), 1313-1316, 2010.
- C12. Lee, G, Doyle, S, Monaco, J, Feldman, MD, Master, SR, Tomaszewski, JE, Madabhushi, A. "A knowledge representation framework for integration, classification of multi-scale imaging and non-imaging data: Preliminary results in predicting prostate cancer recurrence by fusing mass spectrometry and histology," Biomedical Imaging: From Nano to Macro, 2009 IEEE International Symposium on (ISBI), 77-80, 2009.
- C13. Lee, G, Rodriguez, C, Madabhushi, A, "An Empirical Comparison of Dimensionality Reduction Methods for Classifying Gene and Protein Expression Datasets". Third International Symposium on Bioinformatics Research and Applications, LNCS 4463, 170-181, 2007

Peer Reviewed Abstracts

- A1. Gawlik, A, Lee, G, Whitney, J, Epstein, JI, Veltri, RW, Madabhushi, A. Computer extracted nuclear features from Feulgen and H&E images predict prostate cancer outcomes. Biomedical Engineering Society (BMES) Meeting Oct. 2015 (Accepted for Oral Presentation)
- A2. Lee, G, Veltri, RW, Zhu, G, Carter, B, Landis, P, Epstein, JI, Madabhushi, A. Quantitative Histomorphometric Analysis of Prostate Biopsy Images Predict Favorable Outcome in Active Surveillance Patients. 2015 Annual Meeting of the American Urological Association (AUA) Education and Research Inc. May 2015

- A3. **Lee, G**, Veltri RW, Ali, S, Epstein, JI, Christudass, C, Madabhushi, A. Prostate cancer recurrence can be predicted by measuring nuclear organization and shape parameters in adjacent benign regions on radical prostatectomy specimens. 2015 Annual Meeting of the American Urological Association (AUA) Education and Research Inc. May 2015
- A4. Zhu, G, **Lee, G**, Davis, C, Kagohara, L, Epstein, JI, Landis, J, Carter, HB, Madabhushi, A, Veltri, RW. Prediction of prostate cancer progression with biomarkers and tissue morphometry changes. Proceedings American Association of Cancer Research (AACR) Meeting Apr. 2015. Cancer Research. August 1, 2015 75;4352
- A5. **Lee, G**, Veltri, RW, Ali, S, Epstein JI, Christudass, C, Madabhushi, A. "Prostate cancer recurrence can be predicted by measuring cell graph and nuclear shape parameters in the benign cancer-adjacent field of surgical specimens", United States and Canadian Academy of Pathology (USCAP) Mar. 2015
- A6. **Lee, G**, Veltri, RW, Zhu, G, Epstein, JI, Madabhushi, A. Computerized Nuclear Shape Analysis of Prostate Biopsy Images Predict Favorable Outcome in Active Surveillance Patients" United States and Canadian Academy of Pathology (USCAP) Mar. 2015
- A7. **Lee, G**, Doyle, S, Monaco J. Feldman, M, Tomaszewski, J, Master S., Madabhushi, A. "Fusion of proteomic and histologic image features for predicting prostate cancer recurrence after radical prostatectomy", United States and Canadian Academy of Pathology (USCAP) Feb. 2011.
- A8. **Lee, G**, Madabhushi, A. "Radial Projection Analysis (RPA): A Novel Scheme for Nonlinear Dimensionality Reduction." 4th Annual Machine Learning Symposium hosted by New York Academy of Sciences, Nov. 2009.

Non-Peer Reviewed Abstracts

- A1. Gawlik, A, **Lee, G**, Whitney, J, and Madabhushi, A. Characterizing Feulgen stained prostate pathology slides via computerized image analysis. Research ShowCASE at Case Western Reserve University. May. 2015
- A2. Zhu, G, **Lee, G**, Davis, C, Kagohara, LT, Epstein, JI, Madabhushi, A, Landis, P, Carter, HB, Veltri, RW. Prediction of favorable and unfavorable biopsy pathology results of active surveillance patients using nuclear morphometry and molecular biomarkers. SPORE 8th Annual Multi-Institutional Prostate Cancer Program Retreat. May 2015
- A3. **Lee, G**, Sparks, R, Ali, S, Madabhushi, A. "Co-occurring Gland Tensors in Localized Cluster Graphs: Quantitative Histomorphometry for Predicting Biochemical Recurrence in Prostate Cancer post Radical Prostatectomy". Research ShowCASE at Case Western Reserve University May. 2013
- A4. **Lee, G**, Madabhushi, A. "Discovery of New Cancer Subtypes on Gene and Protein Expression Data via Nonlinear Dimensionality Reduction Methods", Annual Retreat on Cancer Research at UMDNJ-Robert Wood Johnson Medical School, May 2007

G. RESEARCH SUPPORT

Completed Research Support

External

Lee, George (PI)

09/15-07/18

LEE, GEORGE
October 5, 2015

NIH Research Scientist Development Award in Biomedical Big Data Science (K01) \$245,823
Big data convergence of pathology and omics for disease prognosis
Role: PI, Mentored by Anant Madabhushi, Co-Mentored by Sanjay Gupta

Lee, George (PI) 01/12-12/13
CDMRP Pre-doctoral U.S. Department of Defense Health Disparity Training Award \$64,650
Comparing Proteomic, Histological Biomarkers for Biochemical Failure among African Americans and
Caucasians following Radical Prostatectomy
Role: PI, Mentored by Anant Madabhushi

H. TEACHING ACTIVITIES

Undergraduate Students Mentored

A. Rutgers University

1. Abhishek Golugula, Junior (2009-2011)

- 1 first-author peer-reviewed journal paper in BMC Bioinformatics
- 2 first-author peer-reviewed conference abstracts
- 2 poster talks

B. Case Western Reserve University

2. Ania Gawlik, Junior (8/2014-Present)

- 1 accepted oral talk at Biomedical Medical Engineering Society (BMES) Conference
- 1 accepted first-author conference abstract
- 1 poster talk
- The Biomedical Engineering Scholarship Award (2015)
- SOURCE CAA Summer Research Scholar (2015)
- Choose Ohio First Scholarship (2015)

3. Patrick Leo, Sophomore (3/2014-Present)

- 1 first-author conference abstract accepted
- SOURCE CAA Summer Research Scholar (2015)

Courses Taught

A. Rutgers, The State University of New Jersey, New Brunswick, NJ

Undergraduate

Lecturer, Spring 2011: BME 125:416 Pattern Recognition

Lecturer, Spring 2010: BME 125:416 Pattern Recognition

Lecturer, Spring 2009: BME 125:416 Pattern Recognition

Teaching Assistant, Spring 2010: BME 125:315 BME Measurements and Analysis Lab