BIOGRAPHICAL SKETCH

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NAME	POSITION TITLE
Bennett A. Landman	Assistant Professor
eRA COMMONS USER NAME	
blandma1	

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

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
Johns Hopkins University	Ph.D.	2008	Biomedical Engineering
Massachusetts Institute of Technology	M.Eng.	2002	Electrical Eng & Comp Sci
Massachusetts Institute of Technology	B.S.	2001	Electrical Eng & Comp Sci

A. Personal Statement

My primary area of scientific focus is medical image processing. While my academic home is in electrical engineering, my training is in biomedical engineering, including MR sequence development and operation of MR scanners. I am deeply interested in advancing image processing techniques to enable efficient learning from limited examples (including multi-atlas labeling and intra-voxel tissue modeling). I seek to connect the image processing methods with both the medical physics underpinning of the data and their clinical applications. I currently direct the Vanderbilt University Institute of Image Science's (VUIIS) Center for Computational Imaging (VUIIS-CCI). My VUIIS team has constructed a university wide medical image processing system that handles data for 30,526 subjects in 45,412 imaging sessions captured by 227 IRB approved projects (June 2015). Our system links closely with the university's high performance computing center for automated processing of structural, functional, and diffusion MRI data (including tensor and high angular resolution diffusion imaging) and annually consumes approximately 200 CPU-years of cluster time. I have also worked with the Biomedical Informatics Research Network (BIRN) to optimize, evaluate, and standardize acquisition and analysis of diffusion tensor imaging (DTI) and define community standards for multi-site DTI protocols. My continuing efforts focus on improving the capabilities of multi-atlas method to account for large-scale, heterogeneous data and new anatomical targets. We are exploring incorporating information from multiple imaging protocols, non-traditional registration models, and a wide range of pathologies cases.

B. Positions and Employment

Dates	*Position*	*Employer*
1998-1999	Programmer Analyst	U.C. Berkeley Department of Molecular and Cell Biology
2001-2001	Research Assistant	MIT Research Laboratory for Electronics
1999-2001	ViaSense, Inc.	Software Engineer
2001-2003	ViaSense, Inc.	Research and Development Architect
2003-2004	Senior Software Engineer	Neurobehavioral Research, Inc.
2004-2008	Graduate Researcher	Johns Hopkins School of Medicine, Dept. of Biomedical Eng.
2008-2009	Assistant Research Professor	Johns Hopkins Univ., Dept. of Biomedical Eng.
2009-2009	Adjoint Assistant Professor	Vanderbilt University, Dept. of Electrical Engineering
2010-	Assistant Professor	Vanderbilt University, Dept. of Electrical Engineering
2010	Assistant Professor	Vanderbilt University, Biomedical Engineering, Radiological and Radiological Sciences, and Computer Science
2010-	Director	Center for Computational Imaging, Vanderbilt University Institute of Image Science (VUIIS)

C. Contribution to Science

Dr. Landman's research focuses on high throughput quantitative analyses of 3-D medical images. He seeks to perform robust anatomical and parametric analyses of routinely acquired images and applying these techniques at scale.

1. Abdominal Image Processing and Organ Segmentation

Ventral hernia (VH) repair is one of the procedures most commonly performed by general surgeons worldwide, yet extensive variation exists in its delivery. Most VH patients undergo computed tomography (CT) scanning to evaluate their abdominal wall. This information is used to make clinical judgments about a particular patient's hernia for treatment and prognosis, but these decisions are not based on imaging. Dr. Landman has developed algorithms for the automated labeling of abdominal structures in patient populations using current generation clinically acquired CT data. He has created new labeling paradigms so that automated methods can be efficiently learned from expertly labeled training data. He has developed new image processing methods to segment the abdominal organs and handle the large-scale sliding/shearing deformations present in abdominal anatomy.

- Zhoubing Xu, Andrew J. Asman, Peter L. Shanahan, Richard G. Abramson, Bennett A. Landman. "SIMPLE Is a Good Idea (and Better with Context Learning)", In International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), Boston, MA, September 2014. PMID 25333139
- Zhoubing Xu, Wade M. Allen, Rebeccah B. Baucom, Benjamin K. Poulose, **Bennett A. Landman**. "Texture Analysis Improves Level Set Segmentation of the Anterior Abdominal Wall." Medical Physics. 2013 Dec;40(12):121901. PMC3838426
- Christopher P. Lee, Zhoubing Xu, Ryan P. Burke, Rebeccah B. Baucom, Benjamin K. Poulose, Richard G. Abramson, **Bennett A. Landman**. "Evaluation of Five Image Registration Tools for Abdominal CT: Pitfalls and Opportunities with Soft Anatomy." In Proceedings of the SPIE Medical Imaging Conference. Orlando, Florida, February 2015.
- Ryan P. Burke, Zhoubing Xu, Christopher P. Lee, Rebeccah Baucom, Benjamin K. Poulose, Richard G. Abramson, **Bennett A. Landman**. "Multi-Atlas Segmentation for Abdominal Organs with Gaussian Mixture Models." In Proceedings of the SPIE Medical Imaging Conference. Orlando, Florida, February 2015.

2. Medical Image Segmentation with Multi-Atlas Labeling

Manual labeling of anatomical structures requires a high level of expertise, is time consuming, and is prone to disagreement among experts. For brain labeling, label transfer via image registration has been widely and successfully applied. Dr. Landman has been a leader in statistical learning from example images (so called multi-atlas labeling) and has published extensively on algorithm development and application areas. These methods have been effective on brain labeling at both a gross level (with large scale tumors) and the more typical fine-grained labeling with healthy. He was the first to show that medical images could be successfully labeled via remote crowd sourcing. Dr. Landman has organized four annual workshop/challenges at the International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI) and have generated increasing attendance year each.

- Andrew J. Asman and **Bennett Landman**, "Hierarchical Performance Estimation in the Statistical Label Fusion Framework." *Medical Image Analysis (MedIA).* Med Image Anal. 2014 Oct;18(7):1070-81. PMID: 25033470
- Andrew J. Asman and **Bennett A. Landman**. "Non-Local Statistical Label Fusion for Multi-Atlas Segmentation." *Medical Image Analysis (MEDIA)*. 2013. 17(2):194-208. PMC23265798
- Andrew J. Asman, Lola Chambless, Reid Thompson, and **Bennett A. Landman**. "Out-of-Atlas Likelihood Estimation using Multi-Atlas Segmentation." *Medical Physics*. 2013 Apr;40(4) PMC23556928 †
- **Bennett A Landman**, Andrew J Asman, Andrew G Scoggins, John A Bogovic, Joshua A Stein; Jerry L Prince, "Foibles, Follies, and Fusion: Web-Based Collaboration for Medical Image Labeling", *NeuroImage.* 2012 Jan 2;59(1):530-9. PMC3195954

3. Large-scale Medical Image Processing

Dr. Landman developed an extensive collection of image processing tools; his primary platform – the Java Image Science Toolkit (JIST) has been downloaded over 13,060 times. His team created a novel Python-RedCAP-XNAT bridge that allows for ready reuse of pipeline across projects and high throughput quality control of imaging data. These capabilities are attracting high caliber collaborators from both within and outside of Vanderbilt. He directs the VUIIS Center for Computational Imaging (CCI) and has constructed a PACS/XNAT system for the VUIIS Center for Human Imaging. Since May 2010, the system has supported 206 IRB approved projects with 29557 subjects, and 43567 imaging sessions. Since May 2013, the CCI has supported real-time capture and anonymization of all clinical CT and MRI data from the Radiology Department of the Vanderbilt University Medical System (VUMC) for the Synthetic Derivative's Imaging Project and has archived over 113 million images. These systems are interlinked with the campus high performance computing facility and currently perform 200 CPU-years of image analysis per year.

- Rueben Banalagay, Kelsie Jade Covington, D.Mitch Wilkes, **Bennett A. Landman**. "Resource Estimation in High Performance Medical Image Computing." *Neuroinformatics*. 2014 Oct;12(4):563-73. PMID: 24906466
- Benjamin C. Yvernault, Charles D. Theobald, Jr., Jolinda C. Smith, Victoria Villalta, David H. Zald, **Bennett A. Landman**. "Validating DICOM transcoding with an open multi-format resource." Neuroinformatics. 2014 Oct;12(4):615-7. PMID: 24777387
- Bo Li, Frederick Bryan, **Bennett A. Landman**, "Next Generation of the JAVA Image Science Toolkit (JIST) Visualization and Validation." *Insight Journal*. August 2012. P 874 †
- Blake C. Lucas, John A. Bogovic, Aaron Carass, Pierre-Loius Bazin, Jerry L. Prince, and **Bennett A. Landman**, "The Java Image Science Toolkit (JIST) for Rapid Prototyping and Publishing of Neuroimaging Software", *Neuroinformatics*. 8(1):5-17.(2010) PMC2860951

4. Multi-Modal Image Processing incorporating Diffusion Weighted MRI

Understanding the biological basis of the central nervous system is crucial for quantitative interrogation of cognitive function and dysfunction. Dr. Landman is working to improve the use of diffusion weighted MRI within the context of multi-modal imaging studies and better understand the biological basis of the multi-parametric signals that are being observed. Dr. Landman conducted the first extensive empirical characterizations of the reproducibility of diffusion tensor MRI. Dr. Landman developed the first compressed sensing method to recover multiple orientations from standard diffusion tensor imaging acquisitions. He acquired and released the largest multi-modal resource of 3T MRI data (downloaded over 17,743 times), and has published frameworks for integrating structural, functional, and diffusion data to infer brain connectomics.

- **Bennett A. Landman**, John A. Bogovic, Aaron Carass, Min Chen, Snehashis Roy, Navid Shiee, Zhen Yang, Bhaskar Kishore, Dzung Pham, Pierre-Louis Bazin, Susan M. Resnick, and Jerry L. Prince. "System for Integrated Neuroimaging Analysis and Processing of Structure." *Neuroinformatics.* 2013 Jan;11(1):91-10 PMC22932976 †
- **Bennett A. Landman,** John A Bogovic; Hanlin Wan; Fatma El Zahraa ElShahaby; Pierre-Louis Bazin, and Jerry L Prince. "Resolution of Crossing Fibers with Constrained Compressed Sensing using Diffusion Tensor MRI", *NeuroImage.* 2012 Feb 1;59(3):2175-86. PMC22019877 †
- **Bennett A. Landman**, Alan J. Huang, Aliya Gifford, Deepti S. Vikram, Issel Anne L. Lim, Jonathan A.D. Farrell, John A. Bogovic, Jun Hua, Min Chen, Samson Jarso, Seth A. Smith, Suresh Joel, Susumu Mori, James J. Pekar, Peter B. Barker, Jerry L. Prince, and Peter C.M. van Zijl. "Multi-Parametric Neuroimaging Reproducibility: A 3T Resource Study", *NeuroImage*. Volume 54, Feb, Issue 4, 14, Pages 2854-2866 (2011) PMC3020263
- **B. A. Landman**, J. A. Farrell, C. K. Jones, S. A. Smith, J. L. Prince, P. C. van Zijl, and S. Mori. "Effects of Diffusion Weighting Schemes on the Reproducibility of DTI-derived Fractional Anisotropy, Mean Diffusivity, and Principal Eigenvector Measurements at 1.5T", *NeuroImage*. 36(4): 1123-1138. July 2007. PMID17532649

5. Segmentation of the optic nerve and orbital structures

Collectively, diseases of the optic nerve (**ON**) are the number one cause of irreversible blindness worldwide. Dr. Landman is working to translate medical imaging computing procedures from the neuroimaging community to provide robust, quantitative tools for assessing the ON on clinical and research imaging sequences. He has published the first successful multi-atlas techniques for segmenting the optic nerve and orbital structures on clinically acquired MRI and CT. His team has successfully applied these approaches to segment the spinal cord and cerebellum.

- Robert L. Harrigan, Andrew J. Plassard, Frederick W. Bryan, Gabriela Caires, Louise A. Mawn, Lindsey M. Dethrage, Siddharama Pawate, Robert L. Galloway, Seth A. Smith, **Bennett A. Landman**. “Disambiguating the Optic Nerve from the Surrounding Cerebrospinal Fluid: Application to MS-related Atrophy.” *Magnetic Resonance in Medicine*. In press 2014.
- Robert Harrigan, Swetasudha Panda, Andrew J. Asman, Michael P. DeLisi, Benjamin C. W. Yvernault, Seth A. Smith, Robert L. Galloway, Louise A. Mawn, **Bennett A. Landman** “Robust Optic Nerve Segmentation on Clinically Acquired CT.” *Journal of Medical Imaging*. In press 2014
- Swetasudha Panda, Andrew J Asman, Shweta P Khare, Lindsey Thompson, Louise A Mawn, Seth A Smith, **Bennett A Landman.** “Evaluation of Multi-Atlas Label Fusion for Orbital Segmentation on In Vivo MRI.” *Journal of Medical Imaging*. 1(2), 024002 (Jul–Sep 2014)
- Andrew J. Asman, Frederick W. Bryan, Seth A. Smith, Daniel S. Reich, **Bennett A. Landman**. “Groupwise Multi-Atlas Segmentation of the Spinal Cord’s Internal Structure.” *Medical Image Analysis (MedIA).* 2014 Feb 5;18(3):460-471. PMC 24556080

Complete List of Published Work in My Bibliography:
http://www.ncbi.nlm.nih.gov/myncbi/browse/collection/40369522/?sort=date&direction=descending

Scientific Metrics (on June 30, 2015)

- 63 peer-reviewed journal articles
- Google Scholar Profile: http://scholar.google.com/citations?hl=en&user=tmTcH0QAAAAJ
- H-index: 22; I-10 index: 42; Total citations: 1883
- Research Gate profile: http://www.researchgate.net/profile/Bennett_Landman
- Cumulative impact factor: 239.79; RG score: 36.22 (>92.5% percentile)

Laboratory Web site: https://masi.vuse.vanderbilt.edu/index.php/Main_Page

D. Recent Research Support (active in the last 3 years)

1R01 NS075270-03 (Morgan) 03/01/12 – 02/28/17
NIH/NINDS
MRI Structural and Functional Connectivity Changes in Temporal Lobe Epilepsy
This project examines structural and functional brain network reorganization in temporal lobe epilepsy and its effects on disease and cognitive function.
Role: Investigator

1R01 EB015611-02 (Kochunov) 08/01/12-07/30/15
NIH/NIBIB
SOLAR-Eclipse Computational Tools for Imaging Genetics
This subcontract will translate recent advances in imaging-genetic tools for high-throughput study.
Role: Collaborator / Subcontract-PI

1R21EY024036-01 (Landman) 12/01/13 -11/30/15
NIH/NEI
Quantitative Image Analysis Techniques for Optic Nerve Disease
This project goal is to develop image analysis technique for the optic nerve using existing clinically acquired datasets.
Role: PI

2R01NS058639-06 (Anderson) 04/01/13-03/31/17
NIH/NINDS
The Biological Basis of Diffusion MRI of the Brain
The goal of this project is to test and improve new MRI methods for characterizing both long and short-range connections in the brain.
Role: Investigator

5R01MH098098-03 (MPI: Zald) 9/12/12-5/31/16
NIH/NIMH
RD0c constructs: Neural substrates, heritability, and relation to psychopathology
The present study, proposes to test key hypotheses of the Research Domains Criteria (RDoC) initiative, which posits that research on the neurobiological bases of psychopathology has been misled because dysfunctional brain circuits do not align one-to-one with disorders, but align with a number of functional constructs that should be the focus of study. We propose to use a subsample from a large and representative cohort oversampled on psychopathology to elucidate neural circuits associated with five key RDoC constructs, and to test the central RDoC hypothesis that these constructs are associated with psychopathology in a complex but predictable cross-cutting fashion.
Role: Investigator

1R01EY023240-01A1(Smith) 03/01/14 – 2/28/18
NIH/NEI
Microstructural Characterization of the Optic Nerve in the Optic Neuritis
Role: Investigator
The overall goal of this proposal is to develop and implement novel, multi-modal magnetic resonance imaging (MRI) in the human optic nerve capable of understanding the relationship between optic neuritis (ON) and the evolution of visual (dys)function and clinical evaluation. We further propose that quantitative MRI methods sensitive to tissue microstructure (myelin and axonal integrity) and biochemistry can be utilized in prediction models to offer insight into the eventual development of multiple sclerosis (MS).
Role: Investigator

1R21 MH10132101A1 (Woodward/Cascio) 09/01/2014 – 02/29/16
NIH/NINDS
Mapping Thalamocortical Networks Across Development in ASD
Using an innovative resting-state fMRI method, we will determine if thalamocortical networks are altered in ASD (Aim 1); examine the developmental trajectories of thalamocortical networks in ASD (Aim 2); and establish the functional relevance of thalamocortical networks to the expression of ASD symptoms (Aim 3). The proposed work will contribute to our understanding of brain-basis of ASD.
Role: Investigator

1 R01 MH102266-01A1 (Woodward) 09/01/2014 -07/31/2019
NIH/NIMH
Thalamocortical Networks in Psychosis
The Major Goals of this project will use neuroimaging to determine how key brain circuits involved in cognition are affected in chronic and early-stage patients with schizophrenia and psychotic bipolar disorder.
Role: Co-Investigator

1452485 (Landman) 03/01/2015 – 02/29/2020
NSF
CAREER: Modeling Personalized Brain Development with Big Data
The goal of this proposal is to create techniques to work with medical image processing in a big data context.
Role: PI