BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES**.

NAME: **Andrew Francis LAINE**

eRA COMMONS USER NAME (credential, e.g., agency login): Laine1

POSITION TITLE: Professor of Biomedical Engineering and Radiology (Physics)
Department of Biomedical Engineering

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

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Cornell University, Ithaca, NY	B.S.	05/77	Biological Science
University of Connecticut, Storrs, CT	M.S.	05/80	Chemistry
Washington University, St. Louis, MO	M.S.	05/83	Computer Science
Washington University, St. Louis, MO	D.Sc.	05/89	Computer Science

A. Personal Statement

My research interests include methods in quantitative image analysis, image formation, bio-mechanical measures of strain, and bio-imaging informatics (including machine and deep learning). I have been working in the area of medical image analysis for over 25 years and have published over 300 papers in the field. We previously collaborated on a project focused on a challenging problem in the area of biomarkers, used machine learning (ML) to discover new phenotypes of lung disease via low dose CT imaging. This application entitled, **"**Precision Phenotyping of Chronic Lower Respiratory Disease in the Elderly: the MESA Lung Study," This proposal would provide **….** In general, this application is fitting to my passion to solve problems where biomedical imaging can make significant contributions towards understanding a disease process leading to treatment and possible intervention for improving healthcare.

B. Positions and Honors

<u>Positions and Employment</u>

1989-1990 Postdoctoral Fellow, Center for Intelligent Computer Systems, Department of Computer Science, Washington University, St. Louis, MO.

1990-1995 Assistant Professor, Computer and Information Sciences and Engineering Department, University of Florida, Gainesville, FL.

1995-1997 Associate Professor, Department of Computer and Information Sciences and Engineering, Department of Electrical and Computer Engineering, and Department of Radiology, University of Florida, Gainesville, FL. Tenure granted in July, 1995.

1997-2002 Associate Professor of Biomedical Engineering and Radiology (Physics), Columbia University, New York, NY. Tenure granted in April, 2000.

2002-2011 Professor of Biomedical Engineering and Radiology (Physics), Vice Chair, Department of Biomedical Engineering, Columbia University, New York, NY.

2012-2017 Chair, Department of Biomedical Engineering, Columbia University, New York, NY

2011-present Percy K. and Vida L. W. Hudson Professor of Biomedical Engineering and Radiology, Department of Biomedical Engineering, Columbia University, New York, NY.

Other Experience and Professional Memberships

2015, 2016 President, IEEE Engineering in Medicine and Biology Society (EMBS)
2013-2015 Chair, Council of Societies, American Institute of Biological and Medical Engineers (AIMBE)
2012-2014 Chair, Steering Committee, IEEE International Symposium on Biomedical Imaging
1991 2008-2012 IEEE EMBS Executive Committee, Vice President of Publications (consecutive 2 year terms)
1992 2009-2011 IEEE Engineering in Biology and Medicine (EMBS) Conference, Program Chair, Boston, MA, August, 2011.
1993 2004-2006 IEEE Engineering in Biology and Medicine (EMBS) Conference, Program Chair, New York, NY, September, 2006.
1993-1995 1998-2003 National Institutes of Health (NIH), PLCO Cancer Screening Study, consultant and site reviewer.
2000-2009 National Institutes of Health (NIH), NIBIB, Ad-Hoc Panel Reviewer.
1995-present Editorial Board, Emerging Technologies in Biomedical Engineering, Metin Akay, Series Editor and Chief, published by IEEE Press and sponsored by the IEEE Engineering in Medicine and Biology Society.
1993-2001 Editor and Chairman for Proceedings of the Conference in Mathematical Imaging: Wavelet Applications in Signal and Image Processing, International Symposium on Optical Applied Science and Engineering.
1996-1998 Associate Editor for IEEE Transactions on Image Processing, IEEE Press.

Honors

1991 Engineering Research Award, Engineering Foundation and the Institute of Electrical and Electronics Engineers.
1991 Research Initiation Award, National Science Foundation (NSF)
1993 Whitaker Foundation Award in Biomedical Engineering
1998 Alexander Von Humboldt Foundation, Research Fellowship (Computer Science)
2004 Distinguished Alumni Award, Department of Computer Science, Washington University
2005 Senior Member of IEEE (Institute of Electrical and Electronics Engineering
2006 AIMBE Fellow - American Institute for Medical and Biological Engineering (Class of 2006)
2008 IBM Faculty Award – T.J. Watson Research Center (Medical Information Systems)
2009 IEEE Fellow (2010)
2011 Percy K. and Vida L. W. Hudson Professor of Biomedical Engineering and Radiology, School of Engineering and Applied Science, Columbia University, New York, NY
2017 Fellow, International Federation of Medical and Biological Engineers (IFMBE, Class of 2018)

C. Contribution to Science

In the early stages of my career I worked in the application of multi-resolution representations for feature analysis of digital mammography and cardiac ultrasound. This was considered pioneering work in the field of medical imaging that I first introduced in 1994 using nonlinear processing techniques of wavelet representations for contrast enhancement in digital mammography. This difficult imaging problem greatly enhanced the visualization of dense radiographs of the breast to reveal subtle features / findings within the breast. This mathematical model using nonlinear operators could be applied for the first time safely without causing "false positives" or introducing artifacts into reconstructed images, and is now widely used nationally and internationally. It has also been adapted / tuned for diagnostic imaging of the lung in addition to micro-calcifications and detection small masses in the breast. The code was not patented and provided for free to any commercial or academic institution. These methods of adaptive contrast enhancement have been incorporated in the current generation of commercial digital mammography systems.

(1) *Wavelet Applications in Medicine: Digital Mammography*

Laine pioneered the application of multiresolution representations for feature analysis and contrast enhancement of digital mammography and ultrasound. Laine's paper *Mammographic Feature Enhancement by Multiscale Analysis*, A. F. Laine, S. Schuler, J. Fan, and W. Huda, IEEE Transactions on Medical Imaging, VOL 13, NO. 4, pp. 725-752, 1994 was the first to show a quantitative advantage using non-linear processing techniques of wavelet representations for accomplishing contrast enhancement. This was a very difficult imaging problem for dense radiographs of the breast. Laine's innovative method was the first of its kind to show that it was indeed possible for digital mammography to make visible to radiologists, very subtle features within the breast. This method was significant in that it recognized the advantages of translation invariance and over complete presentations for the analysis of medical images.

(2) ***Texture Segmentation***

In the area of image segmentation, contributions are evident in a remarkable (highly cited) paper entitled "*Frame Representations of Texture Segmentation*," A. Laine and J. Fan, IEEE Transactions on Image Processing, Vol. 5, No. 5, pp. 771-780, 1996, Laine used a Hilbert transform as a means of accomplishing envelope detection in a multi-resolution frame. This envelope detection scheme was part of a sophisticated segmentation algorithm which showed precise classification of both natural and synthetic textures with remarkable "super human" performance at the boundaries.

These algorithms have had and continue to have significant impact in the field of medical imaging because most diagnostic protocols rely on quantification of anatomical structures which often exhibit textural characteristics when interacting with certain types of energy such as ultrasound. For example, in an earlier paper entitled "*Speckle Reduction and Contrast Enhancement of Echocardiograms via Multiscale Nonlinear Processing*," X. Zong, A. F. Laine, and E. A. Geiser, IEEE Transactions on Medical Imaging, Vol. 17, No. 4, pp. 532-540, 1998, Laine showed that the clinical performance of cardiologists can be improved by preprocessing with a non-linear operator that adapted to selected spatial-frequency channels. This result is of practical significance in clinical medicine since it can bring the diagnostic performance of a general physician closer to the level of an expert cardiologist.

(3) ***Dynamic Analysis of 4D Cardiac Ultrasound Images***

Laine also made impactful contributions in the area of cardiac ultrasound imaging such as automatic real-time 4D segmentation of the interior volume of the LV taking into account the dynamic shape of the papillary muscle as shown in the paper entitled *LV Volume Quantification via Spatiotemporal Analysis of Real-Time 3-D Echocardiography,* E. D. Angelini, A. F. Laine, S. Takuma, J. W. Holmes, and S. Homma, IEEE Transactions in Medical Imaging., vol. 20, no. 6, pp. 457-469, 2001. This result was previously thought "impossible" by the cardiac imaging community, due to the complex 4D dynamics of motion inside the cardiac chambers of a beating heart.

(4) Unsupervised Machine Learning to discover new COPD subtypes

In the past ten years, Laine has focused his research to machine and deep learning methods application in medical imaging. In 5R01HL121270 (Barr-Laine PIs) our team successfully applied graph-based **unsupervised machine learning** to spatial and visual features of lung parenchyma in HRCT scans, independent of all clinical information, which resulted in the discovery of six new CT quantitative emphysema subtypes, five of which bear marked similarities to the classic but discarded COPD subtypes and three of which had specific genetic associations with biologically plausible genes (paper under review at The Lancet). The current proposal will apply similar graph-based **unsupervised machine learning** to airway trees, to define quantitative trees (**Qutees**) subtypes in the general population.

Full list of publications may be found at: https://hbil.bme.columbia.edu/content/publications

D. Research Support

Ongoing Research Support

NIH 2 R01 HL121270-05 (Co PI's – R.G. Barr, A.F. Laine) 05/01/19 – 4/30/23

“Novel Quantitative Emphysema Subtypes in MESA and SPIROMICS”
This project focuses on the development of key computational tools needed to perform the clinical correlation studies to exploit / leverage CT lung imaging as a new 'microscope' for lung structure examination and will define quantitative emphysema subtypes (QES) for clinical and research use (sLTP).

BioMed-X Translational Technology Accelerator 7/1/19 – 6/30/23
Identify and support via small grants, physician and engineer teams, with biotechnology / medical devices that could develop into commerical exists and / or attract investors or licensing of product technology, leading to improvement of patient outcome and healthcare.
Role: Principal Investigator

Completed Research Support

NIH 1 R01 HL121270 (Co PI’s – R.G. Barr, A.F. Laine) 8/1/14 – 4/30/19
“Novel Quantitative Emphysema Subtypes in MESA and SPIROMICS” *(Renewal scored at 9th percentile)*
This project focuses on the development of key computational tools needed to perform the clinical correlation studies to exploit / leverage CT lung imaging as a new 'microscope' for lung structure examination and will define quantitative emphysema subtypes (QES) for clinical and research use (sLTP).

Coulter Foundation WHCF CU12-0369 11/1/11 – 5/30/19
“Translational Partnership Award”
Identify and support via small grants biotechnology / medical devices that could develop into to attract investors and/or licensing of product technology.
Role: Principal Investigator

Philips Research, N.A. 9/7/13 – 9/6/18
Philips Research, USA, Pol Fellowship Program Award
“Ventilation & Anesthesia: Real-time Clinical Decision Support (CDS) & Closed-Loop Control in ICU”
The project will enhance and augment a CP model by adding more organs and functionality, and by validating and optimizing the computational model. The CP model will be used in the design of high-level closed-loop controllers for ventilator and anesthesia machines, ultimately leading to CDS applications.
Role: Principal Investigator

Philips Research, N.A. 1/1/12 - 12/31/17
Philips Research, USA, Pol Fellowship
“Compressive Sensing in Ultrasound Imaging”
This project aims to develop methods to improve the time required to acquire 4D (3D + time) ultrasound signals by reducing the number of samples required to reconstruct the image in real-time. Applications of this technology would benefit cardiac imaging, imaging in pediatrics, and imaging patients in critical care.
Role: Principal Investigator

R01 EY021470 (PI, R. Smith) 4/1/11 – 3/31/16
“Hyperspectral Imaging of the Normal and Age-Related Macular Degeneration Fundus”
NIH/NEI
The goal of this project is to achieve in vivo molecular/spectral classifications of drusen and assays for important ocular components such as macular pigment with a single snapshot hyperspectral device.
Role: Co-Investigator