

BIOGRAPHICAL SKETCH

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NAME: Shandong Wu, PhD

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

POSITION TITLE: Assistant Professor of Radiology (primary), Biomedical Informatics, Computer Science, Intelligent Systems, Bioengineering, Clinical and Translational Science;
Director, Intelligent Computing for Clinical Imaging (ICCI) Lab; Technical Director for AI Innovations in Radiology.

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
Shanghai University, China	B.S.	9/1994 – 7/1998	Computer Engineering
Shanghai University, China	M.S.	9/2000 – 3/2003	Computer Science
City University of Hong Kong, Hong Kong	Ph.D.	9/2004 – 2/2009	Computer Vision
University of Central Florida, Orlando, FL	Postdoc	4/2009 – 4/2011	Biomedical Imaging and Computer Vision
University of Pennsylvania, Philadelphia, PA	Postdoc	4/2011 – 6/2013	Radiology & Imaging

A. Personal Statement

My background is in Computer Science (Computer Vision) with additional training in radiology and clinical study. My combined education, training, and research experience have placed me in a unique position to conduct cutting-edge cancer imaging research for clinical and translational applications. My joint appointments in multiple disciplines reflect the nature of interdisciplinary research. I founded and direct the Intelligent Computing for Clinical Imaging (ICCI) lab, currently consisting of 16 trainees (3 Postdocs, 4 PhD students, 2 Master students, 4 visiting radiologists/scholars, and 3 research assistants), in addition to 15 associated clinician/physician collaborators. My team possess complementary expertise in computer science, artificial intelligence (AI), radiology, pathology, oncology, surgery, biology, and biostatistics. I also serve as the Technical Director for AI Innovations in Radiology, coordinating our departmental level research efforts in AI. My main research areas include computational biomedical imaging analysis, big (health) data coupled with machine/deep learning, AI in clinical applications and informatics, quantitative imaging-based clinical study, and radiomics/radio-genomics/radio-proteomics. I have been focused on investigating quantitative breast cancer imaging as a biomarker for improving personalized clinical decision-making for screening, risk assessment, diagnosis, prognosis, and treatment. In recent years, my research spectrum continues to expand to other diseases such as liver cancer, brain tumor, prostate cancer, intestinalis, orthopedics, pancreatic cancer, lung cancer, etc. My research is supported by NIH/NCI, RSNA, UPMC Enterprise, Pittsburgh Health Data Alliance, Pittsburgh Foundation, and many internal funding sources. To date, I have published more than 80 journal papers and conference papers/abstracts.

1. Sarah S. Aboutalib, Aly Mohamed, Wendie A. Berg, Margarita L. Zuley, Jules H. Sumkin, **Shandong Wu**, Deep Learning to Distinguish Recalled but Benign Mammography Images in Breast Cancer Screening, Clinical Cancer Research, Oct. 2018, doi: 10.1158/1078-0432.CCR-18-1115. [Epub ahead of print].
2. Aly Mohamed, Wendie A. Berg, H. Peng, Y. Luo, R.C. Jankowitz, **Shandong Wu**, A deep learning method for classifying mammographic breast density categories, Medical Physics, Jan. 2018, 45(1):314-321.
3. **Shandong Wu**, Wendie A. Berg, Margarita L. Zuley, Brenda F. Kurland, Rachel C. Jankowitz, Robert Nishikawa, David Gur, and Jules H. Sumkin, Breast MRI contrast enhancement kinetics of normal parenchyma correlate with presence of breast cancer, Breast Cancer Research, 18(1):76, July 2016.
4. **Shandong Wu**, Susan P. Weinstein, Michael J DeLeo III, Emily F. Conant, Jinbo Chen, Susan M. Domchek,

Despina Kontos, Quantitative assessment of Background Parenchymal Enhancement in breast MRI predicts response to Risk-Reducing Salpingo-Oophorectomy: Preliminary evaluation in a cohort of BRCA1/2 mutation carriers, Breast Cancer Research, 17(1):67-77, May 2015.

B. Positions and Honors

Positions and Employment

9/1998—8/2000	Research Assistant, School of Computer Engineering and Science, Shanghai University
3/2003—8/2004	Lecturer, School of Computer Engineering and Science, Shanghai University, China
4/2009—4/2011	Postdoctoral Associate, Computer Vision Lab, University of Central Florida, FL
4/2011—6/2013	Postdoctoral Researcher, Department of Radiology, University of Pennsylvania, PA
7/2013—6/2015	Research Assistant Professor, Department of Radiology, University of Pittsburgh, PA
7/2015—Present	Assistant Professor (tenure-track), Department of Radiology, University of Pittsburgh, PA
4/2017—Present	Adjunct faculty, Department of Machine Learning, Carnegie Mellon University, Pittsburgh
11/2018- Present	Technical Director for AI Innovations in Radiology, University of Pittsburgh, PA

Professional Services/Appointments

- Core Faculty Member, Biomedical Informatics Training Program, Department of Biomedical Informatics, University of Pittsburgh, PA
- Member, UPMC Hillman Cancer Center and Magee Women's Cancer Research Center, Breast and Ovarian Cancer Program (BOCP)
- RSNA Scientific Program Committee for Breast Imaging
- RSNA R&E Foundation, Fund Development Committee - Corporate Giving Subcommittee
- ECOG (Eastern Cooperative Oncology Group) - ACRIN (American College of Radiology Imaging Network) Cancer Research Group: Radiomics Imaging Committee Member
- SPIE Medical Imaging Conference Technical Committee Member: "Computer-Aided Diagnosis (CAD) Conference" and "Imaging Informatics for Healthcare, Research, and Applications"
- Associate Editor, Journal of Digital Imaging
- Guest Professor, Medical Image Analysis Lab, Suzhou Institute of Biomedical Engineering and Technology, Chinese Academy of Science, China.
- Guest Professor, China Medical University Cancer, China.
- Vice Chairman and Chief Scientist of Experts Panel, Breast Cancer Early Detection, Prevention, and Risk Assessment Committee, Wu Jie-Ping Medical Foundation, China

Invited Grant Reviewers

- NIH/NIBIB, ZEB1 OSR-D (O1) S K (Career Development) Award R13 Reviewer Panel, 2018.
- RSNA Trainee (Residents and Fellows) Research Grant Study Section, 2018.
- International Review Panel Member, Adaptive Oncology Initiative, Ontario Institute for Cancer Research (OICR), Canada, 2018.
- Panel Member, NIH/NCI Division of Extramural Activities. ZCA1 TCRB-V (M2) S, Special Emphasis Panel (R21 and R03), 2018.
- Member, NIH/NCI Division of Translational and Clinical Sciences, Oncology 2 - Translational Clinical IRG (OTC), Cancer Biomarkers (CBSS) Study Section, 2017, 2018.
- Member, NIH/NCI ZRG1 DTCS-A (81) Center for Scientific Review Special Emphasis Panel, study section Clinical and Translational Imaging Applications, 2015, 2016.
- Biomedical Research Programs, Florida Department of Health, 2016, 2017.
- Department of Defense (DoD) Congressionally Directed Medical Research Programs (CDMRP), Breast Cancer Research Program (BCRP), peer review panel member, 2015.
- Breast Cancer Now, the UK's largest breast cancer charity, 2015, 2016, 2017.
- United States-Israel Binational Science Foundation, 2015.
- Netherlands Organisation for Scientific Research, Innovational Research Incentives Scheme, 2014.

Awards and Honors

- My postdoc, Dooman Arefan, received "Student Travel Award for Young Investigators" in the 2018 RSNA Annual Meeting, Chicago, Nov. 2018.

- My PhD student, Kadie Clancy, received the Clinical and Translational Science Predoctoral Trainee Fellowship within the School of Medicine, Department of Medicine (I am her primary advisor).
- My postdoc, Aly Mohamed, received “Student Travel Award for Young Investigators” in the 2017 RSNA Annual Meeting, Chicago, Nov. 2017.
- My postdoc, Sarah Aboutalib, received “Trainee Research Prize” in the 2017 RSNA Annual Meeting, Chicago, Nov. 2017.
- My postdoc, Aly Mohamed, received “New Investigator Travel Award” in the 2017 SIIM (Society for Imaging Informatics in Medicine) Annual Meeting, Pittsburgh, June 2017.
- My MS student, Esmaeel Reza Dadashzadeh, MD, received 2017 Clinical and Human Translational Research Fellowship in Transplantation (I am his Research Mentor).
- Member, Council of Early Career Investigators in Imaging (CECI2) of the Academy of Radiology Research (ARR) and Coalition for Imaging and Bioengineering Research (CIBR), 2015 (Travel Award, 6th annual Medical Technology Showcase by ARR and CIBR, 2015, Washington, D.C.)
- Best Poster Award, Pittsburgh Community Imaging Retreat, October 2013.
- Trainee (Educational) Stipend Award, International Society for Magnetic Resonance in Medicine (ISMRM) Annual Meeting & Exhibition, Salt Lake City, UT, USA, 20-26 April 2013.
- ISMRM Merit Award (magna cum laude), abstract entitled “Effect of Risk-Reducing Salpingo-Oophorectomy on Breast MRI Fibroglandular Tissue and Background Parenchymal Enhancement in BRCA1/2 Mutation Carriers: A Quantitative Assessment” presented in ISMRM 2013.

C. Contribution to Science

1. I have developed automated computerized algorithms for quantitative analysis of breast MRI, mammograms, and digital breast tomosynthesis. In particular, the core functions for breast MRI analysis pipeline include whole-breast segmentation, fibroglandular tissue identification, background parenchymal enhancement (BPE) quantification, kinetic variables calculation on normal parenchyma. This is one of the first integrated computer framework to fully automatically analyze breast MRI scans for the community and have been tested/validated in > 3,000 MRI scans acquired at multiple medical centers.

- a. **Shandong Wu**, Susan P. Weinstein, Emily F. Conant, Mitchell D. Schnall, and Despina Kontos, Automated chest wall line detection for whole-breast segmentation in sagittal breast MR images, Medical Physics, vol. 40, no. 4, pp. 042301-12, Apr. 2013.
- b. **Shandong Wu**, Susan P. Weinstein, Emily F. Conant, and Despina Kontos. Automated fibroglandular tissue segmentation and volumetric density estimation in breast MRI using an atlas-aided fuzzy C-means method. Medical Physics 40(12):122301-12, Dec. 2013.
- c. A. Mohamed, Y. Luo, R.C. Jankowitz, **Shandong Wu**, Understanding clinical mammographic breast density assessment: a deep learning perspective, Journal of Digital Imaging, Aug 2018; 31(4):387-392.
- d. Fan Zhang, **Shandong Wu**, Cheng Zhang, Qian Chen, Xiaodong Yang, Ke Jiang, and Jian Zheng, Multi-domain features for reducing false positives in automated detection of clustered microcalcifications in digital breast tomosynthesis, Medical Physics, Jan 2019. (Accepted)

2. I applied latest AI/deep learning techniques and our automated quantitative algorithms to address significant clinical applications, including reducing false recalls in mammography screening, automated assessment of mammographic breast density, and evaluating quantitative DCE-MRI measures as a response biomarker for risk-reducing interventions (such as salpingo-oophorectomy and steady exercise).

- a. Sarah S. Aboutalib, Aly Mohamed, Wendie A. Berg, Margarita L. Zuley, Jules H. Sumkin, **Shandong Wu**, Deep Learning to Distinguish Recalled but Benign Mammography Images in Breast Cancer Screening, Clinical Cancer Research, Oct. 2018, doi: 10.1158/1078-0432.CCR-18-1115.
- b. A. Mohamed, W. Berg, H. Peng, Y. Luo, R.C. Jankowitz, **Shandong Wu**, A deep learning method for classifying mammographic breast density categories, Medical Physics, 2018 Jan; 45(1):314-321.
- c. **Shandong Wu**, Susan P. Weinstein, Michael J DeLeo III, Emily F. Conant, Jinbo Chen, Susan M. Domchek, Despina Kontos, Quantitative assessment of Background Parenchymal Enhancement in breast MRI predicts response to Risk-Reducing Salpingo-Oophorectomy: Preliminary evaluation in a cohort of BRCA1/2 mutation carriers, Breast Cancer Research, 17(1):67-77, May 2015.
- d. Justin C Brown, Despina Kontos, Mitchell Schnall, **Shandong Wu**, Kathryn H Schmitz. The Dose-Response Effects of Aerobic Exercise on Body Composition and Breast Tissue among Women at

High Risk for Breast Cancer: A Randomized Trial. Cancer Prevention Research, 2016 Jul;9(7):581-8

3. I investigated radiomics approaches to study quantitative breast image measures for assessing breast cancer molecular subtypes, tumor hypoxia factors, heterogeneity of MRI BPE, and kinetics of normal breast tissue.

- a. Wenjuan Ma, Yumei Zhao, Yu Ji, Xinpeng Guo, Xiqi Jian, Peifang Liu, **Shandong Wu**, Breast Cancer Molecular Subtypes Prediction by Mammographic Radiomics Features, Academic Radiology, 2018 Mar 8. pii: S1076-6332(18) 30052-7.
- b. **Shandong Wu**, Wendie A. Berg, Margarita L. Zuley, Brenda F. Kurland, Rachel C. Jankowitz, Robert Nishikawa, David Gur, and Jules H. Sumkin, Breast MRI contrast enhancement kinetics of normal parenchyma correlate with presence of breast cancer, Breast Cancer Research, 18(1):76, July 2016.
- c. **Shandong Wu**, Margarita Zuley, Wendie A. Berg, Brenda F Kurland, Rachel Jankowitz, Jules Sumkin, David Gur, DCE-MRI Background Parenchymal Enhancement Quantified from an Early versus Delayed Post-contrast Sequence: Association with Breast Cancer Presence, Scientific Reports, 7(1):2115, May 2017.
- d. Ruimei Chai, He Ma, Mingjie Xu, Dooman Arefan, Xiaoyu Cui, Yi Liu, Lina Zhang, **Shandong Wu** (co-corresponding author), Ke Xu, Differentiating axillary lymph node metastasis in invasive breast cancer patients: A comparison of radiomic signatures from multiparametric breast MR sequences, Journal of Magnetic Resonance Imaging, 07 March 2019 (in press).

4. In addition to my contributions in breast cancer imaging research, I have extended quantitative imaging research work on other biomedical imaging modalities and organs, including lung CT, cervical MRI, brain MRI, phase-contrast microscopic images, etc.

- a. Ting Luo, Ke Xu, Zheng Zhang, Xin Li, Yan Guo, Lina Zhang, **Shandong Wu**, Radiomic Features from Computed Tomography to Differentiate Invasive Pulmonary Adenocarcinomas from Non-invasive Pulmonary Adenocarcinomas Appearing as Part-solid Ground-Glass Nodules, Chinese Journal of Cancer Research, Dec. 2018 (Accepted)
- b. Xiangsheng Li, **Shandong Wu**, Dechang Li, Tao Yu, Hongxian Zhu, Yunlong Song, Limin Meng, Hongxia Fan, Lizhi Xie, Intravoxel incoherent motion combined with dynamic contrast-enhanced perfusion MRI of early cervical carcinoma: correlations between multi-modal parameters and HIF-1 α expression, Journal of Magnetic Resonance Imaging, Nov. 2018, (Accepted).
- c. **Shandong Wu**, David J. Rippe, Nicholas G. Avgeropoulos, Tumor segmentation in brain MRI by sparse optimization, Proc. SPIE 8669, Medical Imaging 2013: Image Processing, 86691H, March, 2013
- a. Kingsley Osuala, Kathleen Telusma, Saad M. Khan, **Shandong Wu**, Mubarak Shah, Candice Baker, Sabikha Alam, Ibrahim Abukenda, Aura Fuentes, Hani B. Seifein, and Steven N. Ebert, Distinctive left-sided distribution of adrenergic-derived myocytes in the adult mouse heart, PLoS ONE, 6(7), 2011.

5. My research in classic computer vision and machine learning focus on developing advanced algorithms for image/video analysis, motion descriptors, action recognition, and anomaly detection. Of note, this field is heavily driven by conference papers and my work have been published as full papers at most prestigious conferences (i.e., CVPR and ICCV, weighted equivalently to top journals of this area) and extensively cited by my peers.

- a. **Shandong Wu** and Y.F. Li, On Signature Invariants for Effective Motion Trajectory Recognition, The International Journal of Robotics Research, vol. 27, no. 8, pp. 895-917, Aug. 2008.
- b. **Shandong Wu** and Y.F. Li, Flexible Signature Descriptions for Adaptive Motion Trajectory Representation, Perception and Recognition, Pattern Recognition, vol. 42, no. 1, pp. 194-214, 2009.
- c. **Shandong Wu**, Brian E. Moore, and Mubarak Shah, Chaotic Invariants of Lagrangian Particle Trajectories for Anomaly Detection in Crowded Scenes, in Proc. IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2010), San Francisco, CA, USA, June 13-18, 2010.
- d. **Shandong Wu**, Omar Oreifej, Mubarak Shah, Action Recognition in Videos Acquired by a Moving Camera Using Motion Decomposition of Lagrangian Particle Trajectories, in Proc. International Conference on Computer Vision (ICCV2011), Barcelona, Spain, 6-13 Nov. 2011.

6. My research also covers robotic applications such as robot learning from demonstration and visual tracking.

- a. **Shandong Wu** and Y.F. Li, Motion Trajectory Reproduction from Generalized Signature Description, Pattern Recognition, vol. 43, no. 1, pp. 204-221, Jan. 2010.
- b. Yong Wang, Shiqiang Hu, and **Shandong Wu**, Visual tracking based on group sparsity learning, Machine Vision and Applications, volume 26, issue 1, pp 127-139, Jan. 2015.
- c. Yong Wang, Shiqiang Hu, **Shandong Wu**, Object Tracking Based on Huber Loss Function, Visual Computer, May 2018. <https://doi.org/10.1007/s00371-018-1563-1>.

- d. Yong Wang, Wei Shi, **Shandong Wu**, Robust UAV-based Tracking Using Hybrid Classifiers, Machine Vision and Applications, September 15, 2018 (Accepted).

Complete List of Published Work in MyBibliography: (Note that some of my previous works published not in biomedical /health science fields are not available in this list; please also refer to the Google Scholar link).

<http://www.ncbi.nlm.nih.gov/myncbi/browse/collection/46132246/?sort=date&direction=ascending>
<https://scholar.google.com/citations?user=24TkiAkAAAJ&hl=en&oi=ao> (Google Scholar)

D. Research Support

Ongoing

NIH/NCI R01 CA193603 PI: Shandong Wu 7/1/2015 – 6/30/2019

Quantitative assessment of breast MRIs for breast cancer risk prediction

To investigate breast magnetic resonance imaging markers for predicting breast cancer risk on high-risk women.

NIH/NCI R01 Supplement CA193603-03S1 PI: Shandong Wu 1/1/2018 – 6/30/2019

Clinical evaluation of imaging biomarkers to endocrine therapy of breast cancer

To evaluate breast imaging biomarkers for predicting endocrine therapy responsiveness.

NIH/NCI R01 CA218405 PI: Shandong Wu 06/01/2018 – 05/31/2022

Deep interpretation of mammographic images in breast cancer screening

To study deep learning techniques for breast cancer risk prediction and reducing false recalls

UPMC Enterprise/Pittsburgh Health Data Alliance PI: Shandong Wu 11/01/2018 – 10/31/2019

PI-Predictor for breast cancer recurrence risk prediction

To evaluate standard-of-care clinical data and machine learning for predicting breast cancer recurrence risk

Completed

RSNA Research Scholar Grant RSCH1530 PI: Shandong Wu 7/1/2015 – 6/30/2018

Breast DCE-MRI contrast enhancement heterogeneity and breast cancer risk

To quantify dynamic contrast enhancement patterns and heterogeneity for breast cancer risk assessment.

University of Pittsburgh Physicians (UPP) Foundation PI: Shandong Wu 10/01/2017 – 09/30/2018

Evaluation of Quantitative Measures from Diffusion Weighted Breast MRI as Risk Biomarkers

To investigate breast cancer risk biomarkers in diffusion-weighted MR images.

UPMC Competitive Medical Research Funding (CMRF) PI: Shandong Wu 7/15/2014 – 6/14/2016

ROC analysis on the Claus model by incorporating enhancement of breast parenchyma

To evaluate effects of combining quantitative imaging measures with clinical risk factors of the Claus model.

NIH/NIBIB R21 EB015053 PI: R. Nishikawa 7/1/2013 – 6/30/2014

Quantitative Evaluation of Reconstruction Algorithms

To develop a metric to quantify CT image quality based on image features.

Role: Co-Investigator

NIH/NCI R01 CA143019 PI: J. Sumkin 12/1/2009 - 11/30/2014

Digital Breast Tomosynthesis (DBT) in a Screening Environment: a Prospective Study

To confirm in a prospective study the demonstrated potential for a significant decrease in recall rates using DBT.

Role: Faculty/Support person

NIH/NCI R01 CA163300 PI: C. Hakim 3/6/2012 – 1/8/2014

DBT Use in Repeat Breast Screening Examinations: a Performance Assessment Study

To assess the possible benefits of DBT when a prior examination was available to the interpreter.

Role: Faculty/Support person

NIH/NCI R21 CA144055 PI: M. Zuley 7/1/2010 – 6/30/2014

Dose Reduction and Performance Enhancement During DBT Screening

To determine the dose reduction in DBT by using a synthetic FFDM.

Role: Faculty/Support person