Debdoot Sheet

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Personal Statement

My research is focused on understanding the physics of imaging and leveraging machine learning algorithms to characterize tissues using physics based models of energy-tissue interaction thus, laying foundations of *in situ* functional histology. In due course of my research, I have investigated behaviour of ultrasonic and optical imaging signals interacting with different types of tissues, both in normal and pathological or diseased states. These have led to development of patient comfort centric non-invasive solutions for *in situ* histology of atherosclerotic vascular plaques, breast lesion and skin, and white light angiography for eye. Currently, I am working on developing deep and transfer learning techniques for analyzing multimodal imaging signals to achieve *in situ* functional histology.

Education

PhD, School of Medical Science and Technology   Oct. 2010 - Mar. 2014
Indian Institute of Technology Kharagpur, WB, India
- **Major:** Computational Medical Imaging and Image Computing
- **Thesis:** Computation Modelling of Tissue Energy Interaction in Acoustic and Optical Imaging for *In situ* Diagnostic Histopathology

MS, School of Medical Science and Technology   July 2008 - Aug. 2010
Indian Institute of Technology Kharagpur, WB, India
- **Major:** Computer Vision and Pattern Recognition in Medicine
- **Thesis:** Feature Usability Index

B. Tech, Electronics and Communication Engineering   July 2004 - May 2008
West Bengal University of Technology, Kolkata, India
- **Major:** Electronics and Communication Engineering
- **Thesis:** RFID System Design and Application

Positions

Indian Institute of Technology Kharagpur, Department of Electrical Engineering
- Assistant Professor   Jul. 2014 – Present

SkinCurate Research Private Limited
- Founder and Managing Director   Feb. 2014 - Present

IEEE
- Regional Editor, IEEE Pulse   Feb. 2014 - Present
- Editor-in-Chief, IEEE Technology in Engineering Education   Feb. 2014 - Present

Technical University of Munich, Computer Aided Medical Procedures / Informatics
- Visiting Scientist (Host: Prof. Dr. Nassir Navab, Sponsor: DAAD)   Oct. 2011 - Sept. 2012

Indian Institute of Technology Kharagpur, School of Medical Science and Technology
- Senior Research Fellow (Host: Prof. Jyotirmoy Chatterjee)   Jan. 2013 – Dec. 2013
- Research Consultant (Host: Prof. Jyotirmoy Chatterjee)   Oct. 2012 - Dec. 2012
- Senior Scientific Officer (Host: Prof. Jyotirmoy Chatterjee)   Sept. 2010 - May 2011
- Senior Project Assistant (Host: Prof. Ajoy K. Ray)   Jul. 2008 - Aug. 2010

Research Areas

- **Image and multidimensional signal processing:** Stochastic noise models in medical imaging, image denoising, artefact removal, bilateral filtering, non-local means, fuzzy statistics, vector order statistics, computer graphics and visualization, shape models, image registration, compositing, camera and sensor calibration.
- **Machine learning:** Transfer and ensemble learning for discriminative pattern segmentation, classification, regression in high-dimensional, large, sparsely or approximately labelled data; learning with parallel computing and CPU-GPU handshaking.
- **Physics of medical imaging:** Statistical physics of ultrasonics, optical coherence tomography, multispectral optical microscopy, ophthalmoscopy, x-ray mammography.

Collaborations

TU Munich, Germany; Columbia University, New York, USA; UZ Brussels, Belgium; Medical College and Hospitals Kolkata; Samsung; Texas Instruments; i2i TeleSolutions and TeleMedicine; i2Sense

Awards

- GE Edison Challenge 2013 (Dec. 2013), (Award ₹ 10,00,000)
- Young Scientist Travel Grant (Apr. 2013), DST, Govt. of India (Award ₹ 1,96,000)
- Fraunhofer Applications Award (Oct. 2012), Indo-German Grand Science Slam.
- IEEE Computer Society 2012 Richard E. Merwin Student Scholarship (Award $ 1,250).
- Sandwich Model PhD Scholarship (2011-2012), DAAD (Award € 18,000).

Grant Writing Experiences

- Computational modelling of ultrasonic backscattering statistical physics for in situ tissue characterization. (Multi-institutional research project) Investigators: Amin Katouzian, Nassir Navab (TU Munich), Debdoot Sheet, Jyotirmoy Chatterjee, Ajoy Kumar Ray (IIT Kharagpur). Sponsor: Samsung Advanced Institute of Technology through the Samsung GRO Award 2013. Grant awarded: US$ 100,080
- Skin lesion diagnosis with in situ imaging and characterization through learning of multispectral signatures for augmentation of clinical Insight in effective rural healthcare delivery. Investigators: Debdoot Sheet, Kausik Basak, Sri Phani Krishna Karri, Tamoghna Ojha. Sponsor: GE through the GE Edison Challenge 2013. Grant awarded: INR 10,00,000

Other Professional Contributions

- Reviewer for Journals, Transactions and Magazines
  - IEEE Trans. Medical Imaging (2013)
  - IEEE Trans. Image Processing (2011)
  - IEEE J. Biomedical and Health Informatics (2014)
  - IET Image Processing (2010)
  - Computer Methods and Programs in Biomedicine (2014)
  - Neurocomputing (2011)
  - IEEE Technology in Engineering Education (2010)
  - IEEE Potentials (2009)
- Technical Program Committee Chair, IEEE TechSym (2011, 2014)
- Publications Chair, IEEE TechSym (2010)
- Steering Committee Member, IEEE TechSym (2010, 2011, 2014)
- Coordinator, IIT Kharagpur ML Reading Group (2013), VACP (2011), PEER (2010)

List of Publications

Journal

Published

[1] **Sheet D**, Karamalis A, Eslami A, Noel PB, Chatterjee J, Ray AK, Laine AF, Carlier SG, Navab N, Katouzian A, "Joint learning of ultrasonic backscattering statistical physics and signal confidence primal for characterizing atherosclerotic plaques using intravascular ultrasound", *Medical Image Analysis*, vol. 18, no. 1, pp. 103-117, 2014. (Impact factor: 4.662)

[2] **Sheet D**, Karamalis A, Eslami A, Noel PB, Virmani R, Nakano M, Chatterjee J, Ray AK, Laine AF, Carlier SG, Navab N, Katouzian A, "Hunting for necrosis in the shadows of intravascular ultrasound", *Computerized Medical Imaging and Graphics*, vol. 38, no. 2, pp. 104-112, 2014. (Impact factor: 1.954)

[3] **Sheet D**, Chaudhary A, Karri SPK, Das D, Katouzian A, Banerjee P, Navab N, Chatterjee J, Ray AK, "*In situ* histology of mice skin through transfer learning of tissue energy interaction in optical coherence tomography", *J. Biomed. Optics*, vol. 18, no. 9, pp. 090503-1-3, 2013. (Impact factor: 3.145)

[4] Katouzian A, Karamalis A, **Sheet D**, Konofagou E, Baseri B, Carlier SG, Eslami A, Koenig A, Navab N, Laine AF, "Iterative self-organizing atherosclerotic tissue labeling in intravascular ultrasound images and comparison with virtual histology", *IEEE Trans. Biomed. Engg.*, vol. 59, no. 11, pp. 3039-3049, 2012. (Impact factor: 2.525)

[5] Garud HT, **Sheet D**, Mahadevappa M, Chatterjee J, Ray AK and Ghosh A, "Breast fine needle aspiration cytology practices and commonly perceived diagnostic significance of cytological features: a pan-India survey", *J. Cytology*, vol. 29, no. 3, pp. 183-189, 2012. (Impact factor: 0.333)

[6] Thakur G, Mitra A, Basak A, **Sheet D**, "Characterization and scanning electron microscopic investigation of cross linked freeze dried gelatin matrices for study of drug diffusivity and release kinetics", *Micron*, vol. 43, no. 2, pp. 311-320, 2012. (Impact factor: 1.912)

[7] **Sheet D**, Chatterjee J and Garud H, "Feature usability index and optimal feature subset selection", *Int. J. Comp. Appl.*, vol. 12, no. 2, pp. 29-32, 2010. (Impact factor: 0.821)

[8] **Sheet D**, Garud H, Suveer A, Chatterjee J and Mahadevappa M, "Brightness preserving dynamic fuzzy histogram equalization", *IEEE Trans., Consumer Electronics*, vol. 56, no. 4, pp. 2475 – 2480, 2010. (Impact factor: 1.092)

Patents

[1] Method and apparatus for enhancing representations of micro-calcifications in a digital mammogram image (2012), Garud H, **Sheet D**, Suveer A, Mahadevappa M, Ray AK, *US Patent*, Pub. no. US2012/0087565 A1, Pub. on 12 Apr. 2012.

[2] Method and system for determining skinline in digital mammogram images (2011), Garud H, Ray AK, Kargallu AG, **Sheet D**, *US Patent*, Pub. no. US 2011/0200238 A1, Pub. on 18 Aug. 2011.

[3] Digital microscopy equipment with image acquisition, image analysis and network communication (2011), Garud H, **Sheet D**, Chatterjee J, Mahadevappa M, Ray AK, *US Patent*, Pub. no. US 2011/0122242 A1, Pub. on 26 May 2011.

[4] Method and system for analyzing breast carcinoma using microscopic image analysis of fine needle aspirates (2010), Garud H, Mitra B, **Sheet D**, Maity PP, Ray AK, Chatterjee J, Chakraborty C, Ghosh A, Banerjee P, *US Patent*, Pub. no. US 2010/0111397 A1, Pub. on 6 May 2010.

[5] System and methods for characterizing tissues in intravascular ultrasound using statistical physics (2013), Laine AF, Katouzian A, **Sheet D**, Karamalis A, *US Patent Application* 68,355, Applied on 15 March 2013.

[6] Intelligent implanted health sensing device and assembly (2012), Katouzian A, Navab N, **Sheet D**, Karamalis A, Hennersperger C, *European Patent Application*, (Invention disclosure submitted on 20 July 2012).

[7] Methods and system for characterizing tissues in optical coherence tomography (2013), **Sheet D**, Chaudhary A, Chatterjee J, Ray AK, Katouzian A, *Indian Patent Application*, (Invention disclosure submitted on 19 June 2013).

[8] Adaptive weighted local difference order statistics filter (2013), Garud H, **Sheet D**, Madadevappa M, Chatterjee J, Ray AK, *US Patent Application*, (Invention disclosure submitted on 5 August 2013).

Book

[1] **Sheet D**, Chatterjee J and Ray AK, *Feature Usability Index,* Lambert Academic Publishing, Germany, 2011.

Book Chapters

[1] Garud H, **Sheet D**, Chatterjee J, Mahadevappa M, Ray AK and Ghosh A, "Computer Vision Theoretic Approach for Breast Cancer Diagnosis: Commonly Perceived Diagnostic Significance of Cytological Features and Feature Usability Analysis of an Existing Breast Cancer Database", In: *Multimodality Breast Imaging: Diagnosis and Treatment*, (Ng EYK, Acharya UR, Rangayyan RM, Suri JS, Eds.) , SPIE, Ch. 13, March 2013.

Magazine Articles

[1] **Sheet D**, "Electronic Dice using AT89C2051", *Electronics for You*, 105, 2010.

Conference (Archived full papers)

[1] Learning Scale-space Representation of Nucleus for Accurate Localization and Segmentation of Epithelial Squamous Nuclei in Cervical Smears (2014), Karri SPK, Garud H, **Sheet D**, Ray AK, Chatterjee J, Mahadevappa M, *Proc. Int. Conf. Biomed., Health Informatics (BHI)*, 772-775.

[2] Transfer Learning of Tissue Photon Interaction in Optical Coherence Tomography towards In vivo Histology of the Oral Mucosa (2014), **Sheet D**, Banerjee S, Karri SPK, Bag S, Anura A, Giri A, Paul RR, Pal M, Sarkar BC, Ghosh R, Katouzian A, Navab N, Ray AK, *Proc. Int. Symp. Biomed. Imaging (ISBI)*.

[3] A Generalized Framework for Stain Separation in Digital Pathology Applications (2014), Ghosh B, Conjeti S, Karri SPK, **Sheet D**, Garud H, Ghosh A, Chatterjee J and Ray AK, *Proc. SPIE Medical Imaging: Digital Pathology.*

[4] Enhancing effective depth-of-field using spectra-specific wavelets based multi-focus image fusion for digital pathology applications (2014), Conjeti S, Ghosh B, Karri SPK, **Sheet D**, Garud H, Chatterjee J and Ray AK, *Proc. SPIE Medical Imaging: Digital Pathology.*

[5] Detection of retinal vessels in fundus images through transfer learning of tissue specific photon interaction statistical physics (2013), **Sheet D**, Karri SPK, Conjeti S, Ghosh S, Chatterjee J and Ray AK, *Proc. Int. Symp. Biomedical Imaging (ISBI).*

[6] Random forest learning of ultrasonic statistical physics and object spaces for lesion detection in 2D sonomammography (2013), **Sheet D**, Karamalis A, Kraft S, Noel PB, Vag T, Sadhu A, Katouzian A, Navab N, Chatterjee J and Ray AK, *Proc. SPIE Medical Imaging: Ultrasonic Imaging, Tomography, and Therapy*, (Bosch JG, Doyley MM, Eds), 8675, 867515-1-8.

[7] Introducing nuclei scatter patterns into histology based intravascular ultrasound simulation framework (2013), Kraft S, Karamalis A, **Sheet D**, Noel PB, Drecoll E, Navab N, Katouzian A, *Proc. SPIE Medical Imaging: Ultrasonic Imaging, Tomography, and Therapy*, (Bosch JG, Doyley MM, Eds), 8675, 86750Y-1-6.

[8] Brightness preserving contrast enhancement in digital pathology (2011), Garud H, **Sheet D**, Suveer A, Karri SPK, Ray AK, Mahadevappa M, Chatterjee J, *Proc. Int. Conf. Image Information Processing*, 1-5.

[9] Volume visualization approach for depth-of-field extension in digital pathology (2011), Garud H, Ray AK, Mandal S, **Sheet D**, Mahadevappa M, Chatterjee J, *Proc. 4th Int. Conf. Image and Signal Processing*, 335-339.

[10] Comparative evaluation of speckle reduction algorithms in optical coherence tomography (2010), Pal S, **Sheet D**, Chakraborty A, Chatterjee J, *IEEE India Ann. Conf.*, 1-4.

[11] Visual importance pooling for image quality assessment of despeckle filters in optical coherence tomography (2010), **Sheet D**, Pal S, Chakraborty A, Chatterjee J, Ray AK, *Int. Conf. Sys. Med. Biol.*, 102-107.

[12] Evaluation of p63 expression in oral sub-mucous fibrosis (2010), Das RK, Venkatraghavan V, **Sheet D**, Chakraborty C, Ray AK, Chatterjee J, Pal M, Paul RR, Int. Conf. Sys. Med. Biol., 166-171.

[13] Image quality assessment for performance evaluation of despeckle filters in optical coherence tomography of human skin (2010), **Sheet D**, Pal S, Chakraborty A, Chatterjee J, Ray AK, *Proc. IEEE EMBS Conf. Biomedical Engineering and Sciences*, 499-504.

[14] Statistical tools for evaluating classification efficacy of feature extraction techniques (2010), **Sheet D**, Venkatraghavan V, Suveer A, Garud H, Chatterjee J, Mahadevappa M, Ray AK, *Proc. 2nd Int. Conf. Digital Image Processing*, SPIE, 7546, 75461B-1-8.

[15] An Electroencephalogram Signal based Triggering Circuit for controlling Hand Grasp in Neuroprosthetics (2009), Karthikeyan G, **Sheet D**, Manjunatha M, *Proc. 13th Int. Conf. Biomedical Engineering*, 691-693.

[16] Voice Filtering over a Wideband Stereophonic Audio Signal (2008), **Sheet D**, *Proc. Nat. Conf. VLSI and Comm.*, 24-28.

[17] RFID based Airport Logistics Management (2008), Datta T, **Sheet D**, Si AK, Biswas SD, Ghosh D, *Proc. 3rd Inn. Conf. on Embedded Systems, Mobile Communication & Computing*, 228-232.

[18] Realization and simulation of the hardware for RFID system and its performance study (2007), **Sheet D**, Kumar A, Dutta A, Dasgupta S, Datta T, Sarkar SK, *Proc. Int. Conf. Information and Communication Technology in Electrical Sciences*, 697-700.

Conference Abstracts:

[19] Learning of Tissue Photon Interaction in Laser Speckle Contrast Imaging for Label-free Retinal Angiography (2014), Basak K, **Sheet D**, Karri SPK, Mahadevappa M, Chatterjee J, Dutta PK, *Int. Symp. Biomedical Imaging (ISBI).*

[20] Deep Learnt Random Forests for Segmentation of Retinal Layers in Optical Coherence Tomography Images (2014), Karri SPK, **Sheet D**, Guha Mazumder A, Ghosh S, Chakraborty D, Chatterjee J, Ray AK, *Int. Symp. Biomedical Imaging (ISBI).*

[21] Computational Histology of Retina through Transfer Learning of Tissue Photon Interaction in Optical Coherence Tomography (2014), Karri SPK, **Sheet D**, Guha Mazumder A, Ghosh S, Chakraborty D, Chatterjee J, Ray AK, *Int. Symp. Biomedical Imaging (ISBI).*

[22] Enhancing effective depth-of-field using spectra-specific wavelet based multi-focus image fusion for digital pathology applications (2013), Conjeti S, Ghosh B, Karri SPK, **Sheet D**, Chatterjee J, *Microscopy Conference MC 2013*, Regensburg, Germany.

[23] Automated Characterization of Pap Stained Cervical Smears Using Physics of Brightfield Microscopy Optics (2013), Karri SPK, Garud H, **Sheet D**, Malviya R, Das L, Ray AK, Chatterjee J, Chakraborty D, Mahadevappa M, *Int. Symp. Biomedical Imaging (ISBI).*

[24] Method and System for Segmentation of Clustered Nuclei in Microscopic Images of Breast Fine Needle Aspiration Cytology Smears (2013), Garud H, Karri SPK, **Sheet D**, Ray AK, Mahadevappa M, Chatterjee J, *Int. Symp. Biomedical Imaging (ISBI).*

[25] Activity Estimation and Lineage Construction of Cells in Densely Populated Colonies Using Numerical Method Based Greedy Search (2013), Karri SPK, **Sheet D**, Garud H, Chaudhary A, Ray AK, Chatterjee J, Chakraborty D, Mahadevappa M, *Int. Symp. Biomedical Imaging (ISBI).*

[26] Ambiguity detection of necrosis in IVUS (2012), Katouzian A, **Sheet D**, Eslami A, Karamalis A, Koenig A, Carlier SG, Navab N, *An. Conf. Eur. Soc. Cardiol. (ESCardio).*

[27] Machine learning of ultrasonic statistical physics primal for tissue characterization in intravascular ultrasound (2012), **Sheet D**, Karamalis A, Navab N, Laine AF, Chatterjee J, Ray AK, Carlier SG, Katouzian A, *An. Conf. IEEE Engg. Med. Biol. Soc. (EMBC)*.

[28] A Biomimetic Computer Vision System for Navigating a Visually Impaired Person (2009), Kumar A, Mandal S, **Sheet D**, Mahadevappa M, Chatterjee J, Mukhopadhyay J, Ray AK, *Int. Symp. Emerging Areas in Biotechnology & Bioengineering*.

PhD Thesis

Computational Modelling of Tissue Energy Interaction in Acoustic and Optical Imaging for *In situ* Diagnostic Histopathology

Soft tissues like skin, fat, muscles and blood vessels experience benign and malignant tumors, excess deposition of extracellular matrix, cellular hyperplasia and hypoplasia, and are medically termed as lesions. In diagnostics, a small quantity of tissue is collected from the lesion as biopsy or through aspiration, followed by evaluation by an expert Pathologist. This invasive procedure involves patient discomfort and results in 48-72 hours of delay in reporting. Moreover, this practice is not feasible for critical organs, eyes, coronary vessels and healing wounds.

In this thesis a set of multidimensional signal and image processing algorithms are proposed and evaluated for *in situ* diagnostic histopathology in real time using non-destructive subsurface imaging. The rational was to develop an analytically converging solution to a set of statistical physics equations to model tissue-energy interaction in acoustic and optical imaging using a transfer learning framework.

In acoustic imaging ultrasonic propagation and backscattering in heterogeneous tissues are modelled and used to characterize tissues. In intravascular ultrasound (IVUS) a model for uncompressed signals identifies fibrous tissue, calcified, lipidic plaque and necrosis at sensitivity of 97%, 99%, 99% and 96% respectively with specificity above 80%. In B-mode ultrasonic imaging, the model identifies BIRADS Cat 2,3,4,5 lesions at 100%, 100%, 100% and 95% detection rates respectively with classification rates in area under ROC of 0.99, 0.99, 0.98 and 0.87.

The photon-tissue interaction for non-ballistic and ballistic photons was modelled in ophthalmic imaging and optical coherence tomography (OCT). Retinal vessels are detected at an accuracy of 98% and ground truth consensus at kappa score of 0.83. Epidermis, papillary dermis, dermis and adipose tissue in healthy and wound tissue in mice skin was identified at sensitivity of 99%, 95%, 99% and 99% respectively using swept source OCT.