Kharagpur Learning, Imaging and Visualization (KLIV) Research Group

Department of Electrical Engineering

Indian Institute of Technology Kharagpur, India

2017

Sponsors and Collaborators

intel

सत्यमेव जयते
Department of Biotechnology Govt. of India

NVIDIA
GPU EDUCATION CENTER

TUM
Technische Universität München

Columbia University in the City of New York

Johns Hopkins Whiting School of Engineering

University of Southampton

LMU Ludwig-Maximilians-Universität München

UMONS Université de Mons

Otto von Guericke Universität Magdeburg

DAAD
Deutscher Akademischer Austauschdienst
German Academic Exchange Service

Group Leader

Debdoot Sheet, *PhD*
Assistant Professor, Department of Electrical Engineering
Indian Institute of Technology Kharagpur
EMAIL: debdoot@ee.iitkgp.ernet.in
WEB: www.facweb.iitkgp.ernet.in/∼debdoot/
PHONE: +91 3222 283082

We currently focus on understanding artificial intelligence and developing deep neural networks for visual computing including medical image analysis and surgical informatics.

Dr. Sheet's research interest include computational medical imaging, machine learning, image and multidimensional signal processing, surgical analytics and informatics, visualization and augmented reality technology design. He received the Ph. D. degree from the Indian Institute of Technology Kharagpur in 2014 for studies in ultrasonic and optical imaging and machine learning for developing *in situ* histopathology. He is a former DAAD fellow and was a visiting scholar at the Technical University of Munich during 2011-12. He is a member of IEEE, ACM, IUPRAI, SPIE, and BMESI and serves as an Editor of IEEE Pulse since 2014.

Research Group Members

 Abhijit Guha Roy

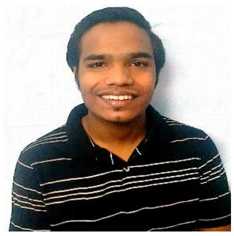
 Kausik Das

 Niladri Garai

 Debarghya China

 Rachana Sathish

 Aupendu Kar

 Ram Nagar

 Akshit Mantri

 Srichandra Chilappagari

 Francis Tom

 Abhinav Agarwal

 Aarushi Agrawal

Research Group Members

Oindrila Saha

Shaswat Datta

Abhishek Pal

Shubh Agrawal

Neha Banerjee

Nikhil Naik

Himanshu Chaud-hary

Prashant Yadav

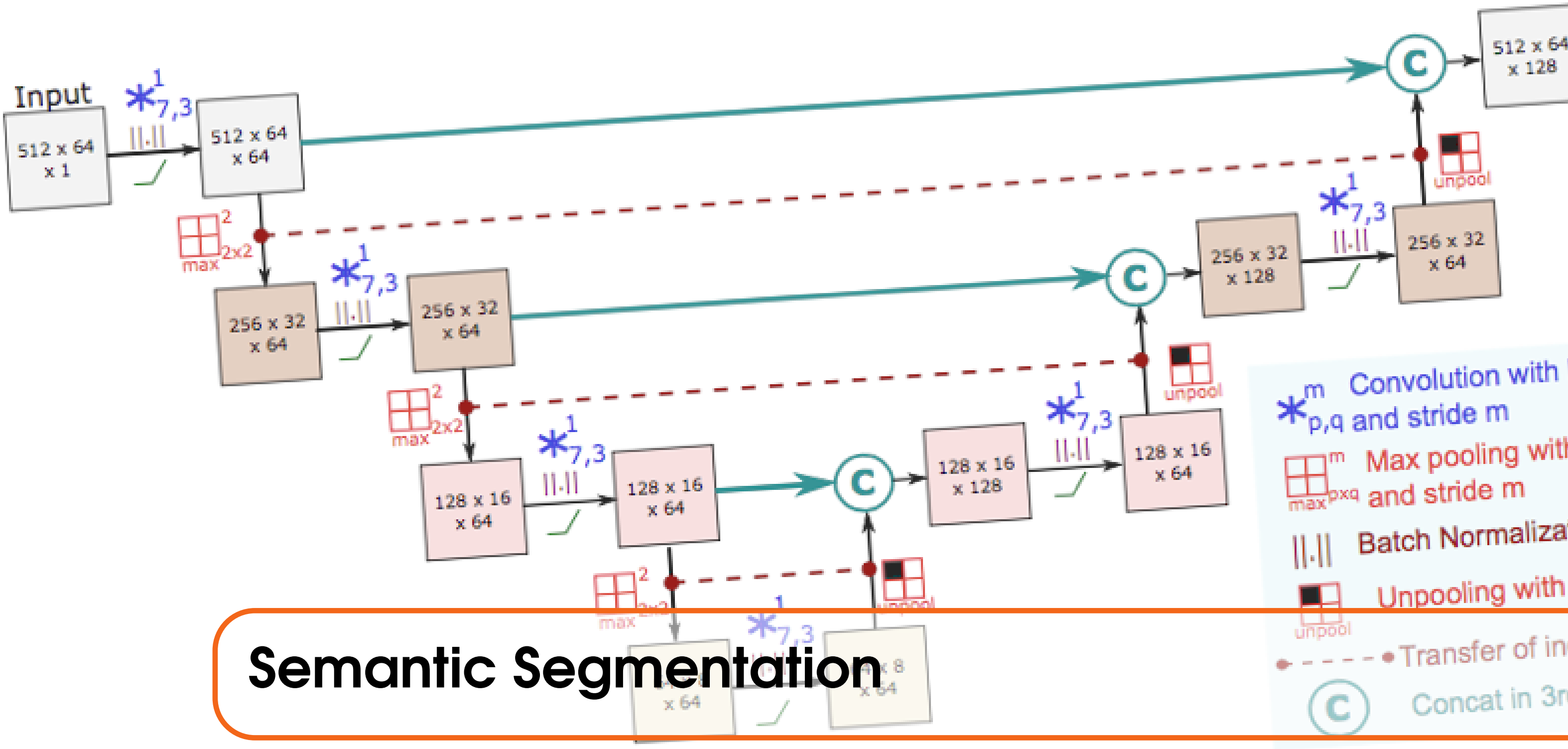
Abhishek Mohap-atra

Inderpreet Kaur

Generative Models for Simulating Ultrasound

Ultrasound imaging makes use of backscattering of waves during their interaction with scatterers present in biological tissues. Simulation of synthetic ultrasound images is a challenging problem on account of inability to completely model various factors of which some include intra-/inter scanline interference, transducer to surface coupling, artifacts on transducer elements, inhomogeneous shadowing and nonlinear attenuation. While various approaches to ultrasound simulation has been developed, approaches that produce patho-realistic images typically solve wave space equations making it computationally expensive and slow to operate. We propose a generative adversarial network (GAN) inspired approach for fast simulation of patho-realistic ultrasound images. We apply the framework to intravascular ultrasound (IVUS) simulation. We demonstrate that the network generates realistic appearing images evaluated with a visual Turing test indicating an equivocal confusion in discriminating simulated from real. We also quantify the shift in tissue specific intensity distributions of the real and simulated images to prove their similarity.

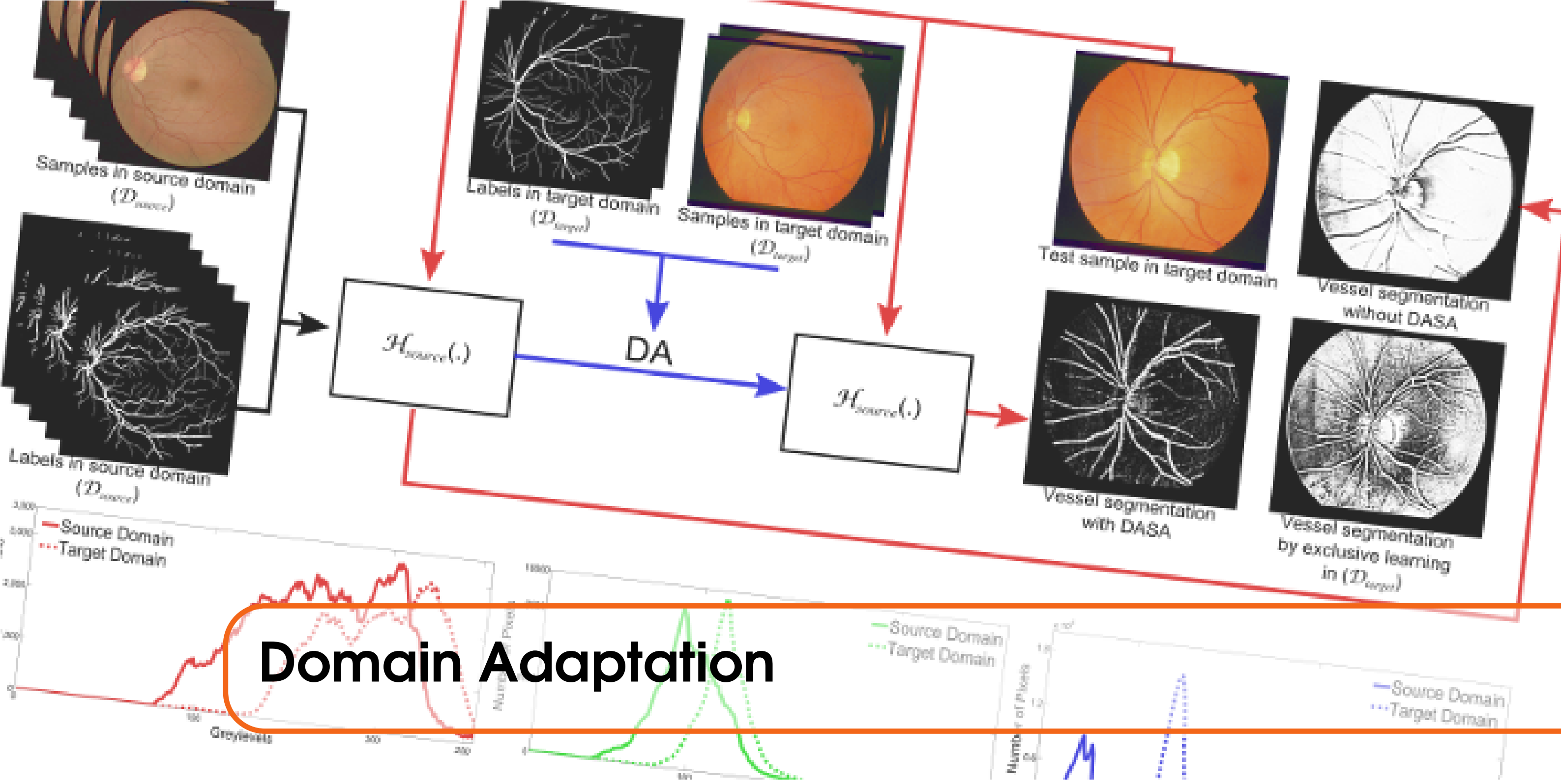
Tom F, Sheet D, "Simulating Patho-realistic Ultrasound Images using Deep Generative Networks with Adversarial Learning", *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, 2018. [`https://arxiv.org/abs/1712.07881`]



Semantic Segmentation

Optical coherence tomography (OCT) is used for non-invasive diagnosis of diabetic macular edema assessing the retinal layers. In this paper, we propose a new fully convolutional deep architecture, termed ReLayNet, for end-to-end segmentation of retinal layers and fluid masses in eye OCT scans. ReLayNet uses a contracting path of convolutional blocks (encoders) to learn a hierarchy of contextual features, followed by an expansive path of convolutional blocks (decoders) for semantic segmentation. ReLayNet is trained to optimize a joint loss function comprising of weighted logistic regression and Dice overlap loss. The framework is validated on a publicly available benchmark dataset with comparisons against five state-of-the-art segmentation methods including two deep learning based approaches to substantiate its effectiveness.

Guha Roy A, Conjeti S, Karri SPK, Sheet D, Katouzian A, Wachinger C, Navab N, "ReLayNet: retinal layer and fluid segmentation of macular optical coherence tomography using fully convolutional networks", *Biomedical Optics Express*, vol. 8, no. 8., pp. 3627-3642, 2017.

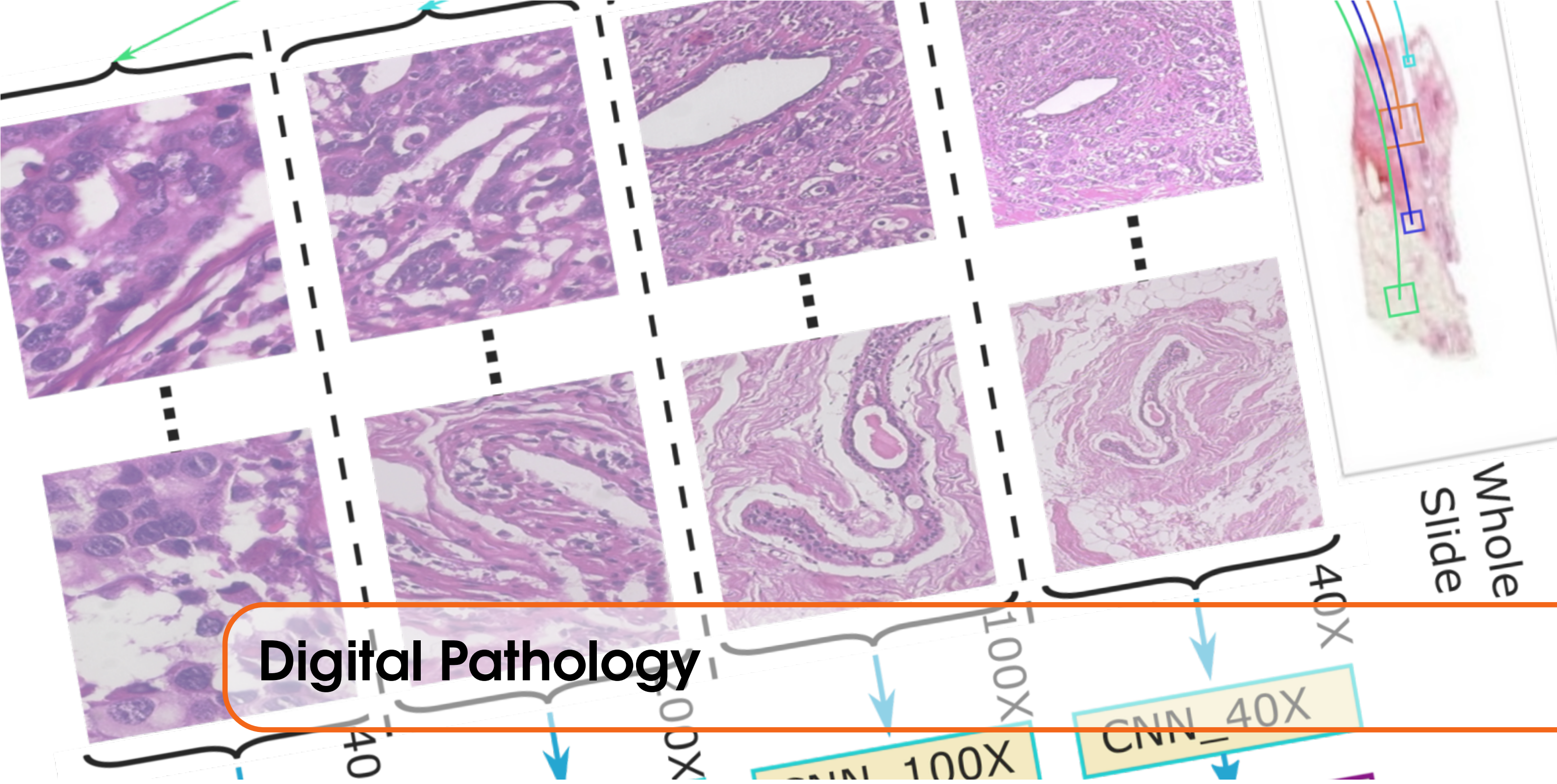


Domain Adaptation

Domain adaptation deals with adapting behaviour of machine learning based systems trained using samples in source domain to their deployment in target domain where the statistics of samples in both domains are dissimilar. The task of directly training or adapting a learner in the target domain is challenged by lack of abundant labeled samples. In this paper we propose a technique for domain adaptation in stacked autoencoder (SAE) based deep neural networks (DNN) performed in two stages: (i) unsupervised weight adaptation using systematic dropouts in mini-batch training, (ii) supervised fine-tuning with limited number of labeled samples in target domain. We experimentally evaluate performance in the problem of retinal vessel segmentation where the SAE-DNN is trained using large number of la- beled samples in the source domain (DRIVE dataset) and adapted using less number of labeled samples in target domain (STARE dataset).

Guha Roy A, Sheet D, “DASA: Domain Adaptation in Stacked Autoencoders using Systematic Dropout”, *Proc. 3rd Asian Conference on Pattern Recognition (ACPR)*, pp. 735-739, 2015.

Conjeti S, Katouzian A, Guha Roy A, Peter L, Sheet D, Carlier S, Laine A, Navab N, “Supervised domain adaptation of decision forests: Transfer of models trained in vitro for in vivo intravascular ultrasound tissue characterization”, *Medical Image Analysis*, vol. 32, no. 1, pp. 1-17, 2016.

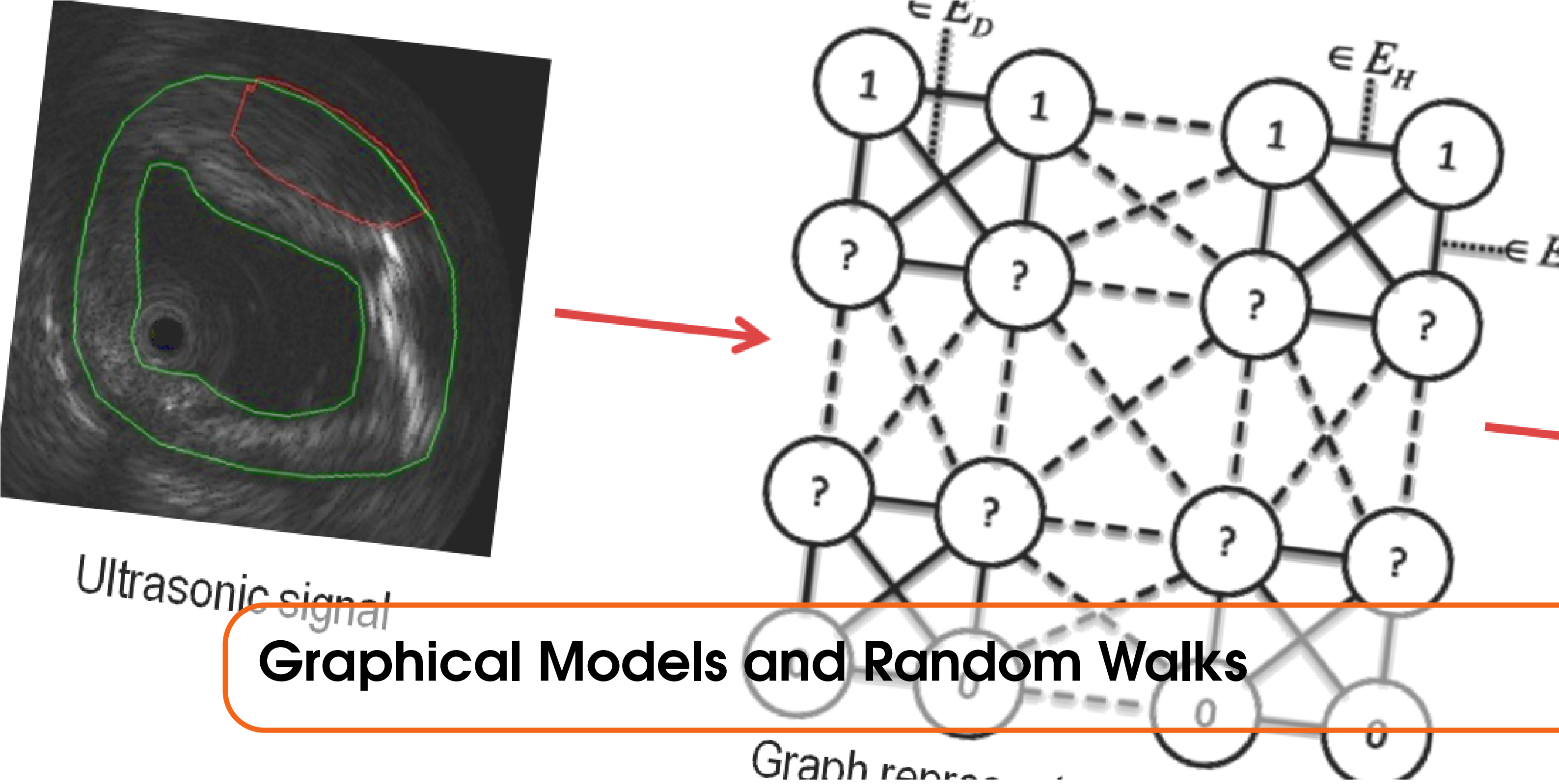


Digital Pathology

Histopathology forms the gold standard for confirmed diagnosis of a suspicious hyperplasia being benign or malignant and for its sub-typing. While techniques like whole-slide imaging have enabled computer assisted analysis for exhaustive reporting of the tissue section, it has also given rise to the big-data deluge and the time complexity associated with processing GBs of image data acquired over multiple magnifications. We propose a deep convolutional neural network (CNN) based solution, where we analyse images from random number of regions of the tissue section at multiple magnifications without any necessity of view correspondence across magnifications.

Das K, Conjeti S, Guha Roy A, Chatterjee J, Sheet D, “Multiple Instance Learning of Deep Convolutional Neural Networks for Breast Histopathology Whole Slide Classification”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, 2018.

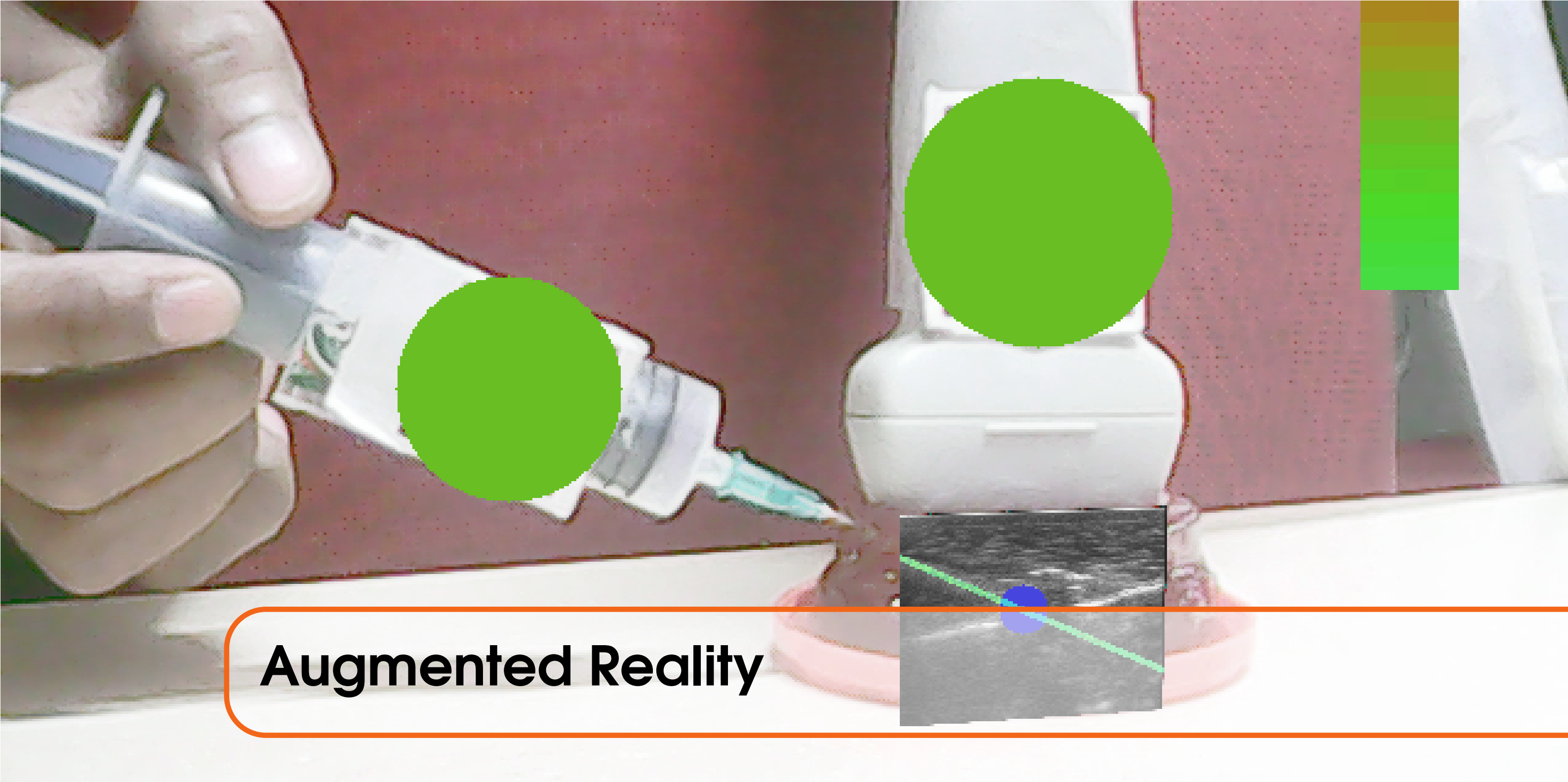
Das K, Karri SPK, Guha Roy A, Chatterjee J, Sheet D, “Classifying Histopathology Whole-Slides using Fusion of Decisions from Deep Convolutional Network on a Collection of Random Multi-views at Multi-magnifications”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, pp. 1024-1027, 2017.



Graphical Models and Random Walks

Intravascular ultrasound (IVUS) is commonly used to adjunct imaging based diagnosis of vascular plaques. Since speckle intensity in IVUS images are inherently stochastic in nature, clinicians critically face the challenge of identifying vessel boundaries. In this chapter we present a method for segmenting the lumen and external elastic laminae in IVUS images of coronary arteries via. a two stage framework. The first stage employs understanding of physics of ultrasound-tissue interaction as a statistical mechanical parametric framework and ensemble learning of this parametric space to initialize lumen and external elastic luminae boundary contour. Subsequently in the second stage these initialized contours are solved using a random walker solver. While both the stages are employed while segmenting individual IVUS frames, in case of complete pullbacks, the two stages are employed only on the first frame and only the second stage is employed on subsequent neighbouring frames using initialization propagated as belief from the previously segmented frame.

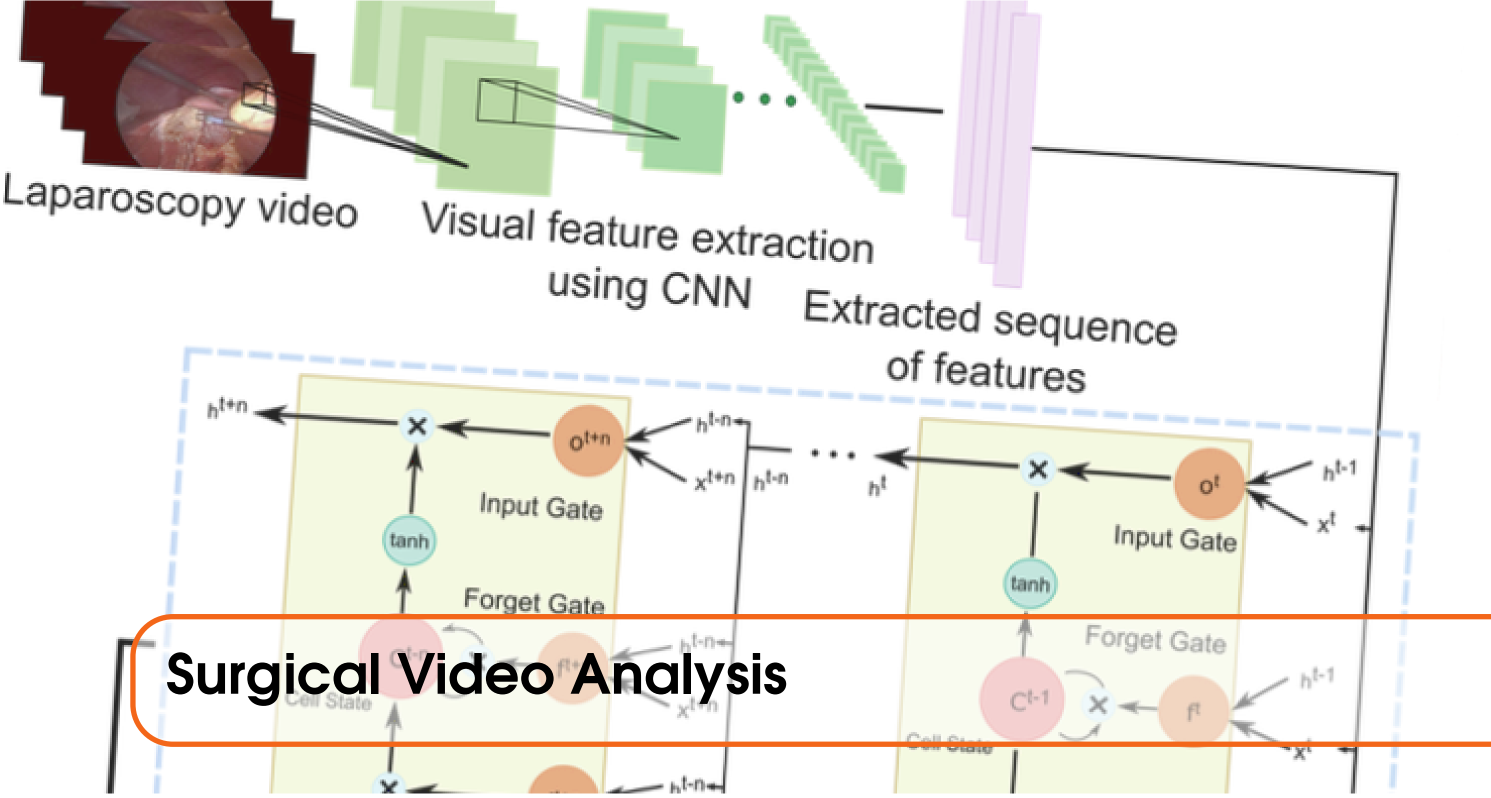
China D, Mitra P, Sheet D, “Segmentation of Lumen and External Elastic Laminae in Intravascular Ultrasound Images using Ultrasonic Backscattering Physics Initialized Multiscale Random Walks”, *Proc. MedImage Workshop - 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, 2016.



Augmented Reality

Ultrasound (US) guided intervention is a surgical procedure where the clinician makes use of imaging in realtime, to track the position of the needle, and correct its trajectory for accurately steering it to the lesion of interest. However, the needle is visible in the US image, only when aligned in-plane with the scanning plane of the US probe. Our present work details an augmented reality (AR) system for patient comfort centric aid to needle intervention through an overlaid visualization of the needle trajectory on the US frame prior to its insertion. This is implemented by continuous visual tracking of the US probe and the needle in 3D world coordinate system using fiducial markers. The tracked marker positions are used to draw the needle trajectory and tip visualized in realtime to augment on the US feed. Subsequently, the continuously tracked US probe and needle, and the navigation assistance information, would be overlaid with the visual feed from a head mounted display (HMD) for generating totally immersive AR experience for the clinician.

Kanithi PK, Chatterjee J, Sheet D, “Immersive augmented reality system for assisting needle positioning during ultrasound guided intervention”, *Proc. 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, ACM, pp. 65-1-6, 2016.



Surgical Video Analysis

Surgical workflow in minimally invasive interventions like laparoscopy can be modeled with the aid of tool usage information. The video stream available during surgery primarily for viewing the surgical site using an endoscope can be leveraged for this purpose without the need for additional sensors or instruments. We propose a method which learns to detect the tool presence in laparoscopy videos by leveraging the temporal connectionist information in a systematically executed surgical procedures by learning the long and short order relationships between higher abstractions of the spatial visual features extracted from the surgical video. We propose a framework consisting of using Convolutional Neural Networks for extracting the visual features and Long Short Term Memory network to encode the temporal information.

Mishra K, Sathish R, Sheet D, "Learning Latent Temporal Connectionism of Deep Residual Visual Abstractions for Identifying Surgical Tools in Laparoscopy Procedures", *Proc. 30th IEEE/CVF Conf. Comp. Vis., Patt. Recog. (CVPR) W. Deep-Vision*, pp. 58-65, 2017.

Mishra K, Sathish R, Sheet D, "Tracking of Retinal Microsurgery Tools using Late Fusion of Responses from Convolutional Neural Network over Pyramidally Decomposed Frames", *Proc. MedImage Workshop - 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, 2016.

Alumni

2017

M. Tech

- Kaustuv Mishra
  Learning Temporal Connectionism of Visual Abstractions using Deep Neural Architectures for Monitoring of Minimally Invasive Surgical Interventions towards Workflow Modelling
  Keshab K. Parhi Endowment Award

B. Tech

- Arna Ghosh
  Deep Semantic Architectures for Mitotic Figure Detection in Breast Histopathology Images
  Institute Silver Medal and Systems Society Best Thesis Award
- Rahul Singh
  Deep Neural Networks for Predicting Driving States of a Vehicle towards Achieving Autonomous Driving
  Best Thesis Award in Electrical Engineering
- Satyarth Singh
  Combined Stereo Imaging System and Deep Learning Architecture for 3D Surface Profilometry of Cutaneous Wounds and their Diagnosis
- Suryateja Chanduru
  Deep Visual Semantic Architectures for Localization and Identification of Road Traffic Signs towards Autonomous Driving Assistance
- Roshan Pati
  Deep Neural Networks for Simultaneously Localizing Fishes and Recognizing their Species in Underwater Videos

- Mayank Gupta
  Computational Neuroaesthetics of Fashionability

2016

M. Tech

- Rachana Sathish
  Learning of Image Saliency for Visual Media Retargeting to Smarten-up Photo Framing
- Kanithi Praveen Kumar
  Augmented Reality System for Assisting Needle Positioning During Ultrasound Guided Intervention
- Praveen Kumar
  Smartphone based Immersive Mixed Reality System for Interctive Medical Visualizations
- Ratala Lalitha
  Organ Segmentation in Whole Body CT Volumes for Generating Digital Anatomy

B. Tech

- D'Souza Shimona Niharika John
  Self Taught Learning Based Optical Fluorescence Microscopy Image Deblurring using Stacked Denoising Auto-encoders
- Avi Gupta
  Deep Architectures for Optical Coherence Tomographic Images using Convolutional Neural Network
- Dadi Venkata Sainath
  Deep Architectures for Photo Acoustic Tomography Image Analysis
- Prabhath Yeluri
  Super-resolution Dermatoscopy with a Consumer Grade Camera using Aperture Mask Based Sub-pixel Translated Images
- Pradeepta Das
  Deep Learning Based Computed Super-resolution Optical Microscopy
- Gagan Goel
  Methods for Reducing Deployment Complexity of Fully Connected Deep Neural Network with Application to Retinal Vessel Segmentation

2015

M. Tech

- Anshuman Y. Pradhan
  Learning Texture Dictionaries using Deep Learning

B. Tech

- Akanksha Kumari
  Building Detection in SAR Images
- Ankit Bathwal
  Learning Texture Kernels to Discriminate Chromatin Density in Optical Microscopic Histology

- Siddam Sai Rachana Patel
  Learning Representations for Optic Disc Segmentation in Retinal Images
- Rupesh Bansal
  Learning Kernels for Tubular Structure Extraction in Speckle Imaging
- Vankudothu Rahul
  Learning Kernels for White Light Retinal Angiography
- Chintada Chaitanya Chandra
  Learning Representations for Image Segmentation in Optical Microscopic Histology

Publications

2018

1. Tom F, Sheet D, “Simulating Patho-realistic Ultrasound Images using Deep Generative Networks with Adversarial Learning”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, 2018. [`https://arxiv.org/abs/1712.07881`]
2. Das K, Conjeti S, Guha Roy A, Chatterjee J, Sheet D, “Multiple Instance Learning of Deep Convolutional Neural Networks for Breast Histopathology Whole Slide Classification”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, 2018.
3. China D, Mitra P, Sheet D, “On the Fly Segmentation of Intravascular Ultrasound Images Powered by Learning of Backscattering Physics”, In: *Classification in BioApps*, Springer, pp. 351-380, 2018.

2017

1. Guha Roy A, Conjeti S, Karri SPK, Sheet D, Katouzian A, Wachinger C, Navab N, “ReLayNet: retinal layer and fluid segmentation of macular optical coherence tomography using fully convolutional networks”, *Biomedical Optics Express*, vol. 8, no. 8., pp. 3627-3642, 2017.
2. Conjeti S, Guha Roy A, Sheet D, Carlier S, Sayeda-Mahmood T, Navab N, Katouzian A, “Domain Adapted Model for In Vivo Intravascular Ultrasound Tissue Characterization”, In: *Computing and Visualization for Intravascular Imaging and Computer Assisted Stenting*, (Balocco S, Zualaga MA, Zahnd G, Lee S, Demirci S Eds.), Academic Press – Elsevier, Ch. 7, 2017.
3. Guha Roy A, Conjeti S, Sheet D, Katouzian A, Navab N, Wachinger C, “Error Corrective Boosting for Learning Fully Convolutional Networks with Limited Data”, *Proc. Med. Image Comput., Comp. Assist. Interv. (MICCAI)*, 2017.
4. Mishra K, Sathish R, Sheet D, “Learning Latent Temporal Connectionism of Deep Residual Visual Abstractions for Identifying Surgical Tools in Laparoscopy Procedures”, *Proc. 30th IEEE/CVF Conference on Computer Vision and Pattern Recog-*

nition (CVPR) Workshop on Deep-Vision: Deep Learning in Computer Vision - Temporal Deep Learning, pp. 58-65, 2017.

5. Garud H, Karri SPK, Sheet D, Ghosh A, Maity AK, Mahadevappa M, Chatterjee J, Ray AK, "High-magnification Multi-views Based Classification of Breast Fine Needle Aspiration Cytology Cell Samples using Fusion of Decisions from Deep Convolutional Networks", *Proc. 30th IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshop on Computer Vision for Microscopy Image Analysis*, pp. 76-81, 2017.
6. Das K, Karri SPK, Guha Roy A, Chatterjee J, Sheet D, "Classifying Histopathology Whole-Slides using Fusion of Decisions from Deep Convolutional Network on a Collection of Random Multi-views at Multi-magnifications", *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, pp. 1024-1027, 2017.

2016

1. Conjeti S, Katouzian A, Guha Roy A, Peter L, Sheet D, Carlier S, Laine A, Navab N, "Supervised domain adaptation of decision forests: Transfer of models trained in vitro for in vivo intravascular ultrasound tissue characterization", *Medical Image Analysis*, vol. 32, no. 1, pp. 1-17, 2016.
2. Banerjee S, Chatterjee S, Anura A, Chakrabarty J, Pal M, Ghosh B, Paul RR, Sheet D, Chatterjee J, "Global Spectral and Local Molecular Connects for Optical Coherence Tomography Features to Classify Oral Lesions towards Unravelling Quantitative Imaging Biomarkers", *RSC Advances*, vol. 6, no. 9, pp. 7511-7520, 2016.
3. Basak K, Dey G, Mahadevappa M, Mandal M, Sheet D, Dutta PK, "Learning of speckle statistics for in vivo and noninvasive characterization of cutaneous wound regions using laser speckle contrast imaging", *Microvascular Research*, vol. 107, pp. 6 – 16, 2016.
4. Guha Roy A, Conjeti S, Carlier S, Dutta PK, Kastrati A, Laine AF, Navab N, Katouzian A, Sheet D, "Lumen Segmentation in Intravascular Optical Coherence Tomography using Backscattering Tracked and Initialized Random Walks", *IEEE Journal of Biomedical and Health Informatics*, vol. 20, no. 2, pp. 606 - 614, 2016.
5. Kanithi PK, Chatterjee J, Sheet D, "Immersive augmented reality system for assisting needle positioning during ultrasound guided intervention", *Proc. 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, ACM, pp. 65-1-6, 2016.
6. Sharma MK, Sarkar S, Sheet D, Biswas PK, "Limitations with measuring performance of techniques for abnormality localization in surveillance video and how to overcome them?", *Proc. 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, ACM, pp. 75-1-6, 2016.
7. China D, Mitra P, Sheet D, "Segmentation of Lumen and External Elastic Laminae in Intravascular Ultrasound Images using Ultrasonic Backscattering Physics Initialized Multiscale Random Walks", *Proc. MedImage Workshop - 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, 2016.
8. Garud HT, Karri SPK, Ghosh A, Sheet D, Chatterjee J, Mahadevappa M, Ray AK, "Methods and System for Segmented of Isolated Nuclei in Microscopic Images of Breast Fine Needle Aspiration Cytology Images", *Proc. MedImage Workshop - 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, 2016.
9. Mishra K, Sathish R, Sheet D, "Tracking of Retinal Microsurgery Tools using Late Fusion of Responses from Convolutional Neural Network over Pyramidally Decom-

posed Frames”, *Proc. MedImage Workshop - 10th Indian Conf. Comp. Vis., Graph., Image Process (ICVGIP)*, 2016.

10. Lahiri A, Guha Roy A, Sheet D, Biswas PK, “Deep Neural Ensemble for Retinal Vessel Segmentation in Fundus Images towards Achieving Label-free Angiography”, *Proc. 38th Ann. Int. Conf. of the IEEE Engineering in Medicine and Biology Society (EMBC)*, pp. 1340-1343, 2016.
11. Sharma M, Sheet D and Biswas PK, “Abnormality Detecting Deep Belief Network”, *Proc. Int. Conf. Adv., Inf. Comm. Tech., Computing*, pp. 11-1-4, 2016.
12. Guha Roy A, Conjeti S, Carlier SG, Houissa K, König A, Kastrati A, Dutta PK, Laine AF, Navab N, Katouzian A and Sheet D, “Multiscale Distribution Preserving Autoencoders for Plaque Detection in Intravascular Optical Coherence Tomography”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, pp. 1359-1362, 2016.
13. Das K, Guha Roy A, Chatterjee J and Sheet D, “Landscaping of Random Forests through Controlled Deforestation”, *Proc. 22nd Nat. Conf. Comm. (NCC)*, pp. 1-5, 2016.

2015

1. Chaudhary A, Bag S, Mandal M, Karri SPK, Barui A, Rajput M, Banerjee P, Sheet D, Chatterjee J, "Modulating prime molecular expressions and in vitro wound healing rate in keratinocyte (HaCaT) population under characteristic honey dilutions", *Journal of Ethnopharmacology*, vol. 166, pp. 211-219 2015.
2. Guha Roy A, Sheet D, “DASA: Domain Adaptation in Stacked Autoencoders using Systematic Dropout”, *Proc. 3rd Asian Conference on Pattern Recognition (ACPR)*, pp. 735-739, 2015.
3. Maji D, Santara A, Ghosh S, Sheet D, Mitra P, “Deep Neural Network and Random Forest Hybrid Architecture for Learning to Detect Retinal Vessels in Fundus Images”, *Proc. 37th Ann. Int. Conf. of the IEEE Engineering in Medicine and Biology Society (EMBC)*, pp. 3029-3032, 2015.
4. Basak K, Dey G, Sheet D, Mahadevappa M, Mandal M, Dutta PK, “Probabilistic Graphical Modeling of Speckle Statistics in Laser Speckle Contrast Imaging for Noninvasive and Label-Free Retinal Angiography”, *Proc. 37th Ann. Int. Conf. of the IEEE Engineering in Medicine and Biology Society (EMBC)*, pp. 6244-6247, 2015.
5. Sheet D, Karri SPK, Katouzian A, Navab N, Ray AK, Chatterjee J, “Deep Learning of Tissue Specific Speckle Representations in Optical Coherence Tomography and Deeper Exploration for in situ Histology”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, pp. 777-780, 2015.
6. Guha Roy A, Conjeti S, Carlier SG, König A, Kastrati A, Dutta PK, Laine AF, Navab N, Sheet D, Katouzian A, “ Bag of Forests for Modelling of Tissue Energy Interaction in Optical Coherence Tomography for Atherosclerotic Plaque Susceptibility Assessment”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, pp. 428-431, 2015.
7. Conjeti S, Yigitsoy M, Peng T, Sheet D, Chatterjee J, Bayer C, Navab N, Katouzian A, “Deformable Registration of Immunofluorescence and Histology Using Iterative Cross-Modal Propagation”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, pp. 601-604, 2015.
8. Conjeti S, Yigitsoy M, Sheet D, Chatterjee J, Navab N, Katouzian A, “Mutually Coherent Structural Representation for Image Registration through Joint Manifold

Embedding and Alignment”, *Proc. IEEE Int. Symp. on Biomedical Imaging (ISBI)*, pp. 310-313, 2015.

Awards and Laurels

2017

- Rachana Sathish
  Winner
  for Technical Poster presentation at Grace Hopper Celebration India 2017, Bangalore.
- Kaustuv Mishra
  Keshab K. Parhi Endowment Award
  for best demonstrable M. Tech thesis across EE, EC and CS departments.
- Arna Ghosh
  Institute Silver Medal at 63rd Convocation
  for securing the highest GPA in the 2017 graduating batch of B.Tech. from Department of Electrical Engineering.
- Arna Ghosh
  Systems Society Award
  for the best B. Tech thesis across EE, IE and ES programs in related theme related.
- Rahul Singh
  Best B. Tech Thesis Award in Electrical Engineering
- Abhijit Guha Roy
  Intel India PhD Fellowship 2016

2016

- Debdoot Sheet
  Distinguished Young Alumni Award
  by the Institute of Engineering and Management, Kolkata.
- Abhijit Guha Roy
  DAAD Sandwich Model PhD Scholarship for the year 2016-17
  for undertaking part of PhD work at the Technical University of Munich.
- Niladri Garai

Shastri Research Student Fellowship (SRSF) for the year 2015-16
by the Shastri Indo-Canadian Institute and the Ministry of Human Resource Development (MHRD), India.

2015

- Abhijit Guha Roy
  Institute Silver Medal at 61st Convocation
  for securing the highest GPA in the 2015 graduating batch of M.Tech. from Department of Electrical Engineering.

We are looking foward to hire Post Doctoral Fellows and PhD candidates in the areas of:

- Deep learning
- Information theory
- Graphical models
- Generative models
- Reinforcement learning
- Visualization and augmented reality
- Video analytics and action recognition
- Visual hashing on large image databases

Send in your CV to debdoot@ee.iitkgp.ernet.in

PUBLISHED BY KLIV

WWW.IITKLIV.GITHUB.IO

Printed at Kharagpur, India in December 2017