Mousumi Roy

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Research Interests

Deep learning, Image Processing, Computer Vision and its application in Biomedical Imaging specifically in Digital Pathology for Object Detection, Segmentation, 3D Volume Reconstruction.

Education

◇ **Stony Brook University**, Stony Brook, NY, USA 2017-2021 expected
Ph.D. candidate, Department of Computer Science GPA: **3.95/4**
Advisers: *Prof. Fusheng Wang*
Thesis Topic: Histopathology Image Analysis: from 2D Segmentation to 3D Registration

◇ **University of Hyderabad**, India July 2014
M.Tech., School of Computer and Information Sciences **GPA: 3.76/4**
Rank: **1st**, **Gold Medalist**
Thesis Topic: A Study of Fuel Air Explosive (FAE) Cloud Dynamics - Image Processing Approach

◇ **Institute of Engineering and Management**, Kolkata, India July 2009
B.Tech., Department of Computer Science and Engineering GPA: **3.42/4**
Thesis Topic: Building Air traffic control system using genetic algorithm techniques

Publications & Research Experience

◇ **Research Assistant**, BMI DB Lab, Stony Brook University Jan. 2017 to Present

- **Mousumi Roy**, Fusheng Wang, George Teodoro, Ritu Aneja and Jun Kong. **"Deep Learning Based Registration of Serial Whole-slide Histopathology Images in Different Stains."** (under submission)

  To register 2D serial sections from multiple stains (e.g., H&E and IHC), we propose a novel translation based registration network CycGANRegNet using deep learning, which requires no prior deformation field information for training. We first generate synthetic IHC slides from H&E slides through a robust image synthesis algorithm. The synthetic IHC images and the real IHC images are then registered through a Fully Convolutional Network with multi-scale deformable vector fields and a joint loss optimization for enhancing image alignment. We perform the registration at original image resolution with a patch-wide approach, thus tissue details at the highest resolution are retained in the results. CycGANRegNet outperforms both the state-of-the-art conventional and deep learning-based registration methods.

- **Mousumi Roy**, Fusheng Wang and Jun Kong. **"Deep Learning based Registration Model for Immunohistochemistry Histopathology Images: HistoRegNet."** (under submission)

  We propose HistoRegNet, an end-to-end unsupervised patch-based deep learning registration model to spatially align IHC histopathology images. The model consists of an affine and a deformable module that learns the Displacement Vector Field by both affine and deformable transformation optimization. The learned DVF is provided to a spatial transformer network that generates registered images. Experimental results demonstrate the superior performance of our proposed model to other methods, suggesting its promising potential for IHC histopathology image registration.

- **Mousumi Roy**, et al."**Deep-learning-based accurate hepatic steatosis quantification for histological assessment of liver biopsies."** Laboratory Investigation 100, no. 10 (2020): 1367-1383.

  We develop a deep learning-based region-boundary integration network for delineating overlapped steatosis droplets of liver biopsies. We propose an integrated approach with a region-based module using dilated UNet to segment the foreground steatosis droplet, a boundary module with HNN to learn the perceptual boundary features for each overlapped steatosis region, and integration of the two modules to train a third deep neural network FCN for dividing overlapped steatosis droplets. The resulting steatosis measures both at the pixel level and object level present strong correlation with pathologist annotations, radiology readouts and clinical data.

- **Mousumi Roy**, Jun Kong, Satyananda Kashyap, Vito Paolo Pastore, Fusheng Wang, Ken C. L. Wong & Vandana Mukherjee. **"Convolutional autoencoder based model HistoCAE for segmentation of viable tumor regions in liver whole-slide images."** Scientific Reports 11, no. 1 (2021): 1-10.

  The detection and evaluation of viable tumor regions in hepatocellular carcinoma present an important clinical significance for assessing chemoradiotherapy response. We present a multi-resolution convolutional autoencoder based model HistoCAE for viable tumor segmentation with a customized reconstruction loss function, followed by a classification module to classify each image patch. The resulting patch-based prediction results are spatially combined to generate the final segmentation results. Our proposed model presents superior performance to other benchmark models with extensive experiments.

- **Mousumi Roy**, et al. **"Segmentation of Overlapped Steatosis in Whole-Slide Liver Histopathology Microscopy Images."** In 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 810-813. IEEE, 2018. (Poster presentation at EMBC Hawaii)

  We developed a new image analysis method to segregate clumped steatosis in whole-slide liver images by extracting individual whole tissue piece at high resolution with minimum background area. This is followed by segmentation and segregation of steatosis regions with high curvature point detection and an ellipse fitting quality assessment method. The experimental results suggest that our method is promising for enhanced support of steatosis quantization during the pathology review for liver disease treatment.

- **Mousumi Roy**, et al. **"Analysis of Cellular Feature Differences of Astrocytomas with Distinct Mutational Profiles Using Digitized Histopathology Images."** In 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 4644-4647. IEEE, 2018. (Oral talk at EMBC Hawaii)

  We propose a self-reliant and efficient analysis framework for quantitative analysis of cellular phenotypic difference across distinct molecular groups. Representative cell instances that are phenotypically different between two groups are retrieved after segmentation, feature computation, data pruning, dimensionality reduction and unsupervised clustering. Our analysis is generic and applicable to a wide set of cell-based bio-medical research.

- Pengyue Zhang, Fusheng Wang, George Teodoro, Yanhui Liang, **Mousumi Roy**, Daniel Brat, Jun Kong. **"Effective Nuclei Segmentation with Sparse Shape Prior and Dynamic Occlusion Constraint for Glioblastoma Pathology Images."** Journal of Medical Imaging, 6(1), 017502.

  We propose a segmentation method for nuclei in glioblastoma histopathologic images based on a sparse shape prior guided variational level set framework. By spectral clustering and sparse coding, a set of shape priors is exploited to accommodate complicated shape variations. Our method is applied to several whole-slide histopathologic image datasets for nuclei segmentation. The proposed method is compared with other state-of-the-art methods and demonstrates good accuracy for nuclei detection and segmentation, suggesting its promise to support biomedical image-based investigations.

- **"Deep Learning based Necrotic Region Segmentation in Whole-slide Histopathology Images with TCGA, IVYGlioblastoma and Norway Datasets."**

  The mortality rate due to brain cancer is the highest in the Asian continent according to WHO report. Glioblastoma (GBM) are malignant Grade IV tumors an aggressive type of cancer. Since cancer diagnosis is high invasive, expensive and time consuming, it is essential to develop a non-invasive, cost-effective and efficient tools for brain cancer characterization and grade estimation. In this study we propose a Recurrent Residual Unet based segmentation framework with multi-resolution feature for semantic regions segmentation such as necrosis, tumor, stroma etc. in Whole-slide histopathology images of breast cancer(Norway) and brain tumor data(TCGA and IVYGlioblastoma). The quantitative and qualitative results suggest the superior performance of our proposed model compared to the state-of-the-art deep learning segmentation models.

- **"Attributes of aromatase expressing cells in breast tumors: morphology and expression level density in tumor and non-tumor cells."**

  In this study immunohistochemistry (ISH) stained breast cancer images are used for feature difference analysis of Aromatase expressing positive vs negative tumor cells. First, we separate H and DAB color channels followed by segmenting tumor regions in each small image patch. Once we have segmented tumor regions in H channel, the existence of corresponding instances in DAB color channel can be used to find the Aromatase expression positive vs negative tumor cells. We used various supervised, and semi supervised deep learning-based models for tumor regions (isolated or clumped with weak separating borders) segmentation along with their performance comparison.

◇ **Research Assistant**, SCIS, University of Hyderabad, India July 2012 to June 2014

Mousumi Roy, Apparao Allam, Arun Agarwal, Rajeev Wankar, and Raghavendra Rao Chillarige. **"Image processing tool for FAE cloud dynamics."** In International Workshop on Multi-disciplinary Trends in Artificial Intelligence, pp. 69-80. Springer, Cham, 2014. (Oral talk at MIWAI Bangalore)

We demonstrated the understanding of cloud dynamics through image processing approach by analyzing video frames. The methodology involves selection of intensity band(HPF), cloud ROI extraction followed by cloud dimensions estimation and empirical model development to characterize the cloud dynamics. The developed model is found to be in good agreement with the reported model in literature.

Work Experience

- **Research Summer Intern: Machine Learning**, **IBM Research - Almaden**, San Jose, USA Jun 2019 - August 2019
  Developed fully convolutional autoencoder based segmentation model for viable tumor regions in liver cancer histopathology images.
- **Software Engineer**, VJ Technologies, NY, USA Nov 2016 - Dec 2016
  Developed algorithm to detect objects using MATROX imaging library.
  Built custom form in C# for image analysis.
- **Graduate Student**, Indian Institute of Technology, Bombay, India 2014 - 2015
  Performed image reconstruction for sparsely acquired frequency-domain image data.
  Implemented a Bayesian framework to de-noise ultrasound images.
- **Assistant System Engineer**, Tata Consultancy Services, Chennai, India 2009-2011
  Worked on a data warehousing project for maintaining client data.
  Used SQL, PL/SQL in TOAD environment to analyze data.

Honors & Awards

- **Graduate Assistance in Areas of National Need (GAANN) Fellowship Award** 2019-2020
- **Grace Hopper Celebration (GHC) 2019 Student Scholar** April 2019
- **Finalist** of **2019 NCWIT Collegiate Award** April 2019
- **Association for Pathology Informatics**:
  Pathology Informatics Summit 2019 Travel Award, Pittsburgh, 05/06/2019-05/09/2019
- **Travel Awards:** ACM Richard Tapia Celebration of Diversity in Computing 2019, CRA-W Grad Cohort for Women 2019, IEEE EMBC 2018
- **Excellent student** award of University of Hyderabad October 2014
- **SBH Gold Medalist** for securing **1st** rank in M.Tech. program 2012-2014
- Merit certificate & National Prize winner for rank 50 (among 10K participants) in school final 2003

Technical Skills

- **Programming:** Python, C, C++, R, SQL, PL/SQL, Matlab
- **Python Data/ML Libraries:** OpenCV, Machine Learning, Deep Learning, Numpy, Pandas, Scipy, Scikit-learn, Tensorflow, Keras, PyTorch
- **Web development:** HTML, Flask, D3
- **OS:** Linux, MacOS, Windows

Teaching Assistant

- **Stony Brook University**
  Computer Game programming & Introduction to Computational and Algorithmic Thinking 2017
- **IIT Bombay**
  Data Structure & Discrete Mathematics (Undergraduate) 2015

Activities

- Poster presenter: **Grace Hopper Celebration 2019**, **TAPIA Conference 2019**, **Pathology Informatics Summit 2019**, **Grad Cohort for Women 2019**
- **Reviewer:** BigSpatial 2018, DAPD Journal, SIGSPATIAL, PAKDD, IEEE BigData, eScience2021, Scientific Reports, ISBI
- **Member:** ACM, IEEE
- Recruit and mentor graduate students and high school students for K12 summer research projects **CSIRE** at Stony Brook University, 2017-18, 2022
- **Mentor** of Graduate Women in Science and Engineering (GWiSE) at Stony Brook University

Coursework

* Computer Vision * Artificial Intelligence * Data Visualization * Theory of Database System