

Balaji Iyer (PhD ABD Candidate)

Artificial Intelligence | Machine Learning | Data Science

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Summary

Data scientist and software developer with 10+ years of experience in applied DL, ML, and statistical modeling. As a founding research student of the lab, pioneered projects across multiple domains of biology and medicine ranging from genomics to neuroscience. Contributed towards 12 projects, resulting in 12 technical manuscripts and 3 talks. Nurtured next generation researchers by mentoring 2 masters, 4 undergraduates, and a high school student across five national and three international collaborations.

Leveraged unsupervised and full/self/semi-supervised learning paradigms to develop generative and discriminative models encompassing a diverse array of data modalities ranging from 1D to 4D. Proficient in addressing challenges such as sparse annotations, data imbalance, and poor data quality, regardless of dataset size. Extensive expertise in established deep learning paradigms, including transformers and diffusion models, while continuously striving to stay abreast of the latest advancements such as Mamba and KAN.

Research Experience

PhD Candidate, Prasath Lab

Dept. of Computer Science, University of Cincinnati & Cincinnati Children's Hospital Medical Center

2019 – Present

- **Reimagining Interpretability in Segmentation: A Multi-Scale Coherence Framework**
 - Pioneered an entirely new perspective of Interpretability for Segmentation through XOR-based Deep Supervision—lighting up hidden multi-scale cues in real time and unveiling how the model forms decisions.
 - Introduced novel consistency heatmaps, exposing exactly where and why the network struggles, letting clinicians “see” AI uncertainty like never before.
 - Created an innovative Out-Of-Distribution detector through game-changing metrics (Transition Dice & Outlier Consistency) that proactively flags distributional shifts—setting a new bar for trustworthy medical image segmentation.
- **maxATAC - Maximizing insights from ATAC-seq. (Assay for Transposase-Accessible Chromatin) data**
 - Led the development of a dilated 1D CNN model and specialized training strategy, resulting in maxATAC, a publicly available collection of 127 Transcription Factor (TF) -specific CNN models capable of predicting TF binding sites from ATAC-seq data, that generalizes well even on Out Of Distribution cell lines.
 - Currently developing maxATAC v2 with Transformer architecture for enhanced performance and interpretability.
- **DeepImmuno: deep learning-empowered prediction and generation of immunogenic peptides for T-cell immunity**
 - Developed a deep learning-based model, **DeepImmuno-CNN**, for the prediction of immunogenic peptides from MHC-peptide pairs, using a beta-binomial distribution for continuous immunogenic score calculation.
 - The model outperforms two other prominent algorithms (DeepHLApan, IEDB), with better precision and recall across challenging datasets like cancer neoantigen and SARS-CoV-2.
 - Created **DeepImmuno-GAN**, for generating synthetic immunogenic peptides with real antigen-like properties, enabling the generation of high-quality synthetic datasets for training and biological applications.
 - **DeepImmuno** is available as open-source code on GitHub and as a user-friendly web interface portal for immunogenicity prediction. Currently, mentoring a Masters student for DeepImmuno v2.
- **AI-Driven Gait Classification from Low Resolution Videos for Cerebral Palsy (CP) Patients**
 - Developed an AI-driven video analysis model to streamline gait analysis for CP patients, reducing resource requirements and test time by 95%, aiming for a portable app-based monitoring system.
 - Created an autoencoder-based CNN model using self-supervised learning, designed data collection protocols, and developed data pipelines.
 - Achieved 65% OGS accuracy with a small dataset, indicating potential performance improvements with more data.
 - Mentored an international master's candidate on VAE and Memory Augmented Autoencoder models, resulting in an IEEE publication.
- **Benchmarking HEP-2 (Human Epithelial) Cell Segmentation Methods in Indirect Immunofluorescence (IIF) Images - Standard Models to Deep Learning**
 - Benchmarked 20 state-of-the-art DL segmentation models, including CNN and Transformer architectures, and proposed GAN-based generative models. Developed a novel domain specific pretraining strategy and proposed 2 different strategies for data augmentation and comprehensively evaluated their performance.
 - Achieved a State-of-the-Art Dice score of 92.2% with results are under peer review.
- **NeuroGleam: Illuminating Small Vessel Disease (SVD) Detection through Deep Learning based Segmentation of Brain MRI White Matter Hyperintensities (WMH)**

- Developed a DL-based WMH segmentation model for improved SVD detection from brain MRI scans, incorporating a two-stage NN model with CNN and Vision Transformer architecture and tested extensively on public (MICCAI WMH Challenge) and in-house clinical dataset
- Achieved a high Dice score of 80% on the public dataset and established a new State-of-the-Art score of 75% on the clinical in-house dataset compared to contemporary models.

Skills

- **Programming:** Python | MATLAB | Julia | C | C++ | Cuda C
- **Libraries:** Numpy | Scipy | Pandas | Sklearn | Docker
- **Deep Learning:** Tensorflow | Keras | PyTorch
- **Web Development:** HTML | CSS | Jekyll | Ruby
- **Modeling:** CNN | Transformer | RNN | LSTM | VAE | GAN | Diffusion | Interpretability | LLM | RAG | Unsupervised | Self-Supervised | Semi-Supervised | Mamba | KAN

Education

PhD, Computer Science, University of Cincinnati	Expected Summer 2025
Dissertation – Multimodal Artificial Intelligence for Bioinformatics Data	
MS, Computer Science, University of Cincinnati	Dec 2018
Thesis – Spindle bearing health prognosis using Machine Learning and Signal Processing.	
BS, Instrumentation & Control Engineering, University of Pune, India	Jun 2008

Research & Teaching Assistantships

Graduate Research Assistantship

- Assisted with 3 NIH grant proposals, contributed to 12 collaborative interdisciplinary projects in the biology and medical domain ranging from genomics, immunology, neuroscience, radiomics and gait analysis. Represented the lab in 6 conferences with 3 talks and 3 posters.

Graduate Teaching Assistantship

- Courses: Intelligent Data Analysis | C++ Programming | Introduction to Computer Systems

Publications

- **Balaji Iyer**, et.al. "Reimagining Interpretability in Segmentation: A Multi-Scale Coherence Framework" (under review)
- T. Cazares,..., **Balaji Iyer**, et.al. "maxATAC: Genome-scale transcription-factor binding prediction from ATAC-seq with deep neural networks." PLOS Computational Biology.
- G. Li, **Balaji Iyer**, et.al. "DeepImmuno: deep learning-empowered prediction and generation of immunogenic peptides for T-cell immunity." Briefings in bioinformatics.
- A. Gundawar,..., **Balaji Iyer**, et.al. "On the Performance of new Higher Order Transformation Functions for Highly Efficient Dense Layers." Neural Processing Letters.
- N. Gaddis,..., **Balaji Iyer**, et.al. LungMAP portal ecosystem: Systems-level exploration of the lung. American Journal of Respiratory Cell and Molecular Biology.
- G. Sumi, **Balaji Iyer**, et.al. Gait analysis for cerebral palsy using memory-augmented auto-encoder model. 11th International Conference on Informatics, Electronics & Vision (ICIEV), Proc. IEEE. (**Excellent Paper Award**)
- **Balaji Iyer**, et.al. Benchmarking HEP-2 cell segmentation methods in indirect immunofluorescence images. (under review)
- **Balaji Iyer**, et.al. AI-driven gait parameters estimation from videos for cerebral palsy patients (In preparation)
- **Balaji Iyer**, et.al. NeuroGleam: Illuminating Small Vessel Disease Detection through Deep Learning based Segmentation of Brain MRI White Matter Hyperintensities. (In preparation)
- **Balaji Iyer**, et.al. ConIFSeg - Confocal immunofluorescence image segmentation with deep learning for discerning developing lung structures. (In preparation)
- Smruti Deoghare,..., **Balaji Iyer**, et.al. PICCLineNet: Detecting peripherally inserted central catheter (PICC) lines and tip malpositioning in neonate X-ray images using artificial intelligence (AI) models (In Preparation)
- **Balaji Iyer**, et.al. Predicting ICH patient outcome from brain CT scans using an ensemble deep learning framework (In Preparation)
- Prasath Lab, Book chapter: "Application of Multimodal Deep Learning in Medicine" (under review).

Presentations

- **Balaji Iyer**, et.al. Deep learning-based segmentation of human epithelial type-2 (HEP-2) cells using indirect immunofluorescence (IIF) images. Advancing Healthcare Innovation Summit (AHIS), November 2023. Talk

- **Balaji Iyer**, et.al. AI-driven gait parameters estimation from videos for cerebral palsy patients. Advancing Healthcare Innovation Summit (AHIS), November 2023. Talk. (**Aspiring Innovator Award, 2nd Best Presentation Award**)
- **Balaji Iyer**, et.al. Predicting ICH patient outcome from brain CT scans using an ensemble deep learning framework. Advanced Computational Neuroscience Network (ACNN), University of Michigan, Ann Arbor, MI, USA. September 2019. Talk
- **Balaji Iyer**, et.al. ConIFSeg - Confocal immunofluorescence image segmentation with deep learning for discerning developing lung structures. First Annual Cincinnati Children's Research Symposium, November 2023. Poster presentation.
- **Balaji Iyer**, et.al. Deep learning based segmentation of human epithelial type-2 (HEp-2) cells using indirect immunofluorescence (IIF) images. First Annual Cincinnati Children's Research Symposium, November 2023. Poster presentation.
- Smruti Deoghare,..., **Balaji Iyer**, et.al. PICCLineNet: Detecting peripherally inserted central catheter (PICC) lines and tip malpositioning in neonate X-ray images using artificial intelligence (AI) models. First Annual Cincinnati Children's Research Symposium, May 2023. Poster Presentation
- Samuel Hacker, **Balaji Iyer**, et. al. Automated ICH Outcome Prediction from CT scans by Ensemble Convolutional Neural Network Architecture. Capstone Poster Symposium, Aug 2019. Poster Presentation (**2nd Best Presentation Award**)

Peer Review

- Journal Reviewer for NCAA. Springer Nature Neural Computing and Applications
- Journal Reviewer for EJRAI. Elsevier European Journal of Radiology Artificial Intelligence
- Journal Reviewer for ESA. Elsevier Expert Systems With Applications
- Journal Reviewer for BSPC. Elsevier Biomedical Signal Processing and Control