Balagopal Unnikrishnan

www.balagopal.me | +1-437-991-1394 | balu@cs.toronto.edu | github.com/theidentity

— Educational Qualifications —

Ph.D. in Computer Science - University of Toronto - CGPA: 4/4 **09/21 - 09/25 (Anticipated)**

- Co-advised by Dr. Michael Brudno & Dr. Chris McIntosh - supported by Vector Institute, University Health Network (UHN) & SickKids Hospital

Masters in Knowledge Engg. / Intelligent Systems - National Univ. of Singapore (NUS) - CGPA: 4.16/5 **2019**

- Advised by Dr. Michael Chua & supported by the Agency for Sc., Technology & Research (A*STAR), Singapore - specializing in computational intelligence focusing on building diagnostic tools for radiology and ophthalmology

Bachelor in Computer Sc. and Engg. - Univ. of Kerala / College of Engg. Trivandrum (CET) - CGPA: 8.49 / 10 **2017**

— Professional / Research Experience —

Ph.D. Student / Graduate Researcher - University of Toronto **2021 - Present**

- **Diffusion for bias mitigation –** Developed a bias mitigation algorithm that debiased classifiers while training on 95% biased data. Achieved similar performance (~within 1% AUC) to models trained on 0% biased data.
- **Papilledema detection from ultrasound videos –** Built and deployed a semi-supervised GUI pipeline for clinical annotation. Utilized deep learning models to detect disease regions (.90 AUC) and localize them (< 2% normalized MSE) and studied the impact of bias due to acquisition devices.
- **Bias Detection and Generalization –** Co-developed an algorithm to study AI model generalization without external data. Showed an average of 21% performance overestimation across 13 medical datasets and correctly predicted external accuracies (<4% error) without external data estimates.

AI Research Engineer - Institute for Infocomm Research (I2R / A*STAR), Singapore **2019 - 21**

- **Algorithm development/translation –** Developed semi-supervised and self-supervised algorithms for 2D/3D medical imaging data – resulting publication being runner-up for the best paper award at MICCAI.
- Performed IP development and translation work for semi-supervised guided medical image annotation.

Research Intern - Institute for Infocomm Research (I2R / A*STAR), Singapore **2018 - 19**

- Co-developed and trained patch-based **semi-supervised GANs** and transfer-learning-based methods for **abnormality/anomaly detection** in diabetic retinopathy and retinopathy of prematurity (ROP) detection
- Developed 2D and 3D segmentation pipelines for MRI data

Systems Engineer C1 - TATA Digital Enterprises, India **2017**

- Differential/special hire as part of the Digital Enterprise program - worked on vision / NLP tasks

Research Intern: Robotics and Cognitive Division - TATA Digital Enterprises, India **2017**

- Developed proof-of-concept for boosted edge detection methods for image processing
- Developed NLP-based knowledge engine for integration into communication system

— Selected Publications —

A full list of 16 articles is available on Google Scholar | Citations: 337, h-index: 6

- "Shortcut Learning in Medical AI Hinders Generalization: Method for Estimating AI Model Generalization without External Data" - Ly, C, O* ., **Unnikrishnan, B*** et. al. (2023). [Under review in npj Digital Medicine]
- "Semi-supervised classification of radiology images with NoTeacher: A teacher that is not mean" - **Unnikrishnan, B**., Nguyen, C., et. al. (2021). **[MICCAI + Extended version in Medical Image Analysis]**
- "Self-path: Self-supervision for classification of pathology images with limited annotations" - Koohbanani, N. A., **Unnikrishnan, B**., et. al. (2021) **[*IEEE Transactions on Medical Imaging*]**
- **"**Semi-supervised and Unsupervised Methods for Heart Sounds Classification in Restricted Data Environments" **Unnikrishnan, B**., Singh, P. R., Yang, X., & Chua, M. C. H. (2020). [Arxiv Preprint – Project]
- "Towards practical unsupervised anomaly detection on retinal images" - Ouardini, K., Yang, H., **Unnikrishnan, B**., et.al. (2019). MICCAI Workshop - Domain Adaptation and Representation Transfer, **[DART / MICCAI].**
- "Semi-supervised deep learning for abnormality classification in retinal images" - Lecouat, B., Chang, K., Foo, C. S., Unnikrishnan, B., et. al(2018). Machine Learning for Health (ML4H) Workshop at NeurIPS [**ML4H / NeurIPS**]

— Skills —

- **AI Research & Engineering –** Capable of **quick AI prototyping** with platforms such as **PyTorch & TensorFlow**
- **Web development & Prototyping –** Have built web-based research prototypes with **Flask & MongoDB** with and **HTML, CSS, JS** – have also deployed solutions using **AWS & Google AutoML**
- Experience in creating **IP, publications**, and technologies for companies and **productizing** them - domain expertise in **vision**, **radiology,** and **medical data**.
- Data Science (Pandas, R, SPSS Modeller, JMP, and Scikit-learn) | **Computer Vision** (OpenCV, Scikit-Image, FiJi) | **Audio Processing**(Librosa, SciPy) | **Natural Language Processing** (NLTK, TextBlob, Pattern)

— Research Projects —

Understanding and mitigating shortcut learning and data bias in healthcare data **2021-Present**

- Studied **performance deterioration** in models from lab to field in mobile health applications. Developed a novel method to identify data outliers and estimate performance on the field.
- Improved **semi-supervised algorithm performance** on radiology data (.91 to .96 AUC) by developing a new multi-view loss function that promotes the learning of non-spurious features. Additionally achieved 97% of fully supervised performance with 100x fewer labels
- Co-developed an algorithm to study **AI model generalization without external data**. Showed an average of 21% performance overestimation across 13 medical datasets and correctly predicted external accuracies (<4% error) without external data estimates.

Debiasing models using generative AI **2021-Present**

- Developed a bias mitigation algorithm that debiased classifiers while training on 95% biased data. Achieved similar performance (~within 1% AUC) to models trained on 0% biased data.
- Achieved SOTA performance and a 7% margin to the closest competing method.

Papilledema detection from ultrasound videos **2023-Present**

- Built and deployed a semi-supervised GUI pipeline for clinical annotation. Utilized deep learning models to detect disease regions (.90 AUC) and localize them (< 2% normalized MSE) and studied the impact of bias due to acquisition devices.

AI-assisted models for pneumothorax detection **2021 – Present**

- Curated a **200k large X-ray dataset** with public and private data and created a scalable pipeline for pneumothorax detection to improve scan-to-intervention response times – the resulting model is deployed at UHN
- Identified critical data bias and confounder issues, which bottlenecked model generalization and created a proof of concept tool for clinical usage.

Ask-Me-Right Radiology Annotation Platform **2021**

- Built, deployed, and tested a platform to source annotations for X-rays. Used HCI design principles and multi-arm bandits to reframe annotation tasks resulting in a **2x reduction in annotation time** and improved annotator accuracy.

Semi-Supervised Learning for Radiology Images **2020-21**

- Developed NoTeacher, a novel semi-supervised method for reduction in annotation burden in radiology data
- Achieved 90% performance of fully supervised models with just 5% of labels for X-ray and CT data
- Published works in MICCAI 2020 and IEEE Transactions in Medical Imaging (TMI) and was the runner up for the **MICCAI Best Paper Award 2021**.
- Translated into IP – "A Semi-Supervised Process to Guide Annotation for Image Classification Tasks" and has been ***licensed to a private company for revenue***

Self Supervision and Domain Transfer for Pathology Data **2020**

- Developed self-supervision tasks that use multi-resolution and semantic features in histopathology images.
- Achieved state-of-the-art performance with limited annotation on whole slide images.
- Accepted into IEEE Transactions on Medical Imaging (TMI)

Anomaly Detection in qPCR Curves for CoVID Detection **2020**

- Used machine learning techniques to flag anomalies in automated qPCR testing for CoVID - detecting late amplification and fluorescence drift cases.
- Developed an automated tool to enable faster inferences and error reduction in clinicians.

Deep Learning for Tuberculosis Detection **2019**

- Built a proof of concept tuberculosis detection model and studied the effect of transfer learning and architecture for limited data settings.
- Created a web application that provides interpretable results using class activation maps (CAMs)

Heart Sounds Classification in Restricted Data Environments **2018**

- Built a system to detect abnormal heart murmurs from audio data and 2D Mel spectrogram images.
- Used additional hand-engineered features and 1D convolutions to improve model accuracy with 4x lesser parameters

Karyogram Classification for Cancer Detection **2017**

- Used machine learning and computer vision techniques for karyogram generation.
- Improved cytogeneticist workflow using graphs and convolutions for chromosome tagging and pairing.
- **Received Best Engineering Project Award**

— Certifications —

AI Product Manager Nanodegree - Udacity **2020**
AI for Medicine Specialization - Deeplearning.ai / Coursera **2020**
Deep Learning Specialization - Deeplearning.ai / Coursera **2017**
Machine Learning Specialization - Deeplearning.ai / Coursera **2016**
Introduction to the IoT and Embedded Systems - University of California Irvine (UCI) / Coursera **2016**

— Achievements / Awards / Volunteer Positions —

Mentor: Graduate Application Assistance Program (GAAP) **2022 – Present**
Reviewer: IEEE Transactions in Medical Imaging (TMI) **2022 – Present**
University Of Toronto Fellowship, Faculty Of Arts And Science **2023**
Vector Research Grant **2022, 2023**
Executive Council Member: Computer Science Graduate Students' Benevolent Society (CSGSBS) **2022 – 2023**
Chairperson: Singapore Computer Society (SCS) Chapter - NUS ISS **2018 – 2019**
Ministry of Education Grant for International Students **2019**
Richard E Merwin Scholar - IEEE Computer Society **2017**
Youth Excellence Award for Most Promising Engineer - Kerala **2017**
Section Student Representative - IEEE Kerala Section **2016 – 2017**
Chairperson: IEEE Computer Society CET Chapter **2016 – 2017**
Co-Organizer: NASA Space Apps Challenge **2016**
Represented the state in the Asia-Pacific Student Young Professional Congress in Colombo, Sri Lanka **2016**

— Teaching Experience —

Lecture & Tutorial TA: CSC 111: Foundations of Computer Science II **2024**
Lecture TA: CSC 110: Foundation of Computer Science I **2023**
Lecture TA: CSC 108: Introduction to Computer Programming **2022**
Lecture TA: CSC 2431: Artificial Intelligence in Medicine **2022**

- Coordinated students and mentors for two Ukrainian Universities (NaUKMA, UCU) and Ph.D. students at UofT for a unique international course where students developed AI algorithms for medicine/health.
- Created and deployed a responsive website to disseminate project details, teams, and study materials.

Marking TA: CSC 420: Introduction to Image Understanding **2021**

— Selected Talks & Workshops —

AI in Healthcare [Slides] **2021**

- Gave a talk discussing AI in Healthcare use cases for computer science professionals in Singapore.

Research Workshop - [Outcome slides from students**]** **2021**

- Led a workshop for undergraduate students where they learned to review scientific papers.
- Moderated the literature discussion on deep residual learning for image recognition.

Introduction to Artificial Intelligence & Machine Learning - [Slides**]** **2021**

- Showed learning paradigms and AI/ML applications in various fields such as healthcare, finance, etc.
- Discussed with students in MuLearn (a learning community) ways to learn, upskill, and complete live projects

Lecture on Logistic Regression - [Slides**]** **2020**

- Introduced the concept of logistic regression for students in MuLearn community.
- Also showcases the math behind the back-propagation and differentiation involved in the technique

— Misc / Hobbies —

Scuba Diving

- PADI-certified scuba diver trained in dive planning, underwater emergency responses, and safety protocols – capable of undertaking dives of up to 60 feet.

Reading

- Reads 24+ books a year with topics covering science, philosophy, religion, and poetry.
- Reading List on GoodReads