

Azal Ahmad Khan

azalahmadkhan@gmail.com, k.azal@iitg.ac.in
<https://sites.google.com/view/azalahmadkhan>

Research Interest

Deep Learning, Large Deep Learning Models, Federated Learning, Reinforcement Learning, and Computer Optimization. The overarching goal of my research is to explore why and how large deep learning models perform so well. My research interests are also optimization and personalization in heterogeneous environments, with applications to federated learning. I am also interested in reinforcement learning and computer optimization.

Education

Indian Institute of Technology Guwahati

Guwahati, India

B. Tech in Chemical Science and Technology (9.22)

2020 - 2024(Expected)

Courses: Computer-Aided Applied Optimization, Introduction to Computing, Computing Lab, Linear Algebra & Differential Equations, Real Analysis & Multivariable Calculus, Complex Analysis & Partial Differential Equations, Quantum Chemistry, Introduction to Reinforcement Learning[†], Computational Chemistry[†].

[†]January 2023 - May 2023

Experiences

Research Intern, Yale University

June 2022 - August 2022

Advisor: Dr. David Van Dijk, Yale University

Remote

- Used Deep Learning to model brain dynamics in mesoscopic calcium imaging data highlighting cognitive processes.
- Implemented Transformers, Neural Ordinary Differential Equations, and Continuous Transformers on mice brain data.

Research Intern, University of Minnesota

January 2022 - Present

Advisor: Dr. Ali Anwar, University of Minnesota

Remote

Project Title: *Personalized Federated Learning: Empirical Analysis*

- Reviewed the current personalization algorithms in Federated Learning and highlighted their strengths.
- Developed metrics to evaluate the performance, communication cost, convergence, time cost, and fairness of PFL.
- Evaluated 5 personalization techniques in federated learning - Per-FedAvg, FedMTL, FedFomo, APFL, and Ditto.
- Analyzed them on MNIST, FMNIST, and CIFAR-10 datasets with client distribution as Pathological and Dirichlet.

Project Title: *PI-FL: Personalized and Incentivized Federated Learning.* Submitted at **ICML '23**

- Proposed PI-FL, a one-shot personalization solution complemented by a token-based incentive mechanism that rewards personalized training.
- PI-FL to address the challenges of heterogeneity, privacy, and accessibility in the FL setting.
- Outperformed other SOTA approaches like Ditto and FedSoft while maintaining client privacy.

Research Intern, University of New South Wales

January 2022 - Present

Advisor: *Dr. Rohitash Chandra, University of New South Wales*

Remote

Project Title: *A review of ensemble learning and data augmentation models for class imbalanced problems: combination, implementation, and evaluation*

Submitted at **Neurocomputing '23**

- Evaluated 10 types of data augmentation and 10 types of ensemble techniques on 30+ imbalanced datasets.
- Used SMOTE, CTGANs, SMOTified-GAN, and multiple bagging, boosting, voting, and stacking for classification.
- Investigated the results for multiple metrics like accuracy, F-1, AUC, time cost, etc, to propose research insights.

Project Title: *Ensemble Learning Perceptron is better than Bayesian Neural Networks in MCMC.*

Project Title: *Variational deep learning framework for forecasting the decadal world economic outlook.*

Technical Skills

- **Programming Skills:** C, C++, Python, Javascript, MATLAB, FORTRAN
- **Web Technologies:** HTML, CSS, Bootstrap, React.js*, Node.js*, Django*
- **Python Libraries:** PyTorch, Tensorflow, Keras, Scikit-Learn, Numpy, Pandas, Matplotlib, Seaborn
- **Tools:** Jupyter Notebook, Google Colab, Git, GitHub, LATEX
- **Operating System:** MacOS, Windows

**Elementary Proficiency*

Projects

QCMBO, Extended course project, [\[code\]](#), [\[paper\]](#)

August 2022 - Present

Course Instructor: *Prof. Prakash Kotecha, Indian Institute of Technology Guwahati*

- Developed a novel optimization algorithm inspired by quantum chemistry and natural laws.
- Evaluated the algorithm on 14 objective functions and applied it to production planning problems.
- QCMBO outperformed famous pre-developed algorithms like PSO, s-TLBO, and real-coded GA.
- Extending the project to other applications and proposed future works.

Balanced Split, Research project, [\[code\]](#), [\[arXiv\]](#)

October 2022 - December 2022

Paper title: *Balanced Split: A new train-test data splitting strategy for imbalanced datasets.*

- Developed a new train-test data-splitting strategy to tackle the problem of class imbalance in classification.
- Evaluated the strategy against random and stratified splitting and outperformed them.
- Calculated K-Nearest Neighbour and Random Forest results for multiple train ratios.

KaggHelp | ML Calculator

Ongoing

- An online ML calculator focused on helping Kaggle users to test 50+ algorithms on their data effortlessly.
- Allows users to change hyperparameters and gives results of multiple classifications and regression metrics.

Feature Generation using Transformer, Self, [\[code\]](#)

March 2023

- Implemented transformer model for feature generation on the tabular dataset.
- Compared the performance of the transformer generated features with raw, raw+transformer-generated features.

Earthquake Prediction Model, Self, [\[code\]](#)

July 2022

- Developed a model using Neural Networks with GridSearchCV for hyperparameter tuning to predict earthquakes.
- Achieved validation accuracy of 98.141% and reduced square hinge loss to 0.003 on a dataset of 23K instances.

Anomaly Detection on Diabetes Dataset, Self, [\[code\]](#), [\[presentation\]](#)

March 2022

- Designed a Deep Learning model that detects diabetes as an anomaly in Unsupervised Autoencoder Neural Networks.
- Achieved accuracy of 83.4% and reduced mean square error to 0.214 on a dataset of more than 0.253M instances.

IPL Winner Prediction Model, Self, [\[code\]](#)

March 2022

- Modeled multiple ML algorithms and LSTM models to predict IPL winner on 0.19M instances and 16 attributes.
- Achieved accuracy of 71.34% with XGBoost and val-accuracy of 98.77% using LSTMs with Adam optimizer.

Precipitation Prediction in LA, Self, [\[code\]](#)

December 2021

- Developed an ML model using multiple ML Algorithms and predicted whether precipitation occurs.
- Used oversampling to handle class imbalance and achieved an accuracy of 98.49% and a ROC-AUC score of 98.50%.

Responsibilities and Volunteering works

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| ● Core Team - Consulting Analytics Club, IIT Guwahati | 2022 - 2023 |
| ● Volunteer - NSS, IIT Guwahati | 2022 - 2022 |
| ● Associate - Consulting Analytics Club, IIT Guwahati | 2021 - 2022 |
| ● Coordinator - Coding Club, IIT Guwahati | 2021 - 2022 |