Sandesh **Katakam**

BS-MS Mathematics Major · IISER Berhampur

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Research Interests

Scientific Machine learning, Physics-Informed Neural Networks, Neural Differential Equations, High-Performance Computing, Scientific Computing, and Numerical Analysis, Julia programming language, Optimal Transport in Biology, Mathematics of Data Science, and Applied Machine learning for Health Sciences.

Research Experience

Department of Computer Science, IIT Ropar
Ropar, India

RESEARCH INTERN | PI: DR. SUDARSHAN IYENGAR
May. 2023 - July. 2023

- Studied Reinforcement Learning Models for sequential decision making
- worked on incorporating neural differential equations into RL

Bayesian Reasoning and Inference Group, IIT Hyderabad
Hyderabad, India

RESEARCH INTERN | PI: DR. SRIJITH P.K.
May. 2022 - Present

- Studied and reviewed various Neural ODE models for time-series data and sequential data modelling.
- Worked on NeuralODEs for Irregularly sampled Time-series data. We used variation of Heat equation PDE as our Differential Equation to model the parameters of the Neural Network

Laboratory For Visualization of Quantum Materials, IISER Berhampur
Odisha, India

UNDERGRADUATE STUDENT RESEARCHER | PI: DR. RAHUL SHARMA
October. 2022 - April. 2023

- Working on Denoising STM(Scanning Tunneling Microscopy) Images and Adding realistic noise to the simulated STM Images
- Studied STM Imaging Technologies for visualizing atomic-scale high-resolution images of superconducting materials. Learning how to generate simulated STM images using MATLAB.
- Exploring Neural ODE models for Image denoising with the scope of training models with better interpretability.

NeuroImaging and Brain Research Group, IISER Berhampur
Odisha, India

UNDERGRADUATE STUDENT RESEARCHER | PI: DR. VIVEK TIWARI
March. 2022 - December. 2022

- Implemented the Paper NormVAE for Neuroimaging data. Trained the model using ADNI dataset on brain region volumes of healthy controls.
- Worked with Medical Image segmentation models. Used nnU-Net for Brain Tumor segmentation.
- Worked on Contrast enhancement of Brain Tumor MRIs for generating MRI modalities close to Post-gadolinium MRIs

iGEM Team IISER Berhampur
Odisha, India

MATHEMATICAL MODELLING TEAM | PROJECT WEBSITE LINK
June. 2022 - October 2022

- Our Team worked on developing an Aptamer-based UTI(urinary tract infection) detection kit at the point of care
- studied Aptamer-Protein interaction computationally and worked with AlphaFold2 deep learning model for generating 3D structures of proteins from the sequences
- worked on in-silico screening of aptamer library for better affinity towards target protein(FimH) using Molecular Docking and MD Simulations
- worked with Urinary tract infections data obtained from the Global Burden of Disease 2019 survey. Generated Geo-spatial plots of the data to better study UTI incidence rates, prevalence, and mortality around the world.

Education

Indian Institute of Science Education and Research (IISER) Berhampur
Odisha, India

B.S - M.S DUAL DEGREE MATHEMATICS
December . 2020 - Present

- Got admission through JEE Advanced Channel
- Worked as an undergraduate student researcher in Department of Biology and Department of Physics

National Institute of Technology (NIT) Surat
Surat, India

INTEGRATED MSc PHYSICS
August. 2019 - December 2019

- Discontinued after semester-I for preparing for JEE Advanced 2020

FIITJEE Junior College Hyderabad
Hyderabad, India

CLASS XII
April. 2018 - May 2019

- Got admission at National Institute of Technology Surat through JEE Mains 2019

Honors & Awards

2023	**Indian Academy of Sciences - Summer Research Fellowship**, Awarded fellowship under Dr. Sudarshan Iyengar Dept. of CSE, IIT Ropar	*IAS Bangalore*
2022	**Silver Medal**, iGEM Grand Jamboree 2022 | Certificate	*Paris, France*
2020	**IIT-JEE Advanced 2020**, Secured Rank in the merit List: Top 10,000 among 1 Million candidates	*India*

Projects

Neural PDE model for Irregularly Sampled Time series data   *GitHub*
Associated with Department of AI, IIT Hyderabad   *Ongoing*

- I am currently working on developing a novel Neural PDE model along with Dr Srijith P.K. at IIT Hyderabad, which uses a variation of Heat Equation PDE as the differential equation to model the hidden states of a Recurrent Neural Network(like GRU/LSTM cell) for modelling and accounting for the irregularly sampled data coming from an online source.

Denoising STM Images using Machine Learning   *GitHub*
Associated with Department of Physics, IISER Berhampur   *Ongoing*

- I am currently working on developing a novel Neural ODE model for denoising images from Scanning tunneling microscope
- I am working with dataset containing images of 11 energy layers of quasiparticle interference pattern in LiFeAs.

Code Implementations of papers

Neural ODE Model for Brain Tumor Segmentation   *GitHub*
Associated with Neuroimaging group IISER Berhampur   *December 2022*

- Implementation of paper "Neural ODE Model for Visualizing Deep Neural Network Behaviors in Multi-parametric based Glioma segmentation
- Developed a multi-parametric Neural ODE model for Brain Tumor segmentation

3D-Bayes U-Net For Virtual Contrast enhancement of MRIs   *GitHub*
Associated with Neuroimaging Group IISER Berhampur   *August 2022*

- Implemented 3D-Bayes U-Net from the paper: "Can Virtual Contrast enhancement in Brain MRI replace gadolinium? A Feasibility Study". Trained the 3D-Bayes U-Net model on the TCGA-GBM dataset containing multi-modal MRIs of Glioblastoma patients.

NormVAE Model on NeuroImaging Data   *GitHub*
Associated with Neuroimaging group IISER Berhampur   *July 2022*

- Implemented the paper: "NormVAE: Normative modelling on NeuroImaging data using Variational Autoencoders"
- I trained the model with our custom dataset of MCI/AD patient data obtained from ADNI. Generated the deviation maps for studying how much the diseased brain region volumes deviate from that of Healthy Controls

Open source projects

Generative Models in JAX   *GitHub*
open source project   *April 2023*

- Implementation of Various Generative Model Architectures(GANs, VAEs, Flow-Based Models) in JAX Framework
- Designed for easy reproducibility and training of generative models on custom datasets on both CPUs and GPUs.

Spinning Up RL: Julia Implementation   *GitHub*
open source project   *April 2023*

- Implementation of Spinning Up RL Algos by OpenAI in Julia

Numerics.jl : Julia Implementations of Numerical methods   *GitHub*
open source project   *April 2023*

- Implementation of Scientific Computing Techniques and Numerical Methods in Julia

Machine Learning Library   *GitHub*
Implementation of ML Algorithms from scratch using Numpy and Pandas   *May 2022*

- Implemented basic Machine Learning Algorithms in Python from scratch using Numpy and Pandas. Algorithms Implemented: Decision Tree, KNN, K-Means, Neural Network(MLP), Logistic Regression, Linear Regression.

Skills

- **Programming Languages:** C/C++, Python, Julia, MATLAB, Bash(shell-scripting)

- **Machine Learning Frameworks:** TensorFlow, PyTorch, JAX, Flux.jl

- **Data Analysis Libraries:** Numpy, Scikit-learn, OpenCV, Pandas, Matplotlib

- **SciML and Scientific computing libraries:** DifferentialEquations.jl, DiffEqFlux.jl, NeuralPDE.jl, torchdiffeq

- **Version Control Tools:** Git and GitHub

- **Web Development:** HTML, CSS, Javascript and Reveal.js

- **Other Skills:** LateX, Linux system administration, Object-oriented programming

Presentations and Workshops

Julia workshop for Scientific Programming *Slides*

IISER Berhampur *March. 2023*

- Organized Julia workshop and conducted Hands-On exercises in Julia for beginners getting started with scientific programming

Neural Differential Equations in Machine Learning *Slides*

IIT Ropar *May. 2023*

- Presentation on the theory of Neural Differential Equations and Application of Neural DEs in Machine Learning.

How to use Neural Differential Equations for Reinforcement Learning *Slides*

IIT Ropar *May. 2023*

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Conferences, Talks and Workshops

Dec 2022	**Asian Conference on Machine Learning (ACML) 2022**, Volunteer	*Hyderabad, India*
Aug 2022	**Julia Con 2022**, Virtual Attendee	*online Mode*
Jul 2022	**All India iGEM Meet (AIIM) 2022, IISc Bangalore**, iGEM Team IISER Berhampur representative	*Bangalore, India*
Mar 2022	**SciML Con 2022**, Virtual Attendee	*online mode*

MOOCs

2021	**Machine Learning**, Stanford University, Coursera	*Certificate*
2021	**Deep Learning Specialization**, DeepLearning.ai	*Certificate*
2021	**Data Analysis with Python: Zero to Pandas**, Jovian.ai	*Certificate*
2021	**Introduction to Git and GitHub**, Google	*Certificate*

Extra-curriculars

IISER Berhampur DC++ Network *Website*

Hub Operator and Maintainer *January. 2023 - Present*

- Launched the DC++ Hub for peer-to-peer file sharing service at IISER Berhampur for students
- Maintained the DC Hub during my stay at IISER Berhampur

Coding Club IISER Berhampur *Odisha, India*

Co-Founder and Co-ordinator *August. 2022 - Present*

- Started programming initiative at IISER Berhampur through workshops
- Organized Coding and Machine learning hackathons at IISER Berhampur

Machine Learning Blog *Blog Link*

Blog writer *Jan. 2021 - Present*

- Writing on different Machine learning methods and detailed implementation of various deep learning architectures.
- Explained Code Implementation of Research papers in deep learning

References

Dr. Vivek Tiwari

Assitant Professor, IISER Berhampur

Dr. Rahul Sharma

Assitant Professor, IISER Berhampur

Dr. Srjith P.K.

Associate Professor, IIT Hyderabad

Dr. Sudarshan Iyengar

HoD CSE Dept., IIT Ropar