

VIKASH SINGH

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Publications

1. Ganguly, D., **Singh, V.**, Sankar, S., Zhang, B., Zhang, X., Iyengar, S., Han, X., Sharma, A., Kalyanaraman, S., Chaudhary, V., “Grammars of Formal Uncertainty: When to Trust LLMs in Automated Reasoning Tasks,” *arXiv preprint*, May 2025. 📄 </>

Research Interests

- o **Formal Reasoning and Verification:** Developing rigorous formal logic methodologies, leveraging SMT-LIB encodings and solver frameworks to verify, interpret, and enhance the correctness of LLM-generated reasoning.
- o **Fine-Tuning LLMs and Vision Models:** Leveraging techniques such as LoRA to optimize large language and vision models for specific tasks while maintaining computational efficiency.
- o **Redundancy Mitigation in LLMs:** Investigating approaches to reduce redundancy in large language models, enhancing performance and efficiency.
- o **Model Optimization:** Developing strategies for optimizing machine learning models, including pruning and hyperparameter tuning, to improve both accuracy and resource utilization.
- o **Explainable AI:** Advancing interpretability in AI models, focusing on enhancing transparency and providing actionable insights for users.

Research Work

Advancements in XAI with Specialization in Counterfactual Explanation Methods Jan’24 – July’24

Case Western Reserve University (*Python3, DNNs, GNN*) OH, USA

- Engaged in leading-edge research on Explainable AI, particularly specializing in Counterfactual Explanation methods. Actively contributing to the advancement of innovative approaches that enhance the interpretability and transparency of artificial intelligence systems.
- Advisor: **Dr. Jing Ma**, Assistant Professor, Department of Computer Science & Engineering, CWRU

Analyzation of Nano Particles in Environment using Deep Learning June 2020 – June 2021

IIT Mandi (*Machine Learning, Python3, Probabilistic Models*) Mandi, India

- Developing a deep multi-modal architecture for accurately predicting behaviour of nano particles on different species using environmental data.
- Advisor: **Dr. Tanushree Parsai**, Assistant Professor, Department of Environmental Science & Engineering, IIT Mandi

Deep Neural Network model for Early landslide warning system July 2020 – Dec 2020

IIT Mandi (*Machine Learning, Python3, RNN*) Mandi, India

- Led a groundbreaking machine learning initiative centered on the analysis of hillside landslides. Orchestrated extensive surveys in hilly terrains and adeptly harnessed a diverse array of datasets, encompassing variables such as weather conditions, elevation, slope, and temperature. Leveraged advanced predictive analytics techniques to derive actionable insights into landslide patterns and occurrences. This innovative project showcased a strategic integration of data science methodologies to address and understand the complexities of hillside landscape dynamics.
- Advisor: **Dr. Varun Dutt**, Associate Professor, Department of Computer Science & Engineering, IIT Mandi

VAEs for Satellite imagery dataset Jan 2022 – Sep 2022

DRDO, Ministry of Defence (*Machine Learning, Python3, C++, VAEs, Matlab*) Chandigarh, India

- Developed a sophisticated approach to enhance precision in satellite imagery analysis by employing segmentation, labeling, and training methods using Variation Autoencoders (VAEs). The models were further fine-tuned, resulting in an impressive 83% accuracy.
- Advisor: **Dr. MK Kalra**, Scientist G, Defence Geoinformatics Research Establishment (DGRE), DRDO

Experience

Summer Internship

June 2024 – August 2024

MGenio (Machine Learning, Web and Mobile dev, IoT)

OH, USA

- Self Driven research on Machine learning models and their Integration on IoT platforms.
- Developed an efficient platform to manage data flow and monitoring Machine learning models training.
- Designed a pipeline flow and Automated data preprocessing system for machine learning models to feed directly in IoT Systems.
- Manager: **Satish Ramade**, *CEO*, MGenio

Teaching assistant (Computational Perception)

Jan 2024 – present

Case Western Reserve University (Python3, Graphical Methods, Probability)

OH, USA

- Efficiently grade assignments, ensuring accuracy and providing constructive feedback.
- Deliver engaging lectures on specialized topics, fostering student understanding.
- Conduct effective office hours to address queries and offer additional guidance.
- Professor: **Dr. Michael Lewicki**, *Assistant Professor, Department of Computer Science & Engineering*, CWRU

Teaching assistant (Data Science I & II & III)

Feb 2021 – Aug 2022

Indian Institute of Technology Mandi (Python3, Machine learning, Probability, Deep Learning)

HP, India

- Conducted engaging lectures and facilitated Python hands-on lab sessions, enhancing students' practical skills.
- Assessed student understanding through various evaluation methods, including assignment grading and in-person viva sessions.
- Provided constructive feedback on assignments and assisted students during office hours, fostering a supportive learning environment.
- Professors: **Dr. Deelip AD**, **Dr. Varun Dutt**, **Dr. Manoj Thakur**, *Professors, Department of Computer and Electrical science*, IIT Mandi

Research Internship

May'21 – August'21

Hatch Marine Consultants (Startup) (Python3, Machine learning, Probability, Deep Learning)

New Delhi, India

- Predictive Modeling and Analysis: Utilized advanced machine learning models to predict the scour depth of a river in Taiwan, leveraging data-driven insights to inform strategic decision-making and optimize resource allocation.
- Model Optimization and Fine-Tuning: Demonstrated a commitment to continuous improvement and optimization by fine-tuning the machine learning models to meet specific project requirements, ensuring the highest level of accuracy and precision in predictive modeling and analysis.
- Demonstrated unwavering commitment by expertly developing and fine-tuning machine learning models and achieved accuracy of 90%.
- Advisor: **Dr. Karan Gupta**, *Sr Engineer, Hatch Marine Consul*, IIT Mandi

Education

Case Western Reserve University

Aug 2024 – Present

Doctor of Philosophy in Computer Science

Cleveland, Ohio

- **Key Courses:**
 - * **Large Language Models:** Explored advanced techniques in machine learning, with a focus on practical applications of multitask learning models. Presented a paper titled "Measuring Multitask Language Understanding", which involved analyzing and discussing state-of-the-art models and evaluation metrics in natural language processing (NLP). Gained hands-on experience with advanced machine learning frameworks and methods to handle large-scale datasets. Outcomes: LLMs, Llama, GPT, BERT, Evaluation, Olmo, Reasoning in LLMs, High performance computing, Data Parallelization, Algorithm Parallelization etc.

Case Western Reserve University

Aug 2023 – May 2025

Masters of Science in Computer Science (Specialisation in ML/AI)

Cleveland, Ohio

- **Key Courses:**
 - * **Designing High performant systems for AI: Project:** Incorporated SMM on OneAPI in SYCL — Python3 to enhance YOLOV4 in a course on designing high-performing AI systems (Nov 2023). Led the development of YOLOV4 sycl-python integration, emphasizing advanced object detection algorithms and SYCL-Python optimization. Conducted extensive research, applying machine learning techniques to elevate real-time data processing and enhance visual data accuracy. Outcomes: GEMM, SMM, BMM, High performance computing, Data Parallelization, Algorithm Parallelization etc.
 - * **Analysis of Algorithms:** Acquired comprehensive knowledge in the realm of Data Structures and Algorithms, encompassing foundational concepts such as Greedy Algorithms, Graph Theory, Dynamic Programming, and NP-Completeness. This educational pursuit involved a detailed exploration of algorithmic methodologies and computational complexities, laying a robust foundation in the formal understanding and application of these core principles within the field.

Key Courses:

- * **Deep Learning and its Applications:** Contributed to a project focused on real-time sign language detection, aimed at assisting individuals who may face challenges in verbal communication or choose to conceal their emotions. This initiative seeks to enhance understanding and communication by interpreting sign language gestures, providing a valuable tool for those who rely on non-verbal expressions. Outcomes: LLM, CNN, AutoEncoders, GANs, VAEs, RNN, Perceptron etc.
- * **Pattern Recognition:** Acquired proficiency in Probability, Random Processes, Linear Algebra, and topics including Bayes Decision Theory, Parameter Estimation, Unsupervised Learning, Sequential Pattern Recognition, Nonparametric Density Estimation, Dimensionality Reduction, and Pattern Classification.

Ongoing Work

- Conducting research on **large language model pruning** to reduce memory and computational usage, focusing on innovative and efficient methodologies.
- Exploring **counterfactual generation** in dynamic Graph Neural Networks (GNNs) by incorporating techniques from static graphs into dynamic graph contexts.
- Analyzing **biases in large language models**, with a specific focus on **anchor bias**, in collaboration with the Cognitive Science Department.
- Investigating **mathematical approaches to pruning** large language models under the guidance of **Dr. Shuai**.
- Implementing **hyperparameter tuning using Bayesian group testing** to optimize computational and memory efficiency.

Projects

Exploring Explanatory Methods in AI | *Python3, CNN, GNN* 🔗 **Jan 2024**

- Conducted a comparative analysis of contrastive and counterfactual explanation generation approaches to enhance AI explainability.
- Explored advanced methods to improve understanding and interpretability of AI models.

Enhanced YOLOv4 using SMM on OneAPI in SYCL | *Python3, SYCL, CNN, PyTorch* 🔗 **Nov 2023**

- Developed and integrated Enhanced YOLOv4 with SYCL-Python for advanced object detection algorithms.
- Conducted performance optimization and applied ML techniques to improve real-time data processing and visual interpretation accuracy.

Human Activity Detector | *Machine Learning, Python3* 🔗 **Nov 2023**

- Built models using Logistic Regression, Decision Tree, and Support Vector Classifier with accuracies of 96%, 86%, and 80%, respectively.
- Achieved 96% prediction accuracy using accelerometer and gyroscope sensor data with Logistic Regression.

Landslide Warning System | *Python3, Machine Learning, DNNs* 🔗 **Aug 2020**

- Designed a data-driven predictive system under the guidance of Dr. Varun Dutt, analyzing hillside landslide risk factors like weather, slope, and temperature.

Speech Emotion Analyzer | *Machine Learning, Deep Learning, Python3, JavaScript* 🔗 **Aug 2020**

- Developed a CNN model with 100% accuracy in distinguishing between male and female voices.
- Trained the model to detect emotions with over 70% accuracy, with potential improvements through additional training data.

Technical Skills

Languages: Python3, C++, Java, JavaScript

Developer Tools: VS Code, Google Colab, Overleaf, High-Performance Cloud, OneAPI DevCloud

Technologies/Frameworks: TensorFlow, PyTorch, Scikit-Learn, OpenCV

Platforms: Linux, GitHub, Windows, macOS, Terminal

Academic Achievements & Recognitions

- Awarded the **Silver Medal** and **Director’s Medal** for academic excellence at IIT Mandi.
- Conducted lab sessions for the *”Training Program on Machine Learning for Ocean Acoustics and Climate Data Analysis”* at DRDO-NPOL, Kochi.
- Won two **gold medals** in badminton at the Inter IIT Sports Meet (2019, 2022).
- Secured first place in the **Inter IIT Tech Meet** hackathon at IIT Delhi for developing a machine learning algorithm for plant disease detection.

Relevant Coursework

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|---------------------------------------------|---------------------------|---------------------|
| • Large Language Models | • Deep Learning | • Data Privacy |
| • Data Structures & Algorithms | • Machine Learning | • Data Mining |
| • Designing High-Performance Systems for AI | • Data Science I, II, III | • Computer Security |
| • Analysis of Algorithms | • Computer Vision | |
| | • Pattern Recognition | |

Leadership & Extracurricular Activities

- Member of Club Badminton at CWRU (2024-PRESENT)
- President of Programming and Robotics Club at IIT Mandi (2020-2023).
- President of Space Technology and Astronomy Club (STAC) at IIT Mandi (2020-2023).
- President of Photography and Movie Making Club at IIT Mandi (2022-2023).
- Planning and Management Head for Ranneeti Sports Fest in the Himalayas (2019).
- Management Coordinator of Srijan’19 Technical Fest at IIT Mandi (2019).

Career Highlights

- Developed a satellite image analysis model using VAEs during an internship at DRDO, currently utilized by the Ministry of Defense.
- Designed and deployed a **Landslide Warning System** using Python and DNNs, now operational in Mandi and Manali for community support.