AKHILESH RAJ

akhileshraj91.github.io Akhilesh-Raj Akhilesh Raj akhileshraj91

RESEARCH INTERESTS

- **Reinforcement Learning**: I have worked on maximizing performance parameters under a constrained power supply in HPC nodes. What began as a summer internship project has now evolved into a mainstream research area. This can be framed either as an optimal control problem with or without knowledge of the dynamics or as a reinforcement learning problem that heuristically solves the optimization.
- **HPC**: I design critical algorithms to propose power caps for the operation of HPC applications, paving the way for green computing.
- **Advanced Test Beds**: I am developing advanced test beds for testing Cyber-Security Reinforcement Learning Agents trained to tackle ongoing threats to Operational Technology Networks.

RESEARCH EXPERIENCE

Graduate Research Assistant

Vanderbilt University

Jan 2024 – Present Nashville, USA

- Designed and implemented a realistic cyber-physical testbed integrating GridLAB-D (for power distribution simulation), OpenPLC (for programmable logic control), and Mininet (for emulating operational technology networks).
- Developed and tested Modbus TCP-based communication between SCADA controllers and simulated field devices for real-time data acquisition and control.
- Enabled closed-loop interaction between GridLAB-D and physical control logic via OpenPLC using Python-based middleware for deterministic control and fault injection.
- Emulated cyber-attack vectors and tested their impacts on physical infrastructure to evaluate the resilience and responsiveness of control logic under adversarial scenarios.
- Contributed to the DARPA CASTLE (Cyber Agents for Security Testing and Learning Environments) project, which aims to advance AI-based defense mechanisms for critical infrastructure.
- Facilitated the integration of AI agents for anomaly detection and automated mitigation strategies using the developed cyber-physical infrastructure.

W.J Cody Associate

Argonne National Lab

May 2024 – Aug 2024 Chicago, USA

- Worked on the efficient utilization of edge computational devices while integrating them with AI workflows on HPC.
- Developed a data processing algorithm by designing a controller to spawn edge resources based on the arrival speed of data.
- Published the proposed work at the IPDPS PAISE-2025 workshop.

Student Sub Contractor

Argonne National Lab

Jan 2023 – Sept 2023 Remote Position

- Extended the internship work to multiple applications.
- Focused on making the research application-agnostic.
- Utilized offline reinforcement learning to improve power efficiency by incorporating application- and hardware-agnostic features.

W.J Cody Associate

Argonne National Lab

May 2022 – Aug 2022 Chicago, USA

- Worked on optimizing the performance and power of High-Performance Computing (HPC) nodes.

- Proposed a reinforcement learning-based method implemented using PyTorch with the help of Stable-Baselines-3, outperforming the existing control theory-based approach.
- Tested the RL agent trained using mathematical models of the HPC node on a Skylake processor hosted by **Chameleon Cloud**, with actuation facilitated by Intel RAPL technology.
- The results and code were tabulated and made available for publication.

Project Associate

Indian Institute of Science

March 2021 – July 2021 | Bangalore, India

- Developed an intersection management algorithm for unguarded traffic intersections using **Reinforcement Learning** methods. This approach was an alternative to the expensive combined optimization problem previously used.
- The constraints included collision avoidance, passenger safety, intersection safety, and a demand factor.
- A significant breakthrough of this research was parallelizing existing Python simulations for multi-core processors.

Lead Project Engineer

DROPVAULT TECH. PVT. LTD.

Oct 2020 – Feb 2021 | Bangalore, India

- Created a functional prototype of a secure package collection system.
- Designed, built, and tested a Raspberry Pi-based model.
- Led the team responsible for designing the back-end support.

Research Consultant

BAYESIAN WAYS LLP

Aug 2020 – Oct 2020 | Kerala, India

- Developed MATLAB and Python-based programs for an **optimal event scheduler**.
- The initial prototype development was done in MATLAB using GUROBI and MOSEK (licensed CVX solvers).
- The solver for the event scheduler (a **mixed integer problem**) was then developed in Python using CVXPY and OR-TOOLS.

Research Associate

Missouri University of Science and Technology

Jan 2017 – Dec 2019 | Rolla, USA

- Developed a **distributed state estimation architecture for multi-agent systems** with applications to **target tracking** using MATLAB.
- Used Model Predictive Control (MPC) to formulate a control strategy to track dynamics.
- The project, funded by **Dynamic Data-Driven Applications of the Air Force Office of Scientific Research**, focused on detecting and tracking an enemy aircraft where the dynamics and inputs were unknown.

Project Engineer

IDEA Lab, IIT Kanpur

May 2016 – Nov 2016 | Kanpur, India

- Worked on a Boeing-funded project to develop **computer-vision-based automated guided vehicles** for material handling, achieving a reduced cost of sensors installed on such systems.
- Designed testbed environments using **ROS2** for simulating the Robotic xArm manipulator.

LEADERSHIP AND MENTORING

- Research Mentor – Student Inquiry and Research (SIR) Program, Illinois Mathematics and Science Academy (IMSA), Oct 2024 – Apr 2025
- Mentored Laksh Patel, a high school researcher, on a cyber-physical systems project integrating OpenPLC, GridLAB-D, and Modbus TCP.
- Guided the development and presentation of "Adversarial Attack Mitigation in Formation Control of Multi-Agent Systems" at the 2025 IMSAloquium, IMSA's flagship research symposium.

- Introduced Second-Order State Hallucination (SOSH) — a technique using second-order Taylor expansions to estimate the state of compromised agents in multi-agent systems (MAS). SOSH ensures stability and formation control under adversarial conditions by disconnecting attacked nodes and substituting their dynamics with hallucinated estimates.
- Demonstrated that hallucinated dynamics preserve exponential stability, mitigating cascading errors in MAS scenarios such as search and rescue, platooning, and disaster response.

EDUCATION

Ph.D in Electrical Engineering (Specialization: Control Systems)

Vanderbilt University - CGPA (4.0/4.0)

July 2021 – Dec 2024 | Nashville, USA

- **Optimal control of HPC devices** - a Reinforcement Learning-based approach.
- **Control of Cyber-Physical Systems** with applications to surrogate models.
- **Optimal resource allocation** for reducing transmission load using Reinforcement Learning.

M.Tech in Electrical Engineering

IIT Kanpur - CGPA (8.5/10)

2014 – 2016 | Kanpur, India

- Specialization in **control and automation**.
- Thesis on computer vision-aided Automated Guided Vehicles (AGV).

B.Tech in Electronics and Instrumentation

CET Trivandrum - CGPA (6.56/10)

2009 – 2013 | Trivandrum, India

- Graduated in Applied Electronics and Instrumentation Engineering.

PUBLICATIONS

- Raj, A., Gandhi, K., Nalla, B. T., Verma, N. K. (2019). Object detection and recognition using small labeled datasets. Springer.
- Raj, A., Jagannathan, S., Yucelen, T. (2020). Distributed adaptive state estimation using active-passive sensor networks. IJCSP.
- Raj, A., Swann, P., Gokhale, A. (2023). Performance-aware power reduction in HPC using reinforcement learning. IEEE.

STRENGTHS

Technical

- **Python**: Relevant projects include the Reinforcement Learning-based control problem solved at ANL, Distributed Systems, and Social Network Analysis course projects.
- **Shell Script**: Used for HPC node optimization problems, performed on Chameleon cloud.
- **MATLAB**: Formulated and implemented adaptive control and estimation algorithms, published in American Control Conferences and Journals.
- **WebGME**: Developed a PetriNet framework for modeling processes, hosted on GitHub.

Personal

- **Team Player**: Worked with project groups across the globe, resulting in significant publications and valuable experience. Notable projects include works with Drop Vault Tech. and Bayesian Ways.
- **Enthusiastic**: Eager to learn new subjects through self-study and hard work.
- **Vigilant driver**: Over 16 years of driving experience in both the USA and India.

ACHIEVEMENTS

- **3-MT finalist**, 2023, organized by GSC at Vanderbilt University.
- Obtained a grant with **Argonne National Lab** for the year 2023 as a **student sub-contractor**.
- Cleared **GATE** Examination in 2014 with an **All India Rank 29**.
- **Convener/Coordinator** Dhwani'12 (Annual Cultural Fest of CET).
- **Sponsorship Committee Convener**, Dhrishti'12 (Annual Tech Fest of CET).
- **Convener**, IEEE WCI-2015 (IEEE conference in computational intelligence, IIT Kanpur).
- **Member** of the adventure sports club, IIT Kanpur, in clearing the Kanchenjunga base camp at an altitude of 4000m.
- **Winners** of the Intramural Doubles Badminton tournament, Missouri University of Science and Technology.
- **Runners-up** in the Badminton doubles tournament organized by Missouri S&T CGS.

LANGUAGES

- **English**: Fluent
- **Malayalam**: Fluent
- **Hindi**: Intermediate
- **Spanish**: Basic