Kapil Khanal kk733@cornell.edu

Education

Cornell University Ithaca, NY

Ph.D. Candidate, Systems with concentration: (Applied Mathematics) *Aug. 2021 - Dec. 2025 (expected)*

- Performant systems design, optimization, differentiable simulations, and gradient enhanced training of neural networks (applied to novel autonomous offshore systems).
- Multi-objective optimization to achieve balanced trade-offs among competing system objectives.

Cornell University Ithaca, NY

Masters - Systems Engineering *Aug. 2021 - Dec. 2024*

- Research Focus: Developing integrated prediction and optimization frameworks using gradient-based methods. Focused on a 'predict-and-optimize' approach
- Building predictive models that directly minimize the cost of downstream decision-making tasks, rather than solely optimizing for data loss accuracy.

Winona State University Winona, MN

B.S., Data Science and Mathematics with dual concentrations: (Computer Science, Statistics) *Aug. 2016 – May 2020*

- Research Focus: Statistical modeling, algorithm design, and data-driven decision-making.

Research and Work Experience

PhD Intern June 2024 – Present

Backpropagation implementation for gradient propagation through simulation *Sandia National Laboratories, Albuquerque, NM*

- Develop a differentiable simulation method for fluid dynamics for gradient based optimization.
- Sensitivity and uncertainty analysis of hydrodynamic response of the systems
- Backpropagation implementation for differentiation through boundary element simulation.

Research - SEA Lab Nov 2021 – Present

Optimization, simulation, and optimal controls (applied to offshore systems) *Cornell University, NY*

- Developed a backpropagation algorithm for numerical simulation focusing on PDE-constrained optimization under uncertainty.
- Applied advanced statistical and predictive modeling techniques to design, develop, and deploy machine learning models for hydrodynamic response prediction, leveraging numerical methods and physics-inspired neural networks.
- Applied agile based methods to align research objectives, identify business requirements, and define meaningful outcomes impacting critical offshore system design decisions.
- Designed and implemented design of experiments for sensitivity analysis and test hypothesis on design decisions.
- Utilized the systems framework to optimize software architecture for systems that includes prediction, simulation and optimization for the design of a Platform for Expanding AUV exploration to Longer ranges (PEARL).
- Performed uncertainty quantification of system response due to random ocean waves and monitored sensitivity of optimization results for ongoing improvements to methods and algorithms.
- Communicated analytics results, predictive models, and simulation insights to academic collaborators, business partners, and clients through presentations and technical reports.

Data Analyst Jun 2020 – Jul 2021

Fastenal Company *Winona, MN*

- Integrated data from multiple sources using R and Python, enabling advanced analytics and machine learning projects.
- Developed and implemented data models for enterprise-scale databases, leveraging tools such as SSRS, Pandas, and PySpark.
- Conducted deep-dive exploratory analysis to uncover patterns and insights, addressing key business questions.
- Created interpretable predictive models and validated results using time series based statistical tests.
- Built data workflows to process and analyze time-series data for last mile delivery
- Applied advanced feature engineering techniques, including statistical and temporal transformations, to enhance ARIMA model performance.
- Summarized findings into TABLEAU dashboards, and documentation in confluence.

- Contributed to collaborative data science projects by maintaining code repositories and adhering to version control best practices.

Trainee July 2024 – Aug 2024

Argonne National Lab *Chicago, IL*

- HPC for deep learning and mathematical modeling
- CUDA programming in Julia for rapid training of neural networks and numerical simulations

Undergraduate Research Experience in Data Science June 2019 - August 2019

Statistics, Machine Learning *Carnegie Mellon University, PA*

- Combined network analysis based metrics with statistical models to build a network performance estimator.
- Developed a statistical model for pass chains using spatio-temporal sensor data from soccer games.
- Participated in various research talks covering interdisciplinary topics within data science, economics, and climate modeling.

Conferences presentations

University Marine Energy Conference, Durham NH Oct 2023

- Presented methods and framework on optimizing layout and dimensions of WECs together.

SIAM Optimization Conference, Seattle WA May 2023

- Chaired the session on numerous applications of different kinds of optimization applications.
- Optimization of design concentric cylinders using differentiable semi-analytical matched eigenfunction method

OpenMDAO Conference, NASA Glenn Research Center, Cleveland Ohio Oct 2022

- Performed the coupling of the BEM (Boundary element method) solvers within openMDAO optimization framework.

Midwest Data Science Conference, Optum, MN Oct 2018, 2019

- Presented on the prediction of healthcare cost using RandomForest and XGBoost algorithms.

Posters

- Presented a poster on the simulation of the migration of bats - WSU Research.
- Displayed a poster on network modeling of events data at Carnegie Mellon sports analytics conference.
- System Architecture for eVTOL-based Emergency Medical Services, Kapil Khanal, Danushka Edirimanna, Hins Hu

Honors, Awards and Grants

AWS compute credits award Feb 2023, 2024

- Awarded compute credits worth $15k for computational simulations and machine learning.

Seedling Grant (Phase I & II), Sandia National Laboratories Feb 2023, 2024

- Seedling grant to develop a differentiable BEM numerical method for systems engineering applications.

Systems Graduate Fellowship Aug 2022

- Awarded a graduate fellowship by the Systems Department, Cornell University.

Outstanding Student Award May 2020

- Received an Outstanding Student Award from the WSU Mathematics and Statistics department.
- Recipient of the Presidential Honor Scholarship for high academic achievement.
- MinneAnalytics Scholarship recipient for extensive contributions to the broader analytics community in the Midwest.

MUDAC-Data Analytics competition Aug 2018

- Presented a report on Diabetes and insurance Cost with the prediction of healthcare cost for each anonymized patient, using Python and R libraries and Tableau extensively.

Best Overall Analysis, Police Data Challenge (ASA) Dec 2017

- Participated in a nationwide (USA and Canada) competition organized by the American Statistical Association.
- Presented analysis on the pattern of 911 calls in Seattle to a panel of statisticians and criminal justice reform professionals.

Teaching and Tutoring

- Multidisciplinary Design Optimization, Machine Learning, Data Structure, Object-Oriented Programming, Supervised Learning.

Data Project: Minnesota Lake Quality

- Developed and deployed a REST API for batch predictions in a citizen science project analyzing water quality data of Minnesota lakes.
- Implemented a CI/CD pipeline for machine learning delivery using Heroku, enabling automatic detection of new data files and seamless integration of model updates.
- Designed a data pipeline to handle local data processing and integration with cloud storage services (e.g., Amazon S3).
- Utilized tools commonly used in commercial applications: CI/CD frameworks, REST APIs, and cloud-based deployment.
- Collaborated with data from the Minnesota Department of Natural Resources (DNR) to integrate domain knowledge into the data preparation process.
- Gained hands-on experience delivering a complete data product, emphasizing practical deployment and integration over predictive performance.

Technical Skills

Programming Languages

Python(8+ years), R(8+ years), SQL (8+ years); Julia (5+ years)

Tools and Platforms

Snowflake, AWS (S3, Lambda), Databricks, Heroku, CI/CD frameworks (e.g., GitHub Actions, Jenkins)

Other Skills

Machine learning deployment, REST API design, data pipelines, cloud-based analytics, automatic differentiation and integration

Relevant Courses

- Differentiable Programming, Hydrodynamics , Multidisciplinary Design Optimization (MDO), Mathematical Modeling, Inverse Problems, Complex Systems, Machine Learning, Artificial Intelligence, Statistical Modeling, Data Science at Scale, Advanced Mathematics, Principles of Data Science, System Architecture

Professional Associations

American Statistical Association, MinneAnalytics, INCOSE, Society of Industrial and Applied Mathematics (SIAM), American Society of Mechanical Engineers (ASME)

Publications and Conference Papers

- Kapil Khanal, Carlos A. Michelén Ströfer, Matthieu Ancellin, Maha Haji). Fully Differentiable Boundary Element Solver for Hydrodynamic Sensitivity Analysis of Wave-Structure Interactions , Submitted to Applied Ocean Research
- Multi-Objective Multidisciplinary Optimization of Wave Energy Converter Array Layout and Controls ,https://dx.doi.org/10.2139/ssrn.4891821
- Open-source toolbox for semi-analytical hydrodynamic coefficients via the matched eigenfunction expansion method, McCabe Rebecca, Khanal Kapil, Haji Maha, UMERC Conference, Aug 7, Duluth, Minnesota
- Khanal, K., & Haji, M. N. (2022, October 25). Multidisciplinary Design Optimization for Novel Offshore Systems. Presentation at the openMDAO Workshop, NASA Glenn Research Center, Cleveland, Ohio
- Khanal, K., McCabe, R., & Haji, M. N. (2023). Gradient-Based Design Optimization of Concentric Cylindrical Offshore Structures. In Proceedings of the SIAM Conference on Optimization (OP23), May 31,Seattle. Washington
- Khanal, K., Vitale, O., DeGoede, N., & Haji, M. (2023, October 4-6). Multi-objective Multidisciplinary Optimization of Wave Energy Converter Array Configurations and Controls. Presented at the University Marine Energy Research Community 2023 Conference, Durham, NH, USA

Volunteering

- Budget Expenditure Dashboard, Winona Area Public Schools Dec 2017 Data Extraction from scanned pdf's and a detail visualization of budget and expenditure data to help them prioritize the budget spending for schools.
- Deploy Dashboard for quick access to citizen scientists. Aeon Housing-Non-profit organization. Exploratory analysis on experience of tenants on Aeon's affordable houses.