2024 NHERI and AI Computational Academy Agenda (Tentative)

(all times are in US Central)

2024 NHERI Computational Academy Projects

Project 1: Optimizing ADCIRC simulations using AI/ML

Project description: The project will involve modeling storm surges using full-scale ADCIRC. The team will then train ML models such as XGBoost and random forest to develop a fast and accurate surrogate model. The coastal impact of storm surges across Texas will be evaluated.

Project 2: Graph Network Simulator for surrogate modeling

Project description: GNS is a state of the art neural network simulator that leverages graph structure to represent the domain and learn the local interactions. This project will explore using GNS as a differentiable simulator to solve inverse problems for structural and geotechnical issues, such as earthquake-induced landslides or structural behavior. Using gradient-based differentiable simulators we aim to accelerate optimizing the design of infrastructure and safety features.

Project 3: Equitable emergency response and recovery during flooding

Project description: Situational awareness data inequity could translate to inequitable emergency response and recovery assistance. This project will collect historical community flood reports and contextualize them with sociodemographic and flood inundation data to quantify and visualize situational awareness data equity during a past flood event in Houston. Insights gained during this project will enable inequity-aware emergency response and recovery strategies and promote long-term community resilience.

Project 4: LLMs for liquefaction analysis

Project description: Leveraging ChatGPT to identify new knowledge in liquefaction Accessing ground motion databases and Next Generation Liquefaction dataset requires sophisticated knowledge of API requests or SQL query construction. The project aims to develop a plugin interface to facilitate complex queries and discover new knowledge through Large Language Models, such as ChatGPT.

Project 5: Employing AI/ML to predict wind loads on low-rise buildings.

Project description: Low-rise residential buildings are vulnerable to wind damage during extreme weather events like hurricanes. Accurately predicting the wind loads on these structures for various exposure conditions and building shapes is crucial for mitigating potential wind-related damage. This project leverages aerodynamic datasets

obtained from boundary layer wind tunnel measurements to develop ML-based models for predicting wind loads on archetype low-rise buildings. You will kick off by collecting the necessary dataset via Web API and then investigate the variation of wind pressure on the building surface across different parameters. Then, using PyTorch libraries, you will create deep learning models and train them using the prepared datasets. In the final phase, you will assess the performance of each model in predicting both mean and peak wind pressure patterns for unseen representative configurations.

Project 6: Sensitivity analysis for regional-scale risk assessment.

Project description: Running regional-scale hazard risk analysis requires substantial effort in collecting different kinds of input information ranging from asset characteristics (e.g., number of stories, built year of buildings and bridges), hazard characteristics (e.g., rupture, soil property, water elevation) to local design standards. With a case study example, this project will investigate the consequential impact of each input to the final decision variables, and identify what information is more important than others. Such exercise can better guide the data collection effort and facilitate reasonable assumptions for the regional analysis. To this aim, global sensitivity analysis methods will be investigated. After this session, the participants will be able to

- Run regional-scale risk simulation through R2D
- Understand the benefits and limitations of global sensitivity analysis
- Perform basic sensitivity analysis using python and quoFEM

Project 7: From the Table-Top to the Computer and Back: Using HydroUQ for Experiment-Simulation Validation

Project description: Design against hazards such as tsunamis and landslides are reliant on simulations, but are they correct? Learn how to perform an easy table-top experiment and replicate it in HydroUQ to check your modeling abilities. Then, design a blind-study by modifying the numerical simulation set-up and running a case in HydroUQ. Afterwards, try to match it on the table-top.

Together, perform the initial non-blind experiment and simulation. Individually, perform a shared blind numerical-experiment case. Finally, compare results as a team to observe the biases introduced unintentionally by individuals in simulations and experiments.

This project is suited for those in the fields of landslides, avalanches, tsunamis, and storm-surges where the Material Point Method excels. Students who want to bridge experimental, simulated, and real hazards will benefit, as well as those who'd like to learn more about HydroUQ, the Material Point Method, and GPU-acceleration. Free access will be provided on TACC Frontera and Lonestar6 to high-end nodes equipped with 4 Quadro RTX 5000 and 3 A100 GPUs.

Project 8: Transportation Infrastructure Performance under Seismic Hazards with SimCenter Tools

Project description: This project applies the workflow of seismic hazard analysis, transportation inventory generation, infrastructure performance assessment, and traffic flow simulation in SimCenter's R2D Tool. Participants will apply data mining and processing for regional transportation inventory generation and traffic demand data collection. SimCenter tools will be used to assess likely physical damage on the transportation infrastructure (e.g. roads and bridges) and determine the traffic service disruptions caused by seismic hazards. Extending SimCenter's Pelicun framework by incorporating user-defined fragility functions for infrastructure performance assessment will be explored.

Project 9: Open project. Teams will be formed based on interest. Choose at least two areas.

Choose area of interest:

(1) Scientific Machine Learning
(2) AI/ML algorithms
(3) Computer Vision
(4) Large Language Models
(5) Cyber Infrastructure development
(6) Natural Hazards
(7) Civil Engineering applications

2024 NHERI COMPUTATIONAL ACADEMY AGENDA

Day 1: 23rd July (Tue)	
8:00 - 8:30 AM	Breakfast
8:30 - 8:45 AM	Introduction to NHERI Computational Academy - Dr Rathje Introduction to DesignSafe and SimCenter
8:45 - 10:30 AM	Scientific Python and Launching Jupyter notebooks on DS (Charlie Dey)
10:30 - 10:45 AM	Break
10:45 - 12:00 PM	Project: Team meeting and ice breaker
12:00 - 1:00 PM	Lunch
1:00 - 2:00 PM	Machine Learning/Artificial Intelligence (Krishna Kumar)
2:00 - 3:00 PM	Physics Informed Machine Learning (Somdatta Goswami)
3:00 - 3:15 PM	Break
3:15 - 5:00 PM	Project Time (1.75 hr)
Day 2: 24th July (Wed)	
8:00 - 8:30 AM	Breakfast
8:30 - 9:30 AM	TAPIS and launching SimCenter jobs (Justin Bonus)
9:30 - 10:30 AM	Uncertainty Quantification (SimCenter)
10:30 - 10:45 AM	Break
10:45 - 12:00 PM	Data Analysis (Scott Brandenberg)
12:00 - 1:00 PM	Lunch
1:00 - 2:30 PM	Project Time (1 hr)
2:30 - 2:45 PM	Break
2:45 - 5:00 PM	Project Time (2.25 hrs)

Day 3: 25th July (Thu)	
8:00 - 8:30 AM	Breakfast
8:30 - 9:00 AM	Visualization
11:00 - 12:00 PM	Project Time (1 hrs)
10:00 - 10:15 AM	Break
10:15 - 11:00 AM	Training
11:00 - 12:00 PM	Project Time (1 hrs)
12:00 - 1:00 PM	Lunch [Office hours: Collaborations with SimCenter and DesignSafe]
1:00 - 3:00 PM	Project Time (2 hrs)
3:00 - 3:15 PM	Break
3:15 - 5:00 PM	Project time (1.75 hrs)
Day 4: 26th July (Fri)	
8:00 - 8:30 AM	Breakfast
9:00 - 10:30 AM	Project Time (1.5 hrs)
10:30 - 10:45 AM	Break
10:45 - 12:00 PM	Project Time (1.25 hrs)
12:00 - 1:00 PM	Lunch
1:00 - 2:00 PM	Project Time (1 hr)
2:00 - 4:00 PM	Project Presentations 7 @ 15 min Presentation