



Natural Hazards Engineering Research Infrastructure

Machine Learning Problem Solving 2023 NHHERI SimCenter University of California, Berkeley

- **Summary-** Students will learn about what machine learning is and how it can be used to solve various types of problems. The lesson will incorporate examples of applications to earthquake and wind engineering. After learning about machine learning, students will be asked to brainstorm ideas of how they could use machine learning models to solve problems and be encouraged to investigate programming and engineering as future careers.
- **Engineering Connection-** This lesson is related to engineering as it is a software development approach to solving many types of engineering problems.
- **Audience-** This lesson is targeted towards students in early high school (grades 9-10)
- **Lesson Objectives-** Students will first learn about what machine learning is, with various types of models discussed along with their strengths and applications. Then, they will see a couple of models in action with a physics informed neural network being used to predict maximum displacement of a one-story building during an earthquake, and a multi-layer perceptron predicting peak pressure coefficients on a building surface. Finally, the students will be asked to brainstorm how they could use machine learning to solve problems in their daily lives (for example, if I create a model and train it on coefficients to a quadratic equation, it would be able to factor it for me). The students will be encouraged to learn how to code and learn about the importance of software to society and engineering practices, as well as be encouraged to pursue more STEM courses and consider a career in STEM.
- **Educational Standards-** We want to expose students to the capabilities of machine learning – it's current and future applications. Students in grade 9-12 are becoming more familiar with AI already with AI programs that are available and able to generate songs and art or even summaries and essays like Chat GPT.
- **Material List-**
 - A projector or smartboard will be needed for diagrams and pictures to help explain the models and machine learning.

- A computer will be needed to run the example codes and show how they make predictions and the training process
- A whiteboard and markers will be needed for the brainstorming session
- **Introduction-** Machine learning is a subset of artificial intelligence where computers can learn from data and learn relationships, make decisions, and form accurate predictions without being programmed with the explicit underlying principles governing the relationships between variables. These models have huge potential in engineering as machine learning models can formulate insights into data relationships what human computation or traditional algorithms might not be able to do. Also, it is a very efficient methodology that reduces the amount of computation involved in a problem and can process data in an efficient manner. For example, when processing many images of dogs, the model can learn which image is of which breed of dog, without knowing anything about dog breeds. Machine learning allows engineers to avoid repetitive tasks, achieve greater precision in analysis, learn about relationships in large datasets, and find solutions to many types of problems.
- **Procedure-**
 - Background knowledge
 - Give an overview of what machine learning is and how computers can learn from data.
 - Explain and show a diagram of a decision tree.
 - Explain what neural networks are and compare them to biological neural networks.
 - Explain convolutional neural networks and how they are used in image recognition
 - Before the activity
 - Ask students what they know about artificial intelligence.
 - Ask students what impact they think artificial intelligence will have in the future and how they think it can benefit society.
 - During the activity
 - Show students examples of how ML can be used in natural hazards engineering.
 - Show an example of a physics informed neural network predicting maximum displacement of a building during an earthquake
 - Show an example of a multi-layer perceptron predicting peak wind pressures that a high rise building would experience
 - After the activity

- Ask students to brainstorm data-driven problems that they could solve with machine learning models
 - Ask students to summarize what they learned about machine learning and artificial intelligence
 - Emphasize that software development is going to be a big part in the future and encourage students to learn how to code
- **Assessment-** The lesson objectives will be achieved if students are able to come up with viable examples of how machine learning models could be implemented in their daily lives. This would mean that they truly understand how the models can be used to solve a variety of problems. Furthermore, if the students are able to summarize how machine learning models work, then they understand the material. Lastly, if students are motivated to learn how to code from this lesson, then the lesson served as inspiration to contributing to this front of engineering innovation.
 - **Wrap-up-** The lesson will be concluded with a review quiz on the types of machine learning models and their applications to review the material and ensure retention. Also, having a discussion on the importance of programming in the future of innovation will ensure that students are encouraged to look into coding classes and think about careers in STEM.