Machine Learning in Upper-Level Physics Lab

PICUP Virtual Capstone Conference

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• Project

• Physics Content

• Resources
Project: NDI + ML

Can Non-destructive Inspection benefit from Machine Learning techniques?

- Strike Aluminum sheet
- Record the sound
- Based on audio data, determine if sheet is damaged
  - ML and Classical analyses

Great for engineering research project. But for physics lab?
Physics: Red Flags

• Black Box
  • Model fit... where you don’t know what the model is!

• Ignoring good experimental practice
  • “Lazy” procedure
  • No analysis of uncertainty

*Robustness is a plus for engineering*
Physics Content: Feature Selection

• Conceptual Thinking
  • What is the expected signal?
  • What is the minimum signal needed?

• Data Science Skills & Literacy
  • Preprocessing raw data

h/t Brian O'Shea
Physics Content: DAq + Calibration

Your smartphone is a mobile lab.

https://phyphox.org/

- Tuning fork calibration
Resources: Google Colaboratory

- Common Machine Learning, Data Science libraries available
  - Supervised learning with simple physical systems often train fast

Very accessible for students with no experience
Resources: Google Colaboratory

- Mount and browse Google Drive

```python
from google.colab import drive
drive.mount('/content/drive')
```

```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```
Resources: TensorFlow Tutorials

- Import into Colaboratory
- Includes code for building, compiling, and training neural network

https://www.tensorflow.org/tutorials/keras/classification
Resources: phyphox

- App to access sensor data from a smartphone
- Write CSV file

https://phyphox.org/
Resources: Our Code and Data

- Find our experiment on the Open Science Framework, at
  https://osf.io/excgw/
  
  - Project description
  - Data
  - Links to code (in the Wiki section)
ML in a Physics Lab Class?

How

• Reduce data collection calendar time
  • Data sharing between groups

• Pedagogical ML material

• Code templates

Benefits

• Inexpensive experiments
• Research in an open space
  • Successful ML results are common
Thank you!

Comments, Concerns, and Questions welcome at

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