System of Networked Sensors for Detection and Characterization of Underground Activity

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MOTIVATION

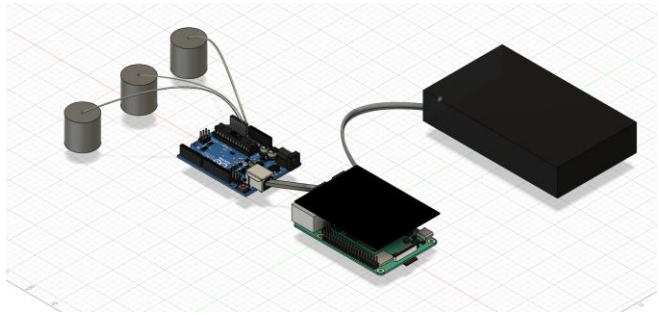
Underground Detection Systems

- Commercial systems are expensive, complex, time consuming to setup, and can be difficult to interpret.
- Goal: Create a system that is portable, cheap, easy to setup, and user-friendly with intentions that project could be scaled up for another Design team in the future.

PROJECT DEFINITION

- Data Acquisition
  - Geophone sensors to capture ground vibrations
  - PCB to acquire full oscillation information
- Arduino Due
  - Analog-to-Digital Conversion
- Raspberry Pi
  - Data Logging, Processing, and Display Results to Display
  - Power Brick Battery daisy-chains power to components

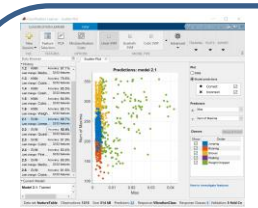
DESIGN DESCRIPTION



The system is mainly composed of three parts:

- Geophone Sensors with DC Offset PCB
  - Passive Vibration sensors will be offset by 1.65V to capture peaks and troughs of oscillations.
- Arduino Due
  - 12-bit Resolution for Analog-to-Digital Conversion
  - Serial communication via USB port to Rpi for data logging.
- Raspberry Pi
  - Data logging of Serial data from Arduino.
  - Python scripts that Preprocess logged data and Extracts Statistical and Analytical Features that are imported into a KNN Machine Learning Model.
  - Displays predictions of Vibrations to GUI, which includes History tab for previously occurred events.
- Power Brick Battery
  - Provides 12V 6000mAh/5V USB DC voltage

DESIGN VALIDATION



	precision	recall	f1-score	support
Jumping	0.88	0.86	0.87	74
Running	0.85	0.88	0.86	72
Shovel	0.88	0.88	0.88	76
Walking	0.89	0.95	0.92	61
Weight Dropped	0.96	0.90	0.93	82
accuracy			0.89	365
macro avg	0.89	0.89	0.89	365
weighted avg	0.89	0.89	0.89	365

MATLAB Classification Learner verified KNN model's accuracy will be 80-85%

Python's individual accuracy for 5 different class of vibrations

GUI displays 89% accuracy for 1200 observations of 5 vibration classes

FINAL PRODUCT, CONCLUSIONS & FUTURE PLAN

Networked Sensors System featuring:

- Low Cost, Portable, Minimal Size, and Weight system that's simple to setup
- Machine Learning model trained for 5 different vibration classes with an accuracy range of 80-90%
- GUI displaying Accuracy and History of Predictions to Rpi 4" LCD screen
- Power Brick Battery that can self-power system for about 10-11 hours
- Project could be expanded by scaling up number of sensors, including filtering/amplifiers to sensors, and increasing signal library to train model to classify more vibration sources

References

[1] D. H. Cross, "Terrain Considerations And DataBase Development For The Design And Testing Of Devices To Detect Intruder-Induced Ground Motion," May-1978. [Online]. Available: https://apps.dtic.mil/sti/pdfs/ADA055602.pdf.
[2] Rubin, Marc & Camp, Tracy & van Herwijnen, Alec. (2012). Automatically Finding Avalanches in Geophone Data: A Pattern Recognition Workflow. International Snow Science Workshop (ISSW).

4/14/21 Acknowledgements: Our group would like to acknowledge the input and support of our CM: William Shepherd and TM: Dr. Tomas Materdey