Music On Mars:
Using Fourier Analysis Spectra to Differentiate Martian Geology
New Mexico
Supercomputing Challenge
Final Report
April 25, 2022

Team: 7
Capital High School

Team Members:
Juan De La Riva
Mariah Mejillas Rivera
Gilberto Morales
Jairo Salas Banda

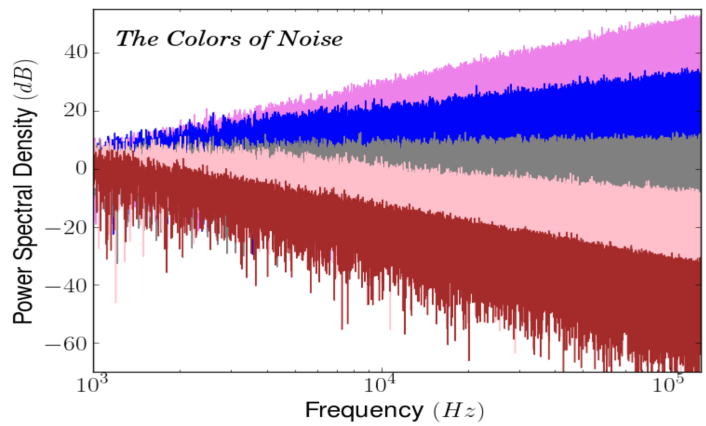
Project Mentor:
Mohit Dubey

In the 2022 Supercomputing challenge, our team is working to find if there is any correlation between the sound of a Laser-Induced Breakdown Spectroscopy, LIBS, impacting a rock on Mars and the resultant spectra. Our initial intent on this project is to analyze the data retrieved from the Planetary Data System (PDS) website. Our purpose is to identify minerals by analyzing the audio files and their characteristics. The information provided by our (PDS) data can help with further research on an unexplored planet. So far, we have gathered data from Mars, such as audio, images, and spectra. In this project, we plan to target the audio files and the differences between the high and low frequencies to find more about the mineralogy of the audio files.

To assist in our goal of identifying mineralogy, we will use Python and Librosa to organize the data computationally. First, the program will be able to take the inputted sound file with audio from the SuperCam Calibrated Spectra data collection. The program outputs a spectrogram of the frequencies from the file, allowing us to analyze the data. The spectrogram would be one way to identify what type of noise the sound file is. Additionally, the program would also output data sets for us to analyze. The data would contain general data like the name of the sound file, the slope, its noise type, and additional information. We will differentiate the colors of noise by checking the line best fit for the frequencies.

At the start of the challenge, we began with some research into some vital topics and information that will be important later. Some things that were unfamiliar to us were subjects such as laser-induced breakdown spectroscopy, the important oxides on Mars, and the missions happening on Mars. Additionally, each team member researched articles, videos, and terminology. With the help of our mentor, we cleared up any questions and learned about solutions to how we could proceed with our project. We used the existing resources that one of our team members had previously done. We then learned how to translate the files to analyze the different colors of noise.

The results that our team hopes to get from this project are generally to understand more about Mars, its terrain, and mineralogy. We expect to get the results from the different frequencies and differentiate the rocks on Mars. The program should be able to produce a spectrogram of the selected file, even if the code was to be changed itself. We will be using this program that's being manipulated to the best of our abilities to benefit further research into Mars.



Here is an example image of the characterization of the different colors of noise. In this example, we can see violet, blue, grey, pink, and red noise. However, brown noise and white noise also exist. These identifications of colors of noise can identify the energy of the sound signal. The spectrograms can help determine the physical essence of the energy distributed in the frequencies. Additionally, it can record the speed of the sound. Each one of these noise colors sounds different to human ears.

Violet noise: https://www.youtube.com/watch?v=GYZy5f92FpQ
Blue noise: https://www.youtube.com/watch?v=WSCU_t3o7KI
Grey noise: https://www.youtube.com/watch?v=0iGdLDeyeso
Pink noise: https://www.youtube.com/watch?v=ZXtimhT-ff4
Red noise: https://www.youtube.com/watch?v=9Fs7-lzyBa4
Brown noise: https://www.youtube.com/watch?v=snlA7rFR0iQ
White noise: https://www.youtube.com/watch?v=nMfPqeZjc2c

Importing of necessary libraries for the main function.

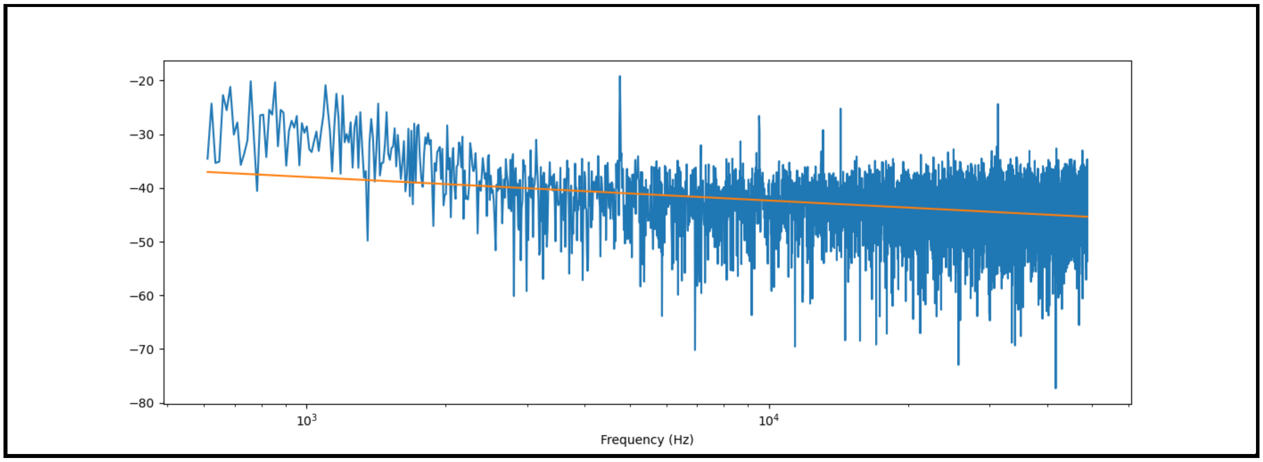
```
#Import all the required libraries...
import librosa, librosa.display
import numpy as np, scipy, matplotlib.pyplot as plt, IPython.display as ipd, pandas as pd, glob
from scipy.optimize import curve_fit
```

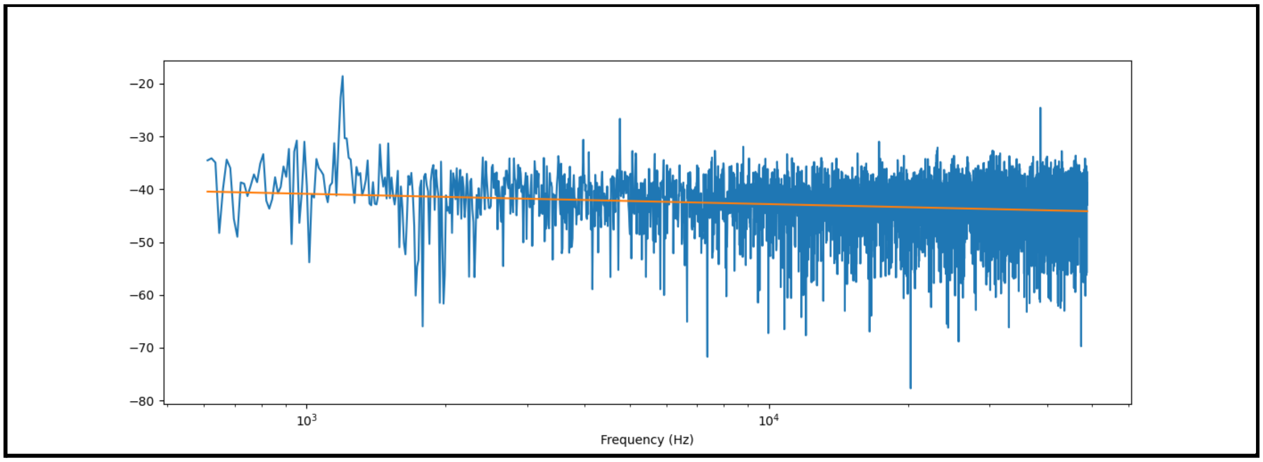
Main function of the program.

```
#Creating a spectrogram set to log-log scale...
def spec_log(sig, rate):
        global popt
        global pcov

        n = np.linspace(0, rate/2, 10096)#4096
        X = scipy.fft.fft(sig[25000:125000])#25000; 125000
        X_mag = np.absolute(X)
        dB = 20*np.log10(X_mag/np.amax(X_mag))

        def f(x, A, B):
                return A*np.log(x) + B

        popt, pcov = curve_fit(f, n[50:4000], dB[50:4000])
        #Use popt as the slope to compare to the other noises.
        print(popt[0])

        if popt[0] < 1 and popt[0] > -1:
                print('The audio file is White noise.')
        elif popt[0] < -2 and popt[0] > -8:
                print('The audio file is Pink noise.')
        elif popt[0] < -8:
                print('The audio file is Brown noise.')
        elif popt[0] > 2 and popt[0] < 8:
                print('The audio file is Blue noise.')
        elif popt[0] > 8:
                print('The audio file is Violet noise.')

        plt.figure(figsize=(14,5))

        plt.plot(n[50:4000], dB[50:4000])
        plt.plot(n[50:4000], f(n, *popt)[50:4000])
        plt.xscale('log')
        plt.xlabel('Frequency (Hz)')
        #plt.show()
```

Outputting and saving the spectrogram of the sound file.

```
#Outputing the data into a single spectrogram.

(sig, rate) = librosa.load('marsData/soundFiles/ascam_sol0076.wav', sr=None)
spec_log(sig, rate)

plt.savefig('ascam_sol0076.png')
```





ascam_sol0004
Unidentified

Executive Summary :

As humans, we were born with a natural curiosity to question life and discover the unknown in our world. That is why we as a team have pondered over whether there may be life outside of Earth. We uncovered that "the intangible desire to explore and challenge" our boundaries had to be tested by us firsthand. We were aware that we could only reach a certain degree to which we could unmask the secrets of space. However, with our capabilities, we knew we could make a trail that could later help scientists in this field determine one day if there were microbial life on Mars. As scientists have taken research from Mars to gather as much information on it, they have also gotten research that we have used to our advantage for our particular interests. We, as a team, have brought a pair of "fresh ears" to analyze different frequencies from the 2020 SuperCam Calibrated Audio data collection.

The value we have gotten from our project has shown us data that we can use as comparisons between the known and the unknown of Mars. The spectrogram of the frequencies from the file has allowed us to learn more about Mars's terrain and mineralogy. With the data we collected on Mars terrain, we could take it further by questioning the mineralogy, color, textures, durability, density, and melting point. The data could prove vital for further investigation on Mars, which is crucial for our future. The discoveries that we've made from the Mars Rovers have allowed us to study mineralogy through frequencies that can be compared with the minerals here on Earth.

However, we haven't finished our project just yet. Although we have made considerable progress, we can do more to improve and learn more about our topic. We have converted the sound files into spectrograms to compare data, but we have yet to find sources of data to compare. In the future, we plan to continue searching for possible data to compare to our data or sound files that we can run through our program to then compare to what we previously gathered. Additionally, we can modify our current program to be more efficient in its function of spectrogram conversion. No matter the case, we still have plenty to work on in our data analysis from the Mars rover, and we hope to learn more about mars and its mineralogy in future work.

Table of Contents:

"Planetary Data system, NASA" https://pds-geosciences.wustl.edu/missions/grsfe/index.htm

"Colors of noise." *Wikipedia*, Jan. 2022, https://en.wikipedia.org/wiki/Colors_of_noise

"Perseverance Rover's SuperCam Science Instrument Delivers First Results." *NASA Science MARS Exploration Program*, 10 March 2021, https://mars.nasa.gov/news/8885/perseverance-rovers-supercam-science-instrument-delivers-first-results/

"The SuperCam Instrument Suite on the Mars 2020 Rover: Science Objectives and Mast-Unit Description." *Springer Link*, 12 April 2021, https://link.springer.com/article/10.1007/s11214-021-00807-w

Pink noise, Wikipedia, https://en.wikipedia.org/wiki/Pink_noise