PLANETS: Remote Sensing

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Introduction

PLANETS (Planetary Learning Advancing the Nexus of Engineering, Technology, and Science) is an out-of-school-time program for students from grades 3-8. Funded by NASA, and in collaboration with USGS, NAU CSTL, Museum of Science Boston, EiE, and WestEd, they provide STEM learning, focusing on planetary science and engineering. They wish to incorporate inclusivity into their lessons, specifically their Remote Sensing Unit. We developed four ways to help blind and low-vision youth access the spectral data of six different minerals from Mars.

Procedures

Python:

We cleaned up source data files with Colab by converting frequency to wavelength, changing scientific notation to floats, and performing pre-processing to ensure readability. We generated white noise and other audio with various sampling frequencies, FIR (finite impulse response) filter orders, and duration. Using FFT on the audio files, we created a fourier series to filter the white noise/audio.

Pure Data:

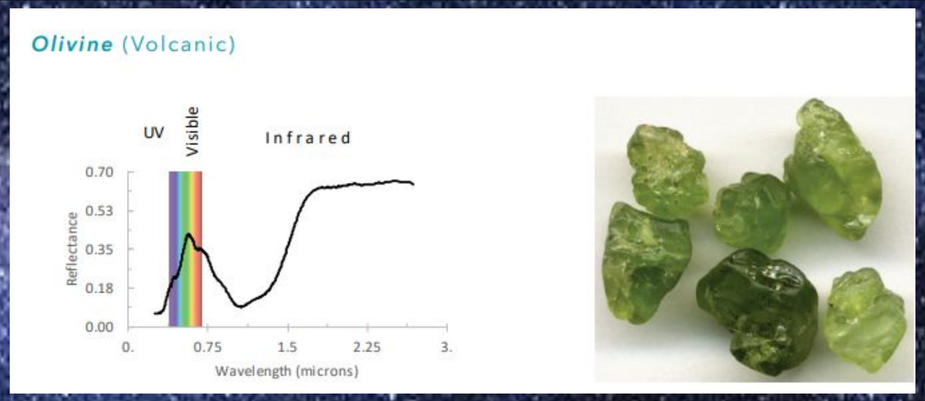
We opened the data as a .txt file and loaded into an array. We iterated through the array using the tabread and the for++ objects. Processing is done to keep the time at 10 seconds. The reflectance was multiplied at each wavelength to an audible frequency. The data was run through an A# pentatonic scale filter and played on oscillator. A new .wav file was opened using the bang trigger and was written to the disk.

Abstract

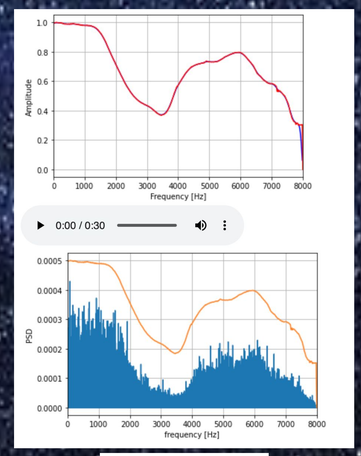
We worked on a project called PLANETS, an out-of-school-time curriculum that integrates NASA planetary science and engineering. With support from NASA, USGS, NAU CSTL, Museum of Science Boston, EiE, WestEd, and our professors, we worked to increase access to PLANETS to support youth experiencing physical disabilities, starting with PLANETS' Remote Sensing Unit. Students will investigate the surface of Mars to landing sites for rovers, which includes analyzing data of six different minerals using their spectra—olivine, pyroxene, kaolinite, nontronite, kieserite, and magnesite. our work provides an avenue for blind and low-vision youth to experience the activity; we sonified the spectra of the minerals, using four different approaches to create audio files.

1. Use Python and its libraries and use the spectra to filter white noise to create audio
2. Use Python and its libraries, filtering various audio files with the minerals' spectra while incorporating stereo sound
3. Use Pure Data to play the audio as a frequency vs. time spectrograph
4. Use Pure Data to play the audio as a pentatonic scale based on the spectra

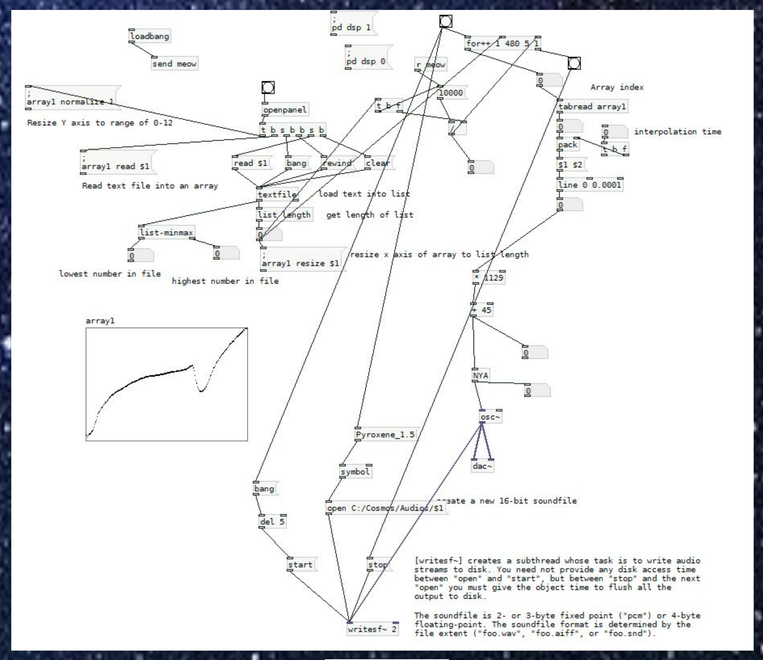
We will continue research of these approaches, and possible others, to improve the project.



Spectral data of olivine, one of the minerals found on Mars



Filtered Audio



Pure Data

```
filenames = ['splib07a_Olivine_GDS70.a_Fo89_165um_BECKb_AREF.txt',
             'splib07a_Kaolinite_CM3_BECKa_AREF.txt',
             'splib07a_Kieserite_KIEDE1.b_fine_gr_ASDFRc_AREF.txt',
             'splib07a_Magnesite+Hydromag_HS47.3B_BECKa_AREF.txt',
             'splib07a_Nontronite_NG-1.a_BECKb_AREF.txt',
             'splib07a_Pyroxene_HS119.3B_BECKc_AREF.txt']

filename = filenames[0]

# load file
ff, fw = load_file('data/' + filename, fs)

# design filter
b, a = design_filter(ff, fw, fs, n)

# compare frequency responses
w, h = signal.freqz(b, a, fs=fs)
plt.plot(w, abs(h), 'b', ff, fw, 'r')
plt.xlim(0, fs/2)
plt.grid()
plt.ylabel('Amplitude')
plt.xlabel('Frequency [Hz]');
plt.show()

# filter noise
y = signal.lfilter(b, a, x)

IPython.display.display(ipd.Audio(data=y, rate=fs))

f, Pxx_den = signal.periodogram(y, fs)
plt.plot(f, Pxx_den, ff, .5*1e-3*fw)
plt.xlim(0, fs/2)
plt.grid()
plt.xlabel('frequency [Hz]')
plt.ylabel('PSD')
plt.show()
```

Designing filters using Python

Materials

- Google Colab
- USGS Spectral Library
- Python Librosa, NumPy, SciPy, IPython, Matplotlib
- USGS Mineral Fingerprints Data Sheet
- Pure Data
- Fast Fourier transform (FFT) algorithm

Results and Analysis

- PD makes the audio easier to understand and distinguish
- Filtering the white noise using Python and its libraries was more difficult
- Helped to propagate education, especially to underserved areas, through PLANETS's main principles of diversity, equity, access, and inclusion
- Produced audio files for educators to download

Conclusion

- The project is likely ongoing as we will continue work with PLANETS, both on sonification of the spectra of rocks and other units in the PLANETS curriculum.
- For the sonification, as of right now, Pure Data (both with and without incorporating the pentatonic scale) has produced audio that is both pleasant to the ear and easy to distinguish from its counterparts.
- Python and audio filter approach needs more research to produce satisfying results.

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