First reflection session:

From a young age, I’ve been passionate about transcribing music by ear on the piano. However, with only relative pitch, my transcriptions are often inaccurate. This changed when I attended the Ross Mathematics Program in 2023 and 2024, where Professor Kurt Bryan introduced me to data processing techniques such as Fourier analysis and compressed sensing. I was fascinated by their wide applications in fields like audio and image processing. One idea that particularly intrigued me was the "marble problem," which illustrates how the different magnitudes of overtones in musical notes—played by various instruments—can help identify the instrument playing a specific note, even if multiple instruments are involved.

For this project, I decided to narrow the scope to situations where the instruments used are the same, simplifying the sparse-finding process. The goal was to develop a system that, when given a complex piece of music, could identify the instruments and output the notes being played. I started by using standard MIDI files for different instruments and applied Fourier analysis to extract the relevant frequency data. Jeff Heaton’s YouTube tutorial on musical note recognition and Professor Bryan’s paper on compressed sensing were both instrumental in shaping my approach.

Interim reflection:

As the project progressed, my focus shifted. Initially, I aimed to detect different instruments using compressed sensing, but I quickly realized that the computational complexity of analyzing multiple instruments and their combinations was a significant challenge. The optimization of music recognition for better accuracy emerged as a more tractable and compelling research topic.

Additionally, I faced challenges in database creation. The Fourier transform initially produced discrete results, but some frequencies were distorted by noise. I worked to refine my data by filtering out these disturbances, but it was more time-consuming than I had anticipated.

Final reflection

This extended essay was an eye-opening experience. It allowed me to combine my academic and personal interests, exploring a topic that had not been previously researched. I also expanded my skill set, learning to use tools like Adobe Illustrator for graph creation and MATLAB for more complex computations. Along the way, I sought feedback from others, including math enthusiasts, which helped me improve my approach.

Overall, this project has been a significant first step in my mathematical research journey. It strengthened my confidence and laid the foundation for future work. Moving forward, I plan to enhance my research by delving deeper into compressed sensing and potentially exploring rhythm analysis using unsupervised learning. This experience has shown me the value of combining different fields of interest and has motivated me to continue pursuing math research in the future.

(429 words)