Alyson Grassi and Molina Nichols
625.620 – Mathematical Methods of Signal Processing
Project Proposal

The goal of our project is to use the Matrix Profile to create code tools that will recognize and return the structure of a song. We intend to use commonly known songs (or some of our favorites!) for which we are already very familiar with the song and its structural makeup of music or lyrics. For example, many popular songs follow a "verse, chorus, verse, chorus, …, bridge, chorus" pattern. In a related fashion, there is often structure to classical music, and fugues in particular exhibit a very specific structure; see https://en.wikipedia.org/wiki/Fugue. (Molly is particularly partial to the fugues from The Well-Tempered Clavier by J.S. Bach) In addition, there are also plenty of popular songs which do not follow a specific verse, chorus structure which could provide useful insight as well (for example, Thunder Road by Bruce Springsteen, Make You Feel My Love by Bob Dylan, and California by Joni Mitchell).

We intend to convert the songs from MP3/MP4 format into WAV format to be able to manipulate the signals and display plots using the tools from ThinkDSP, Matrix Profile, and additional tools that we can develop. ThinkDSP could be used to examine the tonals and primary frequencies for the songs. Once the waveform has been manually examined, Matrix Profile can be employed in order to determine the sections of the wave that are common (or perhaps, dissimilar) to each other. We will develop our own tools or do additional research to find sorting and classification tools to understand the results from the Matrix Profile and identify the structure of the song.

We have thought of a few additional possibilities for analysis that we can attempt to explore. We could attempt to assess similarity between songs, perhaps in the vein that Spotify composes their "Discover Weekly" playlist – songs that are similar to what a user already listens to but which they probably have not heard before. We could simply test this on songs that we do know and see if our code is able to identify their similarity or dissimilarity. Additionally, we could think about how to compose an appealing song based on the most common structures of songs as well as tonals and frequencies. Using our analysis of existing songs, we can collect information and use it to reconstruct a waveform from simpler mathematical functions. This new wave form would hypothetically be an "appealing" song by design.

Some resources we have found:

- SIMPLE: Assessing Music Similarity Using Subsequences Joins (Silva, Yeh, Batista, Keogh)
    - From the Matrix Profile authors
    - https://www.cs.ucr.edu/~eamonn/MP_Music_ISMIR.pdf
- Fast Similarity Matrix Profile for Music Analysis and Exploration (Silva, Yeh, Zhu, Batista, Keogh)
    - From the Matrix Profile authors
    - https://www.cs.ucr.edu/~eamonn/final-fast-similarity-3.pdf
- Perceptual evaluation of music similarity (Novello, McKinney, Kohlrausch)

- o This paper does not take a signal processing approach, but provides some good background for assessing music similarity

  - o https://pdfs.semanticscholar.org/acf4/475a3636186d02a374a74885a348735479a8.pdf
- Time Series Data Mining Using the Matrix Profile: A Unifying View of Motif Discovery, Anomaly Detection, Segmentation, Classification, Clustering and Similarity Joins (Yeh, Zhu, Mueen, Begum, Ding, Dau, Silva, Ulanova, Keogh, Zimmerman, Senobari, Brisk, Gharghabi, Kamgar)
  - o Page 33-34 of the Matrix Profile tutorial, part 1, discusses music analysis
  - o https://www.cs.ucr.edu/~eamonn/Matrix_Profile_Tutorial_Part1.pdf
- Toward Evaluation Techniques for Music Similarity (Logan, Ellis, Berenzweig)
  - o This paper focuses more on identifying similarities between music and would be a useful resource for the "playlist creation" idea
  - o https://www.ee.columbia.edu/~dpwe/pubs/sigir03-wp.pdf