Understanding Music with Higher Order Networks

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ABSTRACT

Music is a natural complex system: notes interact in a sequential way to create melody and interact in a “vertical" way with different instruments to create harmony; only with 12 notes, composers are able to create different styles and music genres. Simple networks have been used to model and analyze music. However, this representation assumes there are no dependencies between notes. To include these dependencies, we model musical pieces as a *Higher Order Network (HON)*. In a higher order network, the dependencies between the nodes are encoded by using sequence of dependent notes as nodes.

We created two sets of higher order networks: HON for music pieces (HON-piece) and HON for music genres (HON-genre). In HON-piece, each musical pieces are represented by a HON; and in HON-genre, we aggregate all the trajectories from musical pieces of the same genre and represent it by a HON. These representations are complementary to each other and serve different purposes. In Figure 1 we show an example of HON-piece.

To demonstrate the utilities of HONs, we proposed various features extracted from the HON-piece and observed that these features align with the common perception of music genres. Additionally, we used the features extracted from HON-piece and random walk on HON-genre to classify music genres.

By using the features from HON-piece, we achieved a classification accuracy of up to 77.7% in Classical vs Folk, and 81.9% in Rock vs Jazz. The genre classification based on random walk on HON-genre is less accurate: 64.7% and 60.9% for Classical vs Folk and Rock vs Jazz respectively. This result indicates that the features that we proposed are indeed able to capture the characteristics that differentiates music of different genre.

To further understand the relationship between HON and music pieces, we conducted a case study on *Blackbird* by *The Beatles*. We identified different parts of the network that corresponded to the beginning of verses, the rest of the verses, and the B-section. This shows the potential of using HONs to analyze the structure of the music piece.

We also investigated the spectral properties of the transition matrix of HONs. We found that the eigenvalue distributions are qualitatively different between different music pieces and have the potential to capture characteristics of music pieces.

There are various avenues for future works in this area, including: 1) incorporating temporal information which is a vital property for music; 2) incorporating multiple instruments for a music piece since our current approach ignores the "vertical" interactions. One potential way to incorporate that is using multilayer networks to represent different instruments; 3) exploring different coding methods such as pitch difference coding.

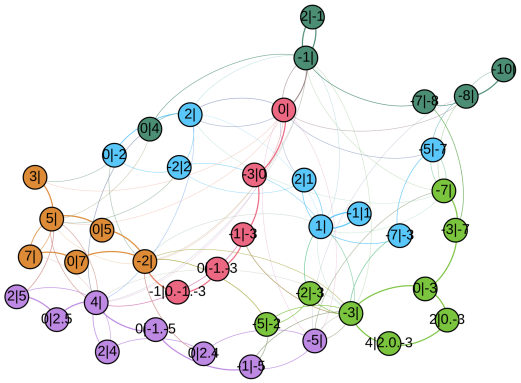

Figure 1. *Bach Prelude from Sonata N6* as Higher Order Network