Towards emotion based music generation: A tonal tension model based on the spiral array

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Introduction

Tension is an integral part of the music listening experience, closely connected to the sensing of emotions. We have explored how a particular aspect of tension, tonal tension, can be modelled and used to guide for automatic music generation.

A model was developed for extracting three aspects of tonal tension (Herremans & Chew, 2016b) from a musical score. The model is based on the spiral array, a three-dimensional model for tonality developed by Chew (2014). This was then integrated in an online interactive system, for easy visualisation, in sync with audio and score. Finally, the tension model was included in a state-of-the-art music generation system called MorpheuS, whereby we use tension to guide the underlying tension fabric of the generated music.

Spiral Array Model

In order to model tonal tension, we first need to be able to model pitches in a meaningful way. This was achieved through the three-dimensional model of tonality called the spiral array (Chew, 2014). The spiral array consists of three sets of helices: one that represents pitch classes, a pair for major and minor triads, and a pair for major and minor keys. The pitch spiral is the one we use for modelling tension. The triads are generated as convex combinations of their member pitches, and keys are represented as convex combinations of their defining chords.

Three new indicators of tension

Tension is a composite characteristic. There are many factors that contribute to the listener's feeling of tension, including loudness, timbre, dissonance, and harmonies. We chose to focus on tonal tension, and propose three characteristics, that are calculated for each time window, or cloud, of notes:

Cloud diameter Calculated as the largest distance between different notes in a cloud, thus capturing the dissonance of a note cluster.

Cloud momentum Calculated as the position change or movement between two adjacent clouds of notes, capturing the amount of harmonic change from one time slice to the next.

Tensile strain Computed as the distance between the centroid of the current slice and that of all pitches, representing the global key.

Figure 1 shows an example of the Tristan chord in the spiral array, a famous tense chord from Wagner's opera Tristan and Isolde. One can immediately see that it spans a large region in the pitch helix, which results in a high cloud diameter.

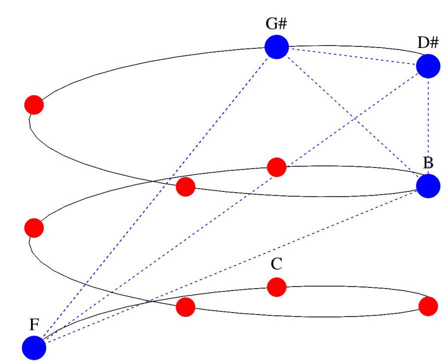

Figure 1: The Tristan chord in the Spiral Array pitch helix.

For a more complete overview of the proposed novel tonal tension model, the reader is referred to (Herremans & Chew, 2016b).

The model can be used for musicological or cognitive science purposes, as we have created an interactive online platform that visualises both tension (Herremans & Chuan, 2017) and arousal valence data (Herremans, Yang, et al., 2017) in sync with musical scores and audio.

Scaffolding music generation

In recent years, automatic music generation systems have become ever more popular due to advances in deep learning. There is a wide range of music generation systems available, e.g. for generating music that matches computer games, harmonizing a melody, etc. For a complete overview, the reader

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Figure 2: Excerpt (bars 1-8) of MorpheuS' piece based on the first of Stravinsky's *Three Pieces for String Quartet*

is referred to the survey paper by Herremans, Chuan, & Chew (2017). In this paper, the current challenges for music generation are identified as generating music with long term structure, and music that communicates certain emotions.

We developed a music generation system, called MorpheuS, which uses combinatorial optimization techniques to generate music with specific tension values over time (i.e., a given tension profile) and recurring pattern structure (Herremans & Chew, 2016a, 2017). MorhpeuS takes as input an existing musical score in MusicXML format. From this piece, the tension is calculated using the model described above. Secondly, recurring note patterns are extracted using the SIA algorithm by Meredith et al. (2002). The user can then use this original tension profile and the detected recurrent pattern structure, or create a new version of these, to scaffold the music generation process.

In the first step of the music generation process, all pitches of the original template piece are erased, but the rhythm is kept intact. A variable neighborhood search algorithm then populates the rhythm template with random pitches, while preserving the repeated pattern structure. The pitches are then optimized to maximize the fit between the current tension profile and the desired tension. For a more in depth explanation, the user is referred to Herremans & Chew (2017).

Figure 2 shows an example of one of the generated pieces by MorpheuS, based on Stravinsky's *Three Pieces for String Quartet*, composed for performance by members of the Singapore Symphony Orchestra on Channel News Asia.

Conclusions

The MorpheuS music generation system tackles one of the biggest remaining challenges in automatic music generation: generating music with structure and with the goal of communicating particular emotions over time. MorpheuS pieces have been performed internationally; recordings of selected pieces can be found online[1].

[1] dorienherremans.com/morpheus

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