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Week # 9
Mar. 10 , 2005

Review #2 (1st paper of the week)

Slicing It All Ways: Mathematical Models for Tonal Induction, Approximation and Segmentation Using the Spiral Array, By Elaine Chew

The algorithm introduced in this paper, which is used for tonal induction, approximation and segmentation, is based on a spiral array model. In the introduction section the author mentions the existing algorithms in which the spiral array is used for computational music analysis, such as for key finding, pitch spelling, and segmentation. Then she introduces and explains about the spiral array models:

This array model is a geometric model that finds the similarities in the tonality, (the hierarchical entities that form the framework of pitch relations), and it segments the data corresponding to those tonal similarities. It is basically summarizing the musical information and saving those as interior points inside a spiral array, in which the tonal similarity is the deciding factor for the proximity of the points: close tonal entities are spatially near each other. This fact is one of the design criteria of these arrays.

Spatial models have several advantages, such as the fact that any collection of notes can be summarized using a center of effect, a combination of its pitch classes. There are several ways for weighting the pitch positions like the total duration of the pitch class, sum of the weights or the corresponding notes, or combination of those. The center of effect is very important for the computational approaches used in this paper for music perception and cognition.

After introducing the spiral arrays, the author talks about the usage of the spiral arrays in "tonal induction", particularly about a method called CEG (center of effect generator) proposed by herself, in which the spiral arrays are used for computing the key context of melody and is based on nearest-neighbor search. She continues with a generalized form of CEG, in which a window of any size is used for defining the tonal context.

The arrays are also used in "pitch spelling" that takes advantage of sliding windows. Pitch spelling is an essential part of automatic transcription, key finding, and tonal induction. In order to find an accurate pitch spelling, in addition to considering the pitch height, they bring to account the c.e. and the spelling is decided using a nearest neighbor search on the pitch class spiral.

Next section is about tonal segmentation in which the author mentions that agreeing on "correct" segmentation is hard even for musical experts. Then she describes two algorithms for tonal segmentation: first, a static method, boundary search algorithm, in which the number of boundaries needs to be known in advance.

The second algorithm is the proposed algorithm, Argus, which is a real-time, O(n) algorithm and uses a pair of sliding windows for tonal segmentation/induction. For each point in time, Argus computes the difference between the local context in the past (back window) and in the future (forward window), then if the value assigned to that difference is more than a threshold, that point is considered a boundary for the segment.

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During the experiments the author has tested different window sizes and thresholds. The algorithm is demonstrated on one and tested on two musical pieces (McDowell's "To a Wild Rose", a Schubert's Allegretto from Moment Musical D780 No. 6, and a Thema from his Impromptu D935 No. 3). Argus accurately found the tonal-segmentation boundaries in all the three pieces, with zero errors in the last two. The best results for the first two achieved when the window size was equal to four bars.

The O(n) complexity of Argus makes it suitable for large databases. The algorithm works better when the forward and back window pitch classes are distant. It also works well when the boundaries are in distinct keys. It might not work as well in distinguishing relative minor/major modes. The algorithm has been criticized for lack of distinction between the harmonic and passing notes.

This algorithm can be used in different applications, such as quantification of tonal tension at each point in time, or music visualization, automated accompaniment, music information retrieval, and expression synthesis.

Overall the paper is well written and explained but a bit long, although more examples and experiments are required.