Full Title*

Subtitle†

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Transformations and musical patterns -> Haskell ->

Additional Key Words and Phrases: transformation, edit distance, musical patterns, evaluation, clustering, ...

1 INTRODUCTION

Hierachical structures in music. Music is known to have rich hierachical structures, from form to phrase, harmonic structures, melodic constructs, etc.. One can comprehend music at different time scales. There have been many theories on this topic, such as the General Theory of Tonal Music (GTTM) [] and the Schekerian theory of melodic reduction []. By examining what is the backbone of the piece and where are the rest, we can view music from different levels of importance and details.

Music Information Retrieval (MIR). In the research area of MIR, with understandings in the hierachical structures in music, many useful tools were made: musical analysis assistant [], compositional tools [] and information retrieval systems [] just to list a few. There have been also much research on how one could understand, represent and extract the hierachical structures automatically. A balance and feedback loop between the theories and the applications have stimulated much interests in the topic of hierachies in music.

Metrical structures. Metrical structure plays an important role in the construction and the perception of the hierachical structures in music. Depending on the locations of the musical events on the metrical grid or their relational positions to other notes, one can assign metrical weights/importance to the notes. The notes at more important metrical positions form the anchors in the hierachical structure.

Fractal Geometry. Fractal geometry is an established area of mathematics. The box-counting way of calculating the fractal dimensions are known to be able to measure the roughness of contours. For example, the fractal dimension of the coastline of the United Kingdom is measured to be... and the ... for Sweden. It has been used in time series analysis, dynamical system, and where there is self-similarity in general.

Zooming-in/out: inspired by fractal dimension calculation, going in-between hierachies, consider different levels of details

Mass: inspired by fractals and the visual correspondence of music objects (the uneven, irregular surface of music notes vs smooth, regular surface). A measurement for each level in the hierachy. Equals to âĹŚduration2+pitchInterval2âĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠâĹŠ Intuitively, it's the sum of the lengths of the holding notes and the lengths of the lines connecting the two notes when there is a pitch change.

Fractal/self-similarity dimension: taking ratios between different levels of mass, summarising the hierachical structure

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Musical features. Musical features refers to summarising music events numerically. There are available toolbox to calculate features, such as jMIR [], MIRtoolbox [], the FANTASTIC toolbox []. There are features such as. One can either take the whole piece or take a series of sliding windows and obtain a time series of features.

Pattern discovery and classification based on features. Musical pattern discovery is an active area of research. It faces many challenges []. By giving a known hierachy in the piece, we can calculate the

Our Methods. We use fractal geometry

Contributions. - Based on fractal geometry and the hierachical structures in music, we propose a new feature that measures the complexity of melodic contours and polyphony shapes in symbolic music.

- Using the proposed feature, we present a toolset for music analysis and pattern discovery.
- We showcase the effectiveness of our system on various corpora and comparing the proposed feature with other existing features of music.

2 THE SIMILARITY DIMENSION

"Fractal Dimension":

$$-D = \frac{logM}{logs}$$

The Definition of "Mass":

$$M \propto s^{-D}$$

Compute the features. 1. split the music entry into m parts, n bars per part

2. perform the following actions for each bar

1) Create hierachy:

1. take the notes in the most important positions in the bar (for example, in a 4/4 bar, we have a importance grid of [5,2,3,2,4,2,3,2] in the resolution of a quiver; so only the notes on position of the first quiver will be taken)

2. take the notes in the most and the second most important positions in the bar (we have the positions of the first and the fifth quiver in this case)

3. repeat till we consider all the importance levels

2) Compute measurement (mass) on the hierachy

1. Calculate the mass within one note: = duration in quarter length

2. Calculate the mass between two notes = $\sum \sqrt{\Delta duration^2 + \Delta pitch^2}$ (eqv to the hypotenuse of the time and frequency difference)

3. Sum up the mass (intuitively as the length of the line tracing through the notes in considerations)

3) Take ratios and the log of the mass between the selected two hierachies: $dim = log_2(mass_{I1}/mass_{I2})$

Interpretting the feature. The feature consists of information from two dimensions, time and pitch. We use a few prototipical example note combinations to illustrate how the fractal dimensions could reflect the changes in music.

The similarity dimension on one piece.

3 THE FRAGEM PACKAGE

The implementation of the tool is in a functional programming language, Haskell.

From modelling music using data types. Model of music: [Time Signiture, [Voice]]

Model of mass: [Note] -> Maybe Double The types give much freedom to how we could calculate the "mass". We choose the length for now for the corresponding visual contours in music. For polyphony, we can extend this to the area enclosed by two voices, and it can capture the amount of contrary motions in the piece, which is crucial for counterpoint.

Model of metrical weights: TimeSig -> [Int] For each time signiture, we assign a list of integers of importance values to the positions of notes. Now we have a quiver as the resolution of the grid of the positions. New time signitures can be added and the resolution can be changed.

Model of computation: midi -> parameters -> [[Double], [midi]] The input of frahem is midi files. From the parameters we introduced above, we can specify on which time scale and how many levels of hierachies we would like to analyse. The output is a time series of the fractal/self-similarity dimension. Based on the dimensions, we can also generate the patterns in the midi format with the same dimensions or up to a threshold.

Types of patterns: threshold

parameters. Zoom level: 1 -> consider all notes, 2 -> consider notes with weights >= 2, âĂę Window size: how many bars are included in the analysis to produce one number Sliding or hopping windows Threshold: what is the maximum gaps between the two groups for them to be considered as belong to the same kind of pattern

@Victor?

4 EXPERIMENT SETTING

4.1 Data

Synthesised Data.

Hanon.

Bach.

4.2 Correlation with known features

Using PCA, we can decompose

4.3 Classification

We use the synthesised data with two levels of randomness, the Hanon exercises and Bach's fugues for the classification experiment.

Examining the heatmap, we see higher fractal dimension in the most complicated piece, Bach's WTC.

4.4 Pattern discovery

Using the MIREX dataaset, we found more patterns than the annotations. But becuase t=if the

5 RESULTS

5.1 Classification

5.2 Pattern discovery

6 DISCUSSION

Summary.

Limitations:

Future work: Polyphonic

A APPENDIX

Text of appendix …