N-GRAM BASED MELODIC CONTOUR ANALYSIS ON TURKISH MAKAM MUSIC USING SYMBOLIC DATA

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ABSTRACT

Musicological analysis of Turkish makam music is underdeveloped. Due to its microtonal structure, complex and rich history, and oral traditions, the computational study of makamlar is lacking. In this study we investigate melodic contours using n-grams to build feature strings representative of the direction of movement of the notes within a sequence. We explore the prevalence of these melodic patterns and the relation they have to other music concepts in Turkish makam music such as *çeşnis* and *seyir*. Ultimately, we provide a new and interesting approach to the study of Turkish makam music.

1. INTRODUCTION

Generally speaking, the word ‘makam’ refers to a modality system used in many genres such as folk, art, and other popular genres. In this paper, we consider the classical Ottoman/Turkish musical tradition.

The elements that shape the structure of Turkish makam are varied and often fluctuating. However, a useful starting point is to define makam as ‘a practical melody theory, grouping melodies by families or categories that are distinguished by the use of careful microtonal inflections of certain tones according to custom, together with idealized notions of melodic contour’ [1]. With this definition in mind, we will attempt to represent and analyze the melodic progression of Turkish makam using feature strings.

A feature string is a string of characters that expresses the size and direction of each interval, disregarding the specific note duration and pitch. This technique can be used for algorithmic theme mining as described by Wang, Li, and Shi [2].

While feature strings disregard more precise note information, the focus of this analysis is on the rough melodic contours of Turkish makam music. In doing so, we will attempt to answer the question of how we can use n-gram analysis on tonal information to identify meaningful common repeating structures in makam music and characterize them.

2. TURKISH MAKAM MUSIC THEORY AND CONCEPTS

2.1 Tuning and notation

The complexity of a microtonal system and oral tradition of Turkish makam has made the definition of music tuning and notation a controversial issue, however, the Arel-Ezgi-Uzdilek (AEU) system is the established notation system [3].

Unlike the 12-tone equal temperament scale, the AEU tuning theory is based on Pythagorean pitch ratios and divides an octave into 24 notes that are not equal-tempered [3]. The AEU system specifies Pythagorean pitch ratios for its basic tuning structure. However, for defining its intervals it uses a basic unit of Holdrian-Mercator comma (Hc, obtained by equal division of an octave in 53 equal steps) [3]. Essentially, this system simplifies the notation by quantizing Pythagorean ratio intervals to integer multiples of Hc [3].

2.2 Seyir

The seyir or melodic progression is the one of the main defining aspects of a makam. It can be thought of as a complex of stereotyped motives, melodic signatures, and latent melodic possibilities that are vital to the identity of a makam [**?**]. In simpler terms, the seyir indicates the modulations and the general shape of the piece, typically understood as either ascending, descending, or both ascending and descending.

2.3 Cins

Another defining characteristic of any makam is that the set of pitches are structured as a series of trichords, tetrachords, and/or pentachords with a particular tonic and dominant note [5]. These trichords, tetrachords, and pentachords are referred to as cins [5]. Each cin has a particular sound or flavor based on its intervallic structure and combining these cins form the “scale” of a Makam [5]. However, the scale of a makam is not a scale in the Western sense as it may not repeat above and below the primary octave, and notes may shift at certain points in the progression of the makam [5]. Additionally, in makam the

cin	interval		
Cargah	(9 Hc)	(9 Hc)	(4 Hc)
Buselik	(9 Hc)	(4 Hc)	(9 Hc)
Kurdi	(4 Hc)	(9 Hc)	(9 Hc)
Rast	(9 Hc)	(8 Hc)	(5Hc)
Ussak	(8 Hc)	(5 Hc)	(9 Hc)
Hicaz	(5 Hc)	(13 Hc)	(5 Hc)

Table 1. The 6 basic tetrachord intervals in Turkish makam

location of the dominant note is not always a fifth from the tonic. Depending on the length of the first cins, the dominant note could be the fourth or sometimes even third from the tonic [5]. The six basic tetrachord cins considered in Turkish music have the following names and interval structures as shown in Table 1. These tetrachord cins can be made into pentachords by adding a whole step (9 Hc) at end.

2.4 Cesni

Building on the concept of cins, one can consider the concept çeşni which literally translates to “flavor”. Unfortunately, there is some ambiguity with the usage of the term amongst researchers and makam performers. Some researchers equate çeşnis to cins while others would define a çeşni as “the smallest melodic concept conveying the explanatory (identifying) power of a makam” [3]. As for performers, some view çeşni as a modulation or a change in the structure of the scale while others use the term to describe melodic phrases that use notes that are part of the makam.

In the context of this paper, we think it’s most useful to consider çeşni as the progression through melodic phrases or the specific melodic motive that uses cins or sub-divisions of cins [3]. The direction of the progression through a cin is usually given by the seyir. In practice, the methods employed by a performer to progress through the melodic phrases of a makam are what give the piece its specific and sometimes definitive “flavor”.

2.5 Project Context and Motivation

N-grams are a tool often used in computational linguistics, but not so often applied to music. An n-gram denotes a sequence of length n derived from a source. In this case, we use an approximation of the melodic contour of a piece to attempt to find repeating patterns that might not be evident from typical analysis of a score.

Some benefits of using feature strings are 1) that similar, but distinct, sequences of notes map to the same feature string; 2) they disregard the absolute pitch of the notes. This way, we can collect similar melodic contours under the same umbrella of a feature string.

In the sequence of music processing, one of the basic steps in pitch organization is contour analysis: the abstraction of pitch trajectories (in terms of pitch direction between adjacent tones without regard to the precise pitch intervals) in order to form a perception of the melodic component of music. [6]

By being exposed to organized musical input our brain “implicitly” learns the statistics of pitch occurrences (either in melodies or in chords).The goal of this investigation is, roughly, to see if we can use feature strings to understand Makam scores in a more intuitive way. This is an exploration.

In the field of computational enthomusicology, the amount of published research is increasing, but computational analyses of Turkish makam are not as plentiful. [3] Historically, Turkish and other middle eastern makam music have relied on the tradition oral / aural method for transmission of information, maintenance of musical standards, and performance of the makam repetoire. [7] While still using this system of teaching, the change within makam music to use western scale notation has increased the recording of important makam musical information. Further computational analysis will only serve to increase the repetoire of material for education of Turkish makam music.

2.6 Research Question

In an exploration using feature strings, which inherently disregard precise note information and give a rough melodic contour based on coarse intervals between notes, what length of n-grams are most informative of melodic structures within Turkish makam music? What conclusions from the n-gram analysis can we learn with Turkish makam pedagogy in mind?

3. METHODOLOGY

We use the SymbTr dataset [8], which contains a collection of 2,200 machine readable scores of Turkish Makam music, tagged with information about makam type, the form, the Usul, and composer.

Each makam score is contained in an MusicXML file, which we analyze with the open-source python library music21. Due to music21 not being able to handle the microtonal accidentals of the Turkish makam tuning, preprocessing of XML score data was required to account for proper accidentals [3] within the Turkish makam score database [**?**]. This involved adjusting the interval between notes in cents.

Within each MusicXML score, we calculate feature strings of subsequent notes by mapping intervals to a set of characters C : R, U, W, D, B where R is an interval of 0 (i.e. a repeated note); U is a small ascending interval of at most 3 semitones; W is a larger ascending interval of more than 3 semitones; D is a smaller descending interval of at most 3 semitones; and B is a larger descending interval of more than 3 semitones. For example a note sequence of C4-D4-D5-D5-D4-D4-C4, which has intervals of 2, 12, 0, -12, 0, -2 would translate to a feature string of “UWRBRD.”

Then we collect n-grams of various lengths, and count how many instances of that n-gram are found in the score.

We sum the results across makam type for each of these 10 types: ['rast', 'acemasiran', 'acemkurdi', 'beyati', 'buselik', 'hicaz', 'huseyni', 'huzzam', 'kurdilihicazkar', 'nihavent'], leaving us with a table containing the n-gram count for each makam type.

We can then use this data to make line density plots which illustrate the relative frequency of each n-gram visually as follows: Each feature string is decoded in steps, so that each character [B, D, R, U, W] is mapped to the step size [-2, -1, 0, 1, 2] respectively. The horizontal value represents the letter index within the feature string, and the vertical axis the cumulative value at each step, so that each feature string has a unique but overlapping path, which roughly indicates its contour. Each line is drawn with an opacity value, so that the more frequent sequences are bolder, for example:

By expressing direction and rough magnitude of sequential notes in a condensed feature string [2], the goal is to see if large scale patterns such as seyir or smaller scale cin can be represented by these feature strings.

4. RESULTS

We looked at the frequency distribution of the top 20 most common sequences for each of the seven analyzed makam types. The resulting histograms show that as the sequence length increases, the upper end of the frequency distribution tends to bunch closer together and account for a much lower overall frequency. For example, in length 3 sequences of acemasiran makam (Figure 1), the two most common account for 22.0 percent and 8.0 percent, respectively. For length 10 sequences of the acemasiran makam (Figure 2), the two most common account for 0.20 percent and 0.15 percent respectively.

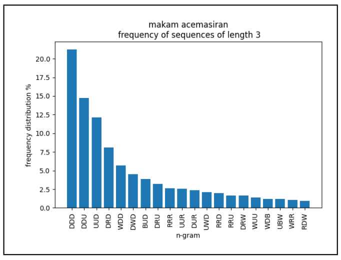

Figure 1. Acemasiran Sequences of Length 3

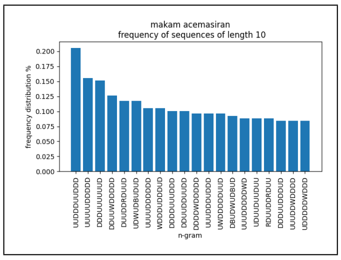

Figure 2. Acemasiran Sequences of Length 10

In looking at the results of sequence length 9, most of the sequences with the highest frequency distribution exhibit somewhat basic melodic contours. For example UUUUDDDDD, DDDUUUDDD, RDRDRDRDR are some of the most frequent sequences and appear in more than one makam.

Another notable observation from the length 9 results is that the frequency distribution of the UUUUDDDDD (small ascending to small descending) sequence of the rast makam (Figure 3) is nearly 0.45 percent while the highest observed frequency distribution for every other makam is between 0.30-0.35 percent.

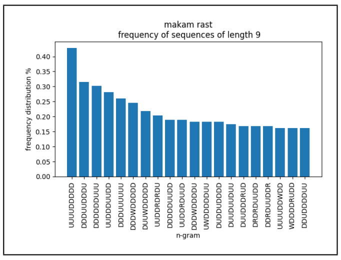

Figure 3. Rast Sequences of Length 9

Focusing also on sequence length 10, we find that this length tends to display a more complexity than length 9 sequences, but with a lower overall frequency distributions. For example, UDUDWUDBUD is the second most common sequence for acemkurdi makam (Figure 4), accounting for a little over 0.125 percent of all 10 length sequences. This sequence shows up in the top 20 most common patterns for just one other makam (0.10 percent for buselik), likely due the complex contour.

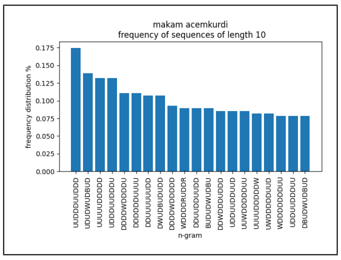

Figure 4. Acemkurdi Sequences of Length 10

5. DISCUSSION

Often, the most common feature strings simply refer to repeated motifs within a piece.For example, in Figure 5 we look at a score in the Rast makam [1] . Shown is a phrase that corresponds to the feature string "DDDDDUUU", or 5 intervals descending, followed by 3 intervals ascending):

However, on other occasions, we see the same sequence present yet transposed and with a different rhythm. In Figure 6., we look at another score in Rast makam. [2]

Or, seemingly, as seen in Figure 7., appearing by chance in a highly improvisatory passage [3] .

[1] rast–sazsemaisi–aksaksemai—-kantemiroglu.xml

[2] rast–nakis–yuruksemai–gulsende_yine–muallim_ismail_hakki_bey.xml

[3] rast–pesrev–devrikebir—-giriftzen_asim_bey.xml

Figure 5. DDDDDUUU Feature Strings in a Rast Makam Score

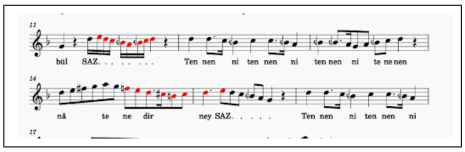

Figure 6. Transposed and Different Rhythm DDDDDUUU Feature Strings in a Rast Makam Score

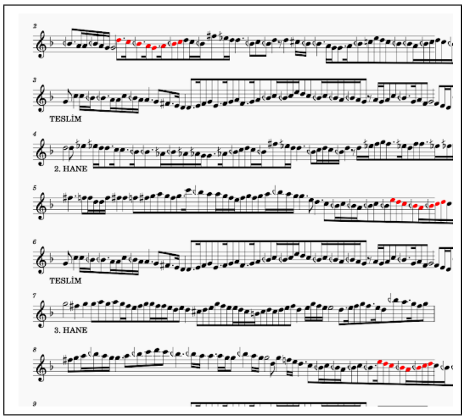

Figure 7. Improvisational DDDDDUUU Feature Strings in a Rast Makam Score

In other places, we see that the largest repeated n-gram corresponds to an important thematic piece of the makam, and within a specific makam type there is a prevalence of one type of sequence over others. We can see this clearly from these density plots, which illustrate the shape of the feature string as well as its frequency. The string is decoded in steps, so that each subsequent character is decoded to be in [-2, -1, 0, 1, 2] for [B, D, R, U, W] respectively. Each line is drawn with an opacity value, so that the more frequent sequences are bolder. We can see in Figure 8 the example for Rast makamlar (which have the most common 10-grams of UUUUUD-DDDD and DDDDDWDDDD) and Acemasiran makamlar in Figure 9 (which have UUDDDUUDDD and UUU-UUDDDDD). Note that UUUUUDDDDD are shared between the two. This is an interesting result with a few

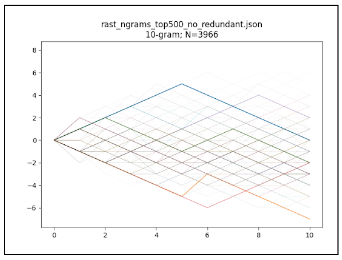

Figure 8. N-Gram Feature String Density Map n=10: Rast makamlar

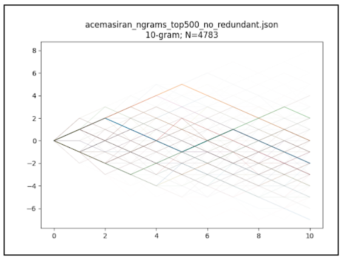

Figure 9. N-Gram Feature String Density Map n=10: Acemasiran makamlar

implications. First, it shows a trend of local note movement within the respective makam. For example, here we see that in the Huseyni makamlar, the melodic contour tends to avoid the UUUUUDDDDD pattern which is prevalent in makamlar Rast and Acemasiran, rather tending to express its inversion DDDDDDUUUU as seen in Figure 8. The most numerous patterns in husenyi makamlar are DDDUUUDDDD and DUDDUDDUDD, consistent with the ascending-descending seyir associated with it. [3] Curiously for husenyi makamlar, we see as the 5th most common: DRDRDRDRDR, indicated by the blue slanted staircase line in Figure 10 We would expect to see this type of pattern in makamlar that have descending seyir.

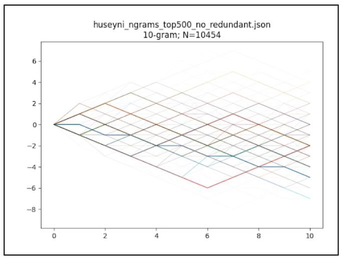

Figure 10. N-Gram Feature String Density Map n=10: Husenyi makamlar

6. CONCLUSION

For this project, the aim was to explore what sort of information can be gained from an n-gram analysis of Turkish makam music, focusing on how feature strings represent the melodic contour of the makam. From this analysis, we were able to learn about the prevalence of certain contour patterns relevant to specific makam types, alongside suggestions that seyir information can be extracted from feature strings of sufficient length. We also explore the variety of rough melodic structures within the makamlar that the feature strings represent, how they differ within and between makam types, and how they may be suggestive of larger scale musical patterns and concepts. We hope that with this analysis, we can contribute to the education and field of study for Turkish makam music. All analysis materials used on the SymbTr dataset can be found here [4] .

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