STATISTICAL ANALYSIS OF MELODY IN TURKISH MAKAM MUSIC

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ABSTRACT

The Ottoman-Turkish makam music tradition has been practiced, developed, and passed on between generations for many centuries. Still, there are many aspects of it that are not well understood to non-practitioners. One of those is the concept of 'Makam', which is often mistakenly used interchangeably with 'scale'. Ottoman-Turkish makam music is also underrepresented in the Music Information Retrieval field, which is dominated by research and tools built to deal with 12-tone equal-tempered eurogenic music.

In this paper, we employ statistical methods to analyze Ottoman-Turkish makam music scores. We draw inspiration from musicological approaches to design processes for extracting various statistics for each makam, centered around their differences in note and interval occurrence and development. We show how some of our results might suggest how some of the melodic conventions of makams might manifest in the scores. Our work makes a small contribution to the quest of understanding makam music by suggesting pathways for further research in this music tradition.

1. INTRODUCTION

1.1 Ottoman-Turkish Makam Music

Ottoman-Turkish Makam Music (OTMM) is a music culture that is derived from a practice covering a large geography including Asia and some parts of Africa and Europe, following a long history of traditions [1]. Unlike the 12-tone equal tempered (12-TET) scale of the Western music, OTMM uses a much more granular tuning system. Multiple theories have tried to explain the underlying tonal intervals, often attempting to fit it into an equal tempered scale. The details and shortcoming of existing theories are compared in [2].

Between these theories, the most commonly used theory in modern Turkey is the Arel-Ezgi-Uzel (AEU) system. The AEU system specifies 24 perdes (notes) per octave which are separated by varying length intervals. These intervals can be closely approximated by the 53-tone equal temperament (53-TET) scale, where each unit is called a koma (comma) [2]. Using the komas, a whole tone in the AEU system is represented by 9, and a half tone by 4 komas.

1.2 Current state of Makam music in Turkey

In modern Turkey, Makam music is enjoyed by small circles of people as an art form and its influences in more recent music genres are enjoyed by the youth in social gatherings. However, its formal education is not included in the curriculum, as opposed to the classical western music, which is being taught in an introductory level.

1.3 What constitutes a makam?

Two key elements of OTMM are makam and usul. While the melodic aspects are explained by the makam, which is a modal structure, the rhythmic aspects are explained by usul. Each makam has a scale, which in itself alone does not have much meaning. On the contrary, a makam attains its meaning through the melodic progression which revolve around the initial (güçlü) and final (karar) tones of its scale [1]. In OTMM music this unique melodic progression is termed seyir. Seyir is such an important aspect of OTMM is that various makams that have the exact same scale obtain different characteristics through their seyir. Therefore, taking the aspect of makam equal to the scale of the western music is insufficient. A makam constitutes both its scale and the movements between the notes of that scale that can be performed. The question is, can we somehow quantify the essence or the characteristics of those movements through a computational analysis of OTMM written compositions?

1.4 Contribution

Our work makes a small but interesting contribution to the effort of understanding what makam is in OTMM. By utilizing computational approaches and working with a large collection of OTMM scores, we extract insights that indicate potential directions for deeper, qualitative research. These insights are not only related to the differences of musical conventions between makams, but also in differences between the theoretical makam framework and its practical application in OTMM composition.

2. RELATED WORK

In the last decade, numerous works have employed computational approaches for the analysis of OTMM, facilitated

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by the creation of an OTMM corpus [3] with audio, scores, lyrics, and annotations. This corpus has resulted in a number of datasets, such as ones with Acapella sections [4], melodic phrases [5], and many others. In turn, researchers have shared work on a variety of tasks, such as makam identification from audio [6–8] and scores [9, 10], melody transcription from audio [11, 12], audio-score alignment [13, 14], and others.

Our motivation for this paper, however, was not on the automatization of processes in OTMM categorization and transcription, but rather on exploring computational approaches which would help us understand better what constitutes a makam. While the question of understanding has mostly generated research from the perspective of more traditional ethnomusicological study, there have been notable computational approaches that have arguably progressed our understanding of OTMM. Şentürk [15] attempts to model the melodic evolution. Öztürk [16] investigates the evolution of the concept of 'makam' from both a scale-centric and a melody-centric perspective, while Bayraktarkatal & Öztürk [17] later attempt to categorize the over-arching structure of seyir.

3. METHODS

3.1 Pre-processing

Tuning systems other than 12-tone equal temperament have been underrepresented in Music Information Retrieval research, and, as a result, computational systems and standards for dealing with them are often non-existent or underdeveloped. In the case of OTMM, a lot of the data processing pipeline still has to be dictated by the approach taken for the symbolic representation of the music.

For this reason, while details of the dataset we used can be found in section 4.1, we include a brief explanation of the symbolic representation here, for further clarity about the tuning representation and the approach taken for the extracted makam statistics. In the dataset, the pitch of the perdes in each score is given by AEU system, in reference to a 12-tone equal temperament pitch class name with an accompanying accidental reference and its octave value, e.g. B4 quarter-flat. Other information such as the note duration in milliseconds and the note velocity is also included. To make the pitch format easier to work with, we parse the perdes to a discrete value referring to the 53-tone equal temperament (53-TET) komas of OTMM as such:

$$value = pitch\_class + accidental + 53 * octave \quad (1)$$

where the 53-TET reference values for the pitch classes and accidentals used can be seen in Figure 3.1.

Along with the implementations of the makam statistics described below, a small library for parsing the MusicXML files in the dataset with functions such as retrieving notes, time signatures, composer details and other information from the scores is made available [1].

[1] Code repository available at `https://github.com/chrispla/OTMM-understanding`

PC name	PC value	A name	A value
		double-slash-flat	-8
C	0	flat	-5
D	9	slash-flat	-4
E	18	quarter-flat	-1
F	22	natural	0
G	31	quarter-sharp	+1
A	40	sharp	+4
B	44	slash-quarter-sharp	+5
		slash-sharp	+8

Figure 1. Pitch class (PC) and accidental (A) values for note parsing to 53-TET

3.2 Statistics

We extracted a number of statistics from the scores with the aim of seeing their differences between makams. For each statistic, the extraction is done on a score-to-score basis, and then the averaged or aggregated results per makam is calculated, as described.

3.2.1 *Note Histograms*

We first investigate the perde distributions of our target makams. One of the primary insights we wanted to gather was the prevalence of the karar (tonic) in each makam. We count the perdes in komas and fold the koma values in a single octave. The folding is done over the anchor note C (Kaba Çargah), with an index of *0* in our representation, instead of by each makam's karar. This is done in order be able to easily visually compare perde distributions across makams in their absolute pitch values and, therefore, positions in the histogram.

3.2.2 *Note ranges*

While octave folding is convenient for understanding pitch -or rather koma- classes, the span of perde used might also vary among makams. For every composition we extract the pitch range and average the minimum and maximum boundary for every composition in a makam.

3.2.3 *Tonic Repetition*

Makam masters specify that during its seyir (melodic development) each makam travels between the perdes in its scale with a unique behavior, spending variable time between neighbourhoods before resolving in its karar perdesi [1]. Therefore if we focus on the seyir as a movement that starts and end in the karar perdesi, the following natural questions arise: How much time passes between each visit and how far does these trips take? Hence we convert the composition to a list of perdes and find out where the karar perdesi is played to answer these questions. Here we disregard the perde duration and time signature to focus on the number of perdes played, but this is a limitation we discuss in 5.

We also investigate the range of perdes that are covered between two occurrences of the karar. This is done by centering the perde array around the lowest occurring tonic in the piece and finding the highest and lowest perdes between each karar occurances and finding the difference. We believe that this difference range indicating the pitch range carries information about the seyir of the makam. After these ranges are accumulated for each makam, various statistics are extracted and displayed in Figure 5.

3.2.4 Interval histogram

While tonic repetitions aim to capture the longer, overarching seyir, an interval histogram can give us more granular insights on the stepwise melodic movement of a composition. Intervals using the distance of successive perde in the 53-TET framework were calculated for every composition, and then aggregated for each makam.

4. EXPERIMENTS

4.1 Dataset

In order to facilitate research on makam music, Karaosmanoglu has prepared a large makam scores collection where he introduces 2200 OTMM scores in SymbTr dataset. [18]. The SymbTr dataset is one of the largest existing score collections and contains scores from a large number of makams. In this collection, scores from various makams are presented in the XML format where perdes are named using the AEU system. We analyze the SymbTr dataset and choose a subset of scores based on the existing makams [18]. We group the scores based on their makams and choose the top 16 makams with most scores. The resulting makams are: Uşşak, Hüzzam, Nihâvent, Muhayyer, Hicaz, Segâh, Rast, Hicazkâr, Kürdîlihicazkâr, Mâhur, Karcığar, Sabâ, Bûselik, Beyâtî, Hüseynî, Acemaşîrân. Although the following statistics are calculated for all these makams, in each experiment we report only a selection of them for visualization clarity.

4.2 Statistics

4.2.1 Note histograms

The perde histograms can be seen in Figure 2. If there is a histogram bin in a location without koma display, it means that even though that perde is considered by composers, the theory disregards the perde. We indicate the theoretical [19, 20] karar perdesi (tonic) in red.

We observe some interesting differences in the presence of the karar. Makam Acemaşîrâna and makam Mâhur were the only makams in our subset of 16 makams to have their karar as their most common perde. In makam Rast, for example, we see a pretty even perde distribution, while in makam Sabâ the karar is one of the least common perde. While an experienced listener can usually understand what the karar of a composition is, it seems like the terms "the most important perde of the makam" or "the center of gravity of the makam" are much more complex to quantify computationally.

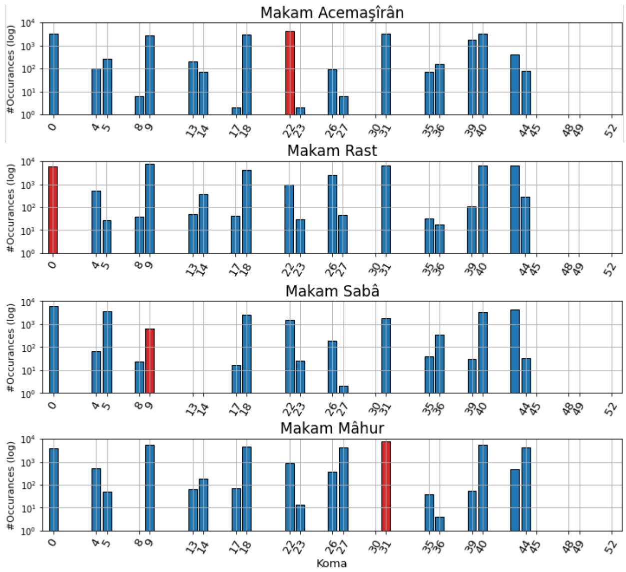

Figure 2. Octave Folded Koma Distributions for 4 makams. Karar (tonic) indicated in red.

4.2.2 Note ranges

In Figure 3 we observe the ranges of notes existing on average among all compositions in each makam. While most ranges aren't drastically different, Nihâvent has by far the most extended range, while Hüseynî has the shortest. While it might be tempting to attribute these results to the difference of melodic development between makams, we have to consider that traditionally, different makams might be associated with different instruments or ensembles of instruments. For example, makam Hicaz is often associated with the Oud, while makam Dugah with ensembles of instruments. These note ranges might in part be a manifestation of instrumentation conventions for each makam.

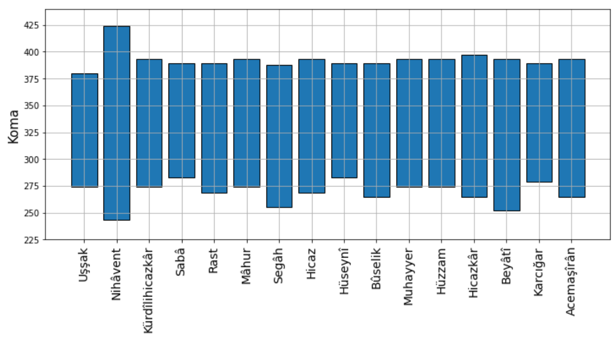

Figure 3. Note ranges for all considered makams

4.2.3 Karar repetition

Figure 4 shows the karar repetition length distributions for Makam Nihavent, Buselik, and Segah. Here we only display below repetition length 35 as the rest is quite sparse. We observe that makam Nihavent and Segah both mostly return back to the tonic below 5 notes. However they differ in their distributions in this region where Segah is domi-

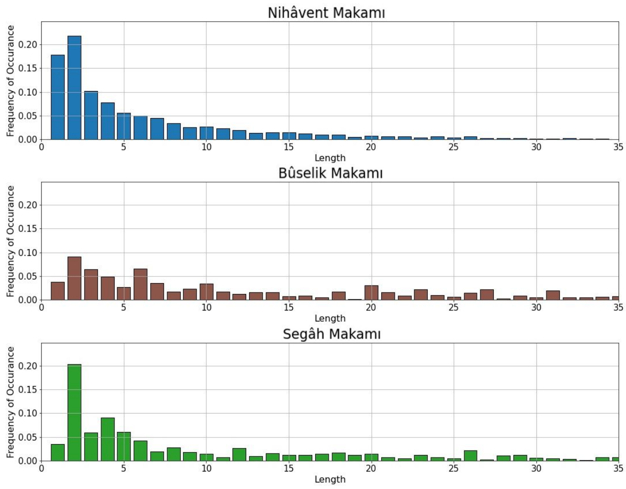

Figure 4. Karar Repetition Lengths for Selected Makams

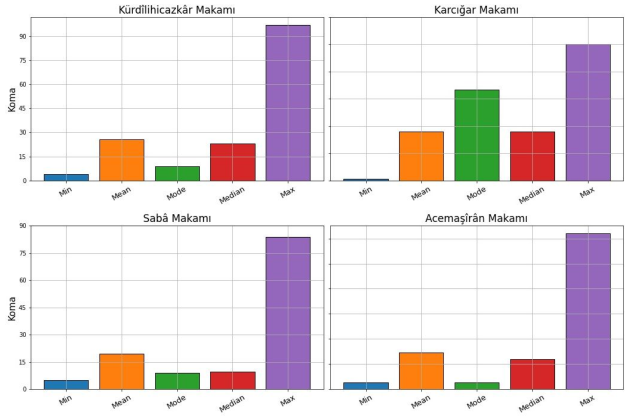

Figure 5. Pitch Range Between Tonic Appearance Statistics

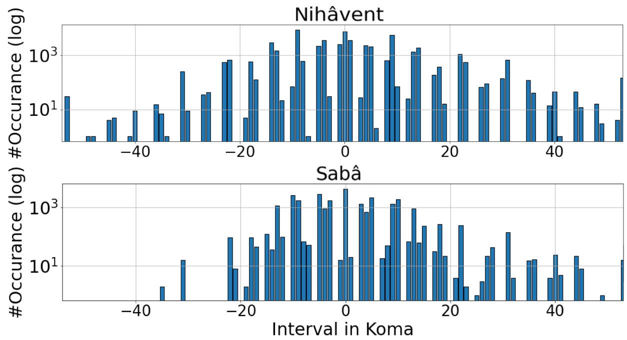

Figure 6. Successive interval histogram

nated by length 1. Makam Buselik on the other hand has an overall more balanced distribution. As these distributions were extracted from the progressions, the differences in them must be attributed to their differing seyir rules. In figure 5, some statistics describing the pitch range that is covered between the two appearances of the karar is displayed. After the pitch ranges between two karar appearances were accumulated for each makam the minimum, mean, mode, median and maximum statistics are calculated. Each of these statistics give us insight about the seyir. The minimum pitch range indicates how close the perdes can be between two karar appearances while maximum pitch range indicates how far they can be, whether they can go beyond an octave or must be confined to an octave. The mode pitch range indicates that, between all the compositions, such a pitch range appeared the most, and travelling between such an amount of pitches is the most normal for that makam's seyir. The median pitch range describes the middle value separating the higher ranges from the lower range, which is a robust statistics describing the typical pitch range for that makam. For example, for makam Kürdilihicazkar, the maximum pitch range is much larger than the mean and the minimum, which indicates that the seyir is skewed towards smaller deviations. Moreover, the median value which is smaller than the mean also support that. We can conclude that although large deviations are allowed, its more natural to stay around the karar perdesi.

4.2.4 Interval histogram

On Figure 6 we observe a histogram of all intervals between successive perde for 2 makams. A significant deviation can be especially seen in descending motion, where Nihâvent contains a fairly balanced distribution between ascending and descending intervals, while Sabâ barely contains descending intervals over 23 komas. Interestingly, Nihâvent also contains octave descends which are one of the most characteristic motions in OTMM, while Sabâ doesn't.

5. DISCUSSION

The motivation behind the proposed dataset statistics lies in extracting musicologically motivated insights through processes that would have been extremely time consuming if they were to be performed manually. While arguably they aren't as complex and context-aware as an analysis from an ethnomusicologist or performer of OTMM could be, they have provided insight that could prompt a deeper, qualitative investigation.

While the extracted statistics point to interesting characteristics of the analyzed scores, it is important to acknowledge that this dataset cannot cover the essence of OTMM completely. One notable example is improvised music, or taqsim, which is a big part of the OTMM tradition. Improvised music contains important conventions that are indicative of the makam, but is, perhaps, even harder to collect, transcribe, and make machine-readable in a standardized way.

Lastly, we have to acknowledge the limitations of the attempt to objectively represent and describe a primarily non-written music tradition. It is evident that even though it's a musical aspect that many have attempted to standardized, pitch in OTMM still doesn't have a representation that can accurately describe it in all cases while avoiding koma binning inaccuracies.

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