Barış BOZKURT[1]

# COMPUTATIONAL ANALYSIS OF OVERALL MELODIC PROGRESSION FOR TURKISH *MAKAM* MUSIC


## Abstract

One of the most essential features of Turkish *makam* music is the melodic progression. Yet, we lack computational methods to study the melodic progression characteristics of a given piece. In this study, we propose a method to obtain a graphical representation of the melodic progression for a given collection that can be used to analyze *seyir* characteristics of a given *makam*. The representation summarizes the change of relative occurrences of pitches with respect to time and can be collected on audio or scores. In this paper, we demonstrate the potential by comparatively analyzing representations obtained for *makamlar* that use the same scale and differ in melodic progression.


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Starting from 2007, he was employed as an Assistant Professor in Izmir Institute of Technology (IYTE), Izmir, Turkey, where he shifted his interest to computational analysis of *makam* music. Since then, his main interest is developing technology for tuning analysis and automatic transcription of *makam* music in Turkey. Barış Bozkurt recently joined Bahçeşehir University, Istanbul, Electrical and Electronics Engineering Department. He is an associate editor of the Journal of Interdisciplinary Music Studies.

## 1. Introduction

Within the context of Turkish *makam* music, the melodic progression, *seyir*, is considered to be one of the most important features of the *makam* concept as specified in various definitions of *makam*. Karadeniz (1980, p. 64) defines *makam* as: "the *çeşni* (flavor/taste) that is created by melodic phrases that are *seyir* (melodic progression) rules within a scale". Gürmeriç (1966): "Makam is a progression that gives the makam a life by starting from somewhere of the *seyir,* moving towards the *güçlü* and going towards *karar*." Touma (1971, p. 2) also considers the fixed "tonal-spatial" (or tonal-temporal) organization as the most essential feature of the *makam* phenomenon. As Ayangil (2001) summarizes, most of the historical theoretical texts present the *makam* concept by descriptions of melodic progression (*seyir*) rules. As an example, we can refer to the description of *makam Rast* as given in (Aydemir, 2010, p. 33): "The melodic progression begins with the Rast flavor on rast (G) due to the makam's ascending character. Following the half cadence played on the dominant neva (D), suspended cadences are played with the Segah flavor on segah and the Dügah flavor[2] on dügah (A). The extended section is presented and the final cadence is played with the Rast with Acem (F) flavor[3] on the tonic rast (G)". The *seyir* is often learned by the musicians by studying the repertoire and learning to improvise, rather than reading/memorizing such theoretical descriptions.

The *seyir* (of a *makam*) follows a certain structure, considering the composition. The sections of *seyir* are: *zemin* (introduction and first cadenza[4]), *meyan* (development) and *karar* (resolution to the *karar* pitch). *seyir* starts with introducing the specific *makam*, steps away from it, and then modulates back to it to find the *karar*, often without repetition of the motivic content. This structure can be observed in many compositions such as the instrumental improvisation (*taksim*), or the most popular vocal form *şarkı*.

The concept of *seyir* has short-time and long-time facets. The short-time dimension is referred with specifications on *makam* specific motifs and flavors. The long-time facet refers to the shape of the overall progression for a complete piece or improvisation in a specific *makam*. The most explicit information mentioned about *seyir* in theory books concerns the long-term dimension. Three categories are used to describe the overall melodic curve: ascending progression, ascending–descending progression and descending progression. We can refer to melographs (melodic contours) of improvisations to observe overall behavior for these categories. In the examples below (Figure 1), we present an example for each type of progression. In theory, *makam Uşşak* is considered to have an

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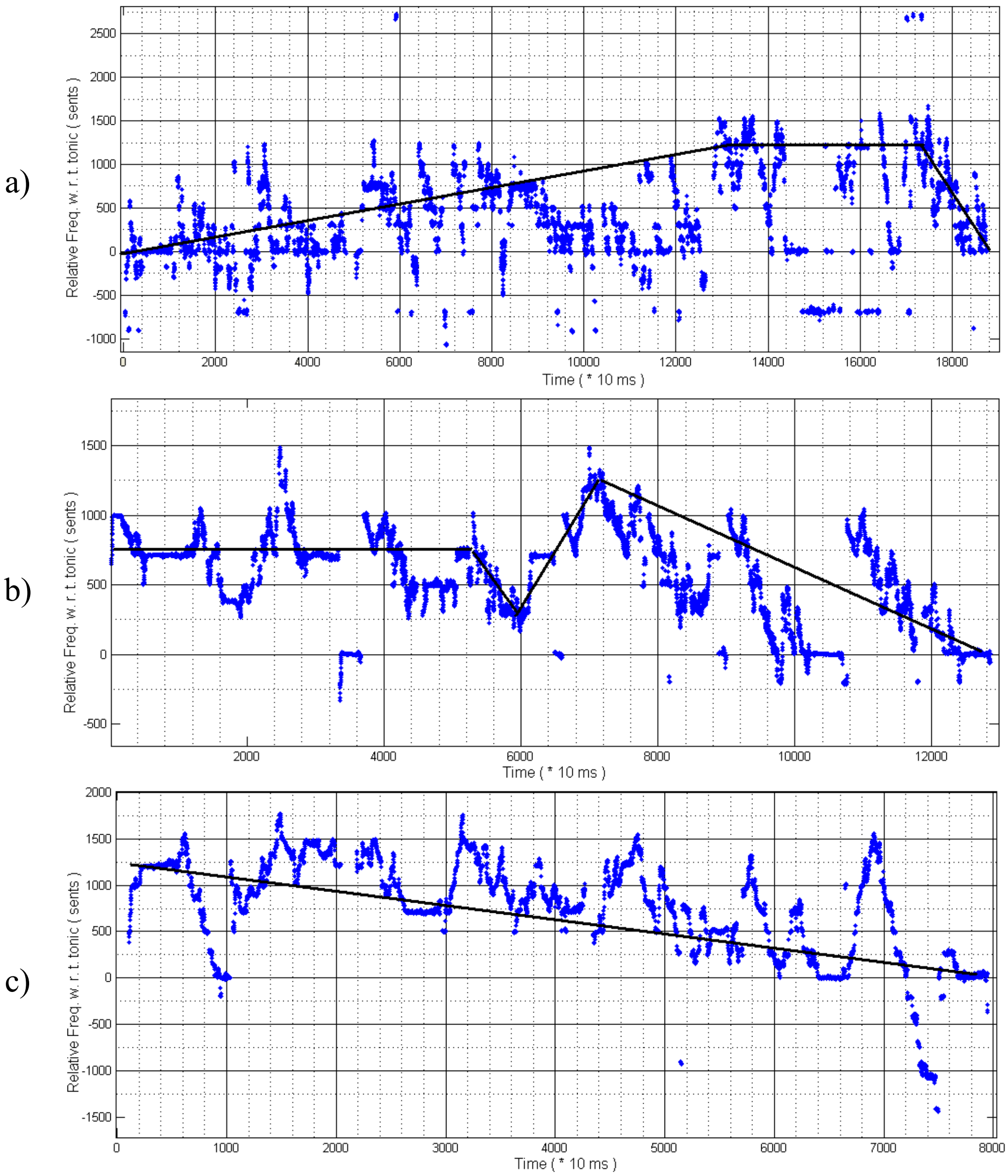
[2] Should be *Uşşak* flavor.

[3] Should be *Rast* flavor with *acem* pitch. This error is possibly due to a translation error.

[4] Most often the term cadence/cadenza is used to refer to resolution by various Turkish musicians such as Aydemir (2010).

ascending *seyir*, *makam Hüseyni*, ascending–descending and *makam Muhayyer* descending. For each example, straight lines are indicated by the author to facilitate the observation.

**Figure 1:** Melographs of *taksims* in three *makamlar*: a) *Uşşak* (*taksim* of Yorgo Bacanos) [ascending progression], b) *Hüseyni* (*taksim* of Fahrettin Çimenli) [ascending-descending progression], c) *Muhayyer* (*taksim* of İhsan Özgen) [descending progression].



As observed on the graphs, the categorical *seyir* information specifies the long-term characteristics of the melodic progression. While this categorization is informative for comparing basic *makamlar* that only differ with *seyir* characteristics, it's specificity is too low (only three classes area available) to explain *seyir* characteristics of all *makamlar*. Detailed analysis of the overall melodic progression for a given large collection in a large number of *makamlar* is needed to improve our understanding of the *seyir* phenomenon. This study proposes a computational and computer aided method to facilitate such research that is practically too costly to carry on large collections.

We propose a new computational analysis method and a graphical representation for studying the long-term facet of the melodic progression, *seyir*, for *makamlar* (plural of *makam*) in the context of Turkish *makam* music. As demonstrated in the following sections, *seyir* characteristics described verbally in theory can be clearly observed on such representations. The main aim is to facilitate comparative study of recording collections to improve understanding about the *makam* concept. In the next section we first review other computational work for extracting some of the *seyir* related parameters. Then we introduce our approach and demonstrate its use on score collections in different *makamlar*.

## 2. Computational approaches dedicated to study of *seyir* related features

Due to the difficulty of access and use of engineering methods by researchers from musicology or music education, we observe that many studies targeting computational analysis of *seyir* base on pitch (class) histograms, a representation where the time variation (hence progression) is lost. In several studies, which target melodic analysis (Eroy, 2010, Gönül, 2010, Sümbüllü and Albuz, 2011), pitch class histograms are used to specify most frequently used notes and intervals as features of melodic progression. The pitch (class) histograms can indeed be used as a feature of relative emphasis of scale degrees and carries some limited information about *seyir*. This is exemplified in Figure 2 and 3.

In Figure 2, pitch histogram templates obtained by averaging pitch histograms of multiple files after aligning the *karar* [as explained in Bozkurt (2008)], for three *makamlar* are given; *Neva*, *Hüseyni* and *Muhayyer* which use the same scale (shown in Figure 3). An important characteristic of a *makam* is that some notes in a scale are emphasized more than others and this emphasis often relates to the note being played more frequently and with long duration in a melody. We can observe from the pitch histograms in Figure 2 that note *neva* is emphasized in *makam Neva* (i.e. the frequency of occurrence of this note is higher comparatively), note *hüseyni* is emphasized in *makam Hüseyni* and note *muhayyer* is emphasized in *makam Muhayyer*. It appears that one of the many ways *makamlar* obtained their names is by using the name of one of its emphasis note. These notes (*neva* in *makam Neva*, *hüseyni* in *makam Hüseyni*, *muhayyer* in *makam Muhayyer*) are also the first emphasized degrees in the melodic progression, referred to as "the initial tone" (Öztürk, 2011). While useful to some extend (as demonstrated here), the pitch histograms are of very limited value for studying the progression, hence *seyir*.

**Figure 2:** Pitch histograms for three *makamlar* obtained from a large number of audio recordings as in (Bozkurt, 2008): *Neva*, *Hüseyni* and *Muhayyer*. Names written close to the peaks correspond to note (*perde*) names. *dügah* (A), *segah* (B♭), *çargah* (C), *neva* (D), *hüseyni* (E), *gerdaniye* (G), *muhayyer* (A).

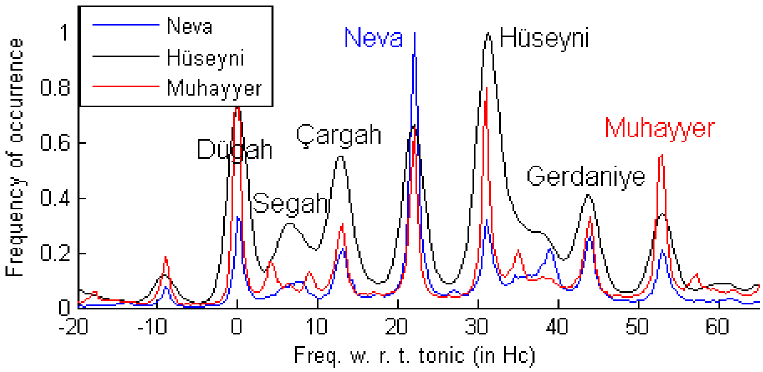
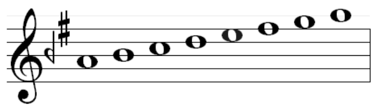



**Figure 3**. Scale of the three *makamlar*: *Neva*, *Hüseyni* and *Muhayyer*. Note (*perde*) names in ascending order: *dügah* (A), *segah* (B♭), *çargah* (C), *neva* (D), *hüseyni* (E), *eviç* (F♯), *gerdaniye* (G), *muhayyer* (A).



A variant of the histogram is the n-grams where frequency of occurrences is gathered for short sequences of notes instead of single notes. Basic n-gram analysis to find typical phrases of a *makam* was considered in a group of papers (Yener, 2004; Yener and Aksu, 2004). These works mainly pick most frequently used n-grams and claim these are the typical phrases. Again, long-term facet of *seyir* is not considered in these studies but the most common short sequences of each *makam*. Şentürk (2011) uses VLMMs (variable length Markov models) to model *makam* melodies. While melodies can be chosen to be very long, due to the resolution being suited to short-time analysis, we also consider Şentürk (2011) among short-time analysis studies.

To our knowledge, automatic computational analysis of long-time melodic progression is not targeted in any study in literature. Computational studies on melodic progression mentioned above are rather limited to consider the short-time aspect of *seyir*. Computationally studying/modeling of a down-sampled or simplified/summarized version of the pitch contour is one alternative to capture the long-term characteristics of *seyir* as we demonstrate in the next sections.

### Insufficiencies in data representations

Due to the difficulties involved in analysis from audio data, the computational melodic analysis literature is mainly based on analysis of scores. Unfortunately, due to theory-practice mismatches, most of these studies are questionable due to the problems inherent in the symbolic representations/notations. Very recently, as more and more musicians are familiar with the use of computer software, the number of scores written using commercial software such as Finale or Sibelius has increased rapidly. Most of the computational studies carried out on symbolic data makes use of such scores exported in the XML format, unfortunately providing very little information about how accidentals have been processed (if discarded or not). It appears to be a common practice to omit Turkish *makam* music specific accidentals and perform analysis on the resulting data quantized to12TET [i.e. the well-tempered 12 tone tuning (e.g. Gedik, Işıkhan, Alpkoçak and Özer, 2005)].

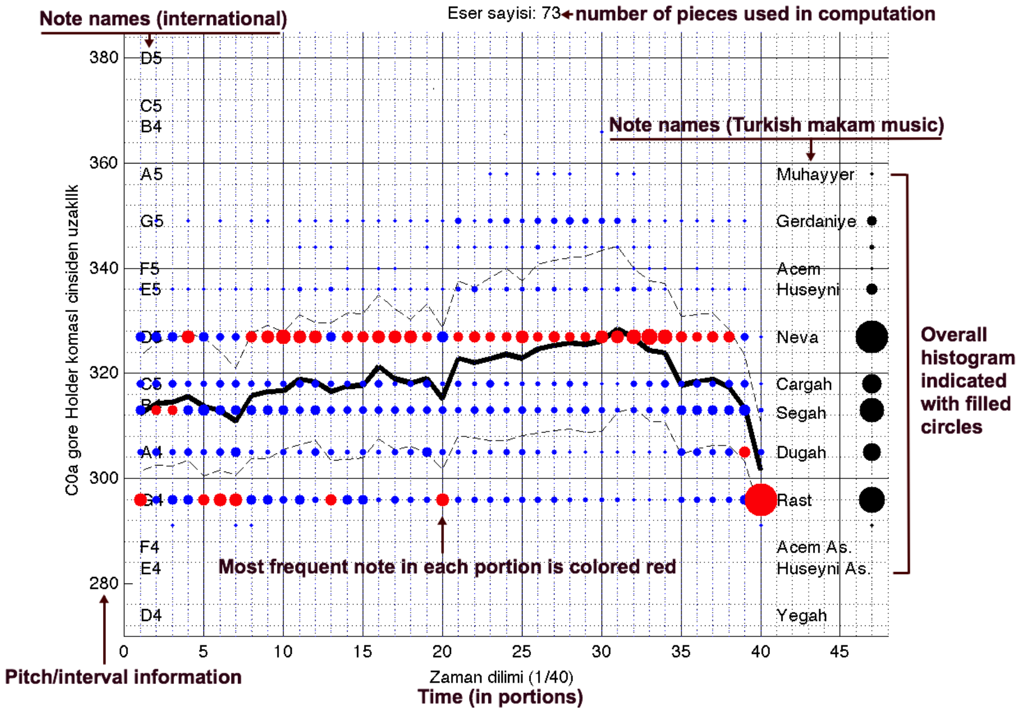
Microtonal notation editor software[5] was not available until very recently. There have been important technical difficulties in building large machine readable symbolic databases even in the most common Arel notation. Fortunately, recent data collection efforts provided us large machine readable scores [SymbTr collection (Karaosmanoğlu, 2012)] on which computational analysis can now be carried.

## 3. Proposed computational method for *seyir* analysis

Recently, we have demonstrated that average melodic curves are potentially useful for studying *seyir* characteristics (Bozkurt, 2012). In this work, we present a new representation developed by gathering time varying statistics from a group of pieces in a given *makam*. To obtain the representation, all melodic contours of the pieces are first down-sampled to have the same size. The average melodic curve is plotted together with the frequency of occurrences of pitches indicated by colored circles for the whole collection on a single graph. This representation shows which pitches are frequently used in which portions of the time, hence provides us the chance to observe how overall melodic contours and emphasis on pitches evolve for a collection. In Figure 4, one example for the proposed representation is given.

[5] Such as Mus2: <http://www.mus2.com.tr/>.

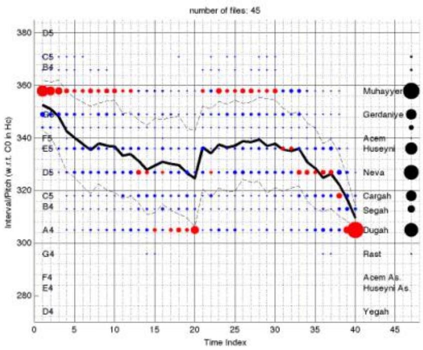
**Figure 4:** The proposed representation (obtained for *makam Rast*, computed on a score collection containing 73 pieces)



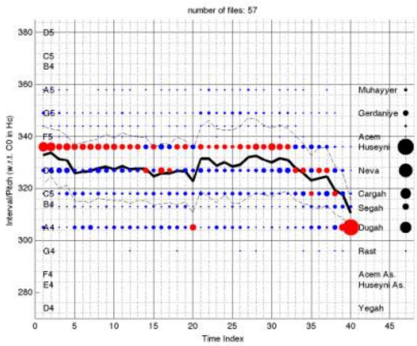

In Figure 4, the representation obtained for *makam Rast* from 73 pieces in the SymbTr collection is given. Each of the 73 pieces was divided into 40 portions and histograms are collected for each portion. Each note is indicated with a filled circle where radius is chosen to be proportional to the frequency of occurrence. The most frequent note in each portion is colored in red. The histogram corresponding to frequency of occurrence in all pieces is represented on the right most (colored in black). From this representation, we observe that the progression starts with emphasis of the note *rast*. Note *segah* and note *neva* are the following emphasized notes where the progression ascends first and finally arrives to conclusion note *rast* as *karar*. The solid line depicted is the average of the melodic progression where dashed lines indicate one standard deviation upper and lower points of this average. We observe that the *seyir* description provided in the introduction for *makam Rast* is inline with observations made on the representation automatically obtained on the collection.

Below in Figure 5, we present example plots for two couples of different *makamlar*, which differ only in melodic progression.

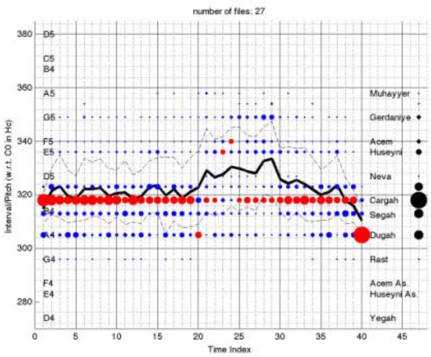
**Figure 5:** Proposed *seyir* representations automatically obtained for makamlar *Muhayyer* (45 pieces), *Hüseyni* (57 pieces), *Saba* (27 pieces) and *Bestenigar* (8 pieces).



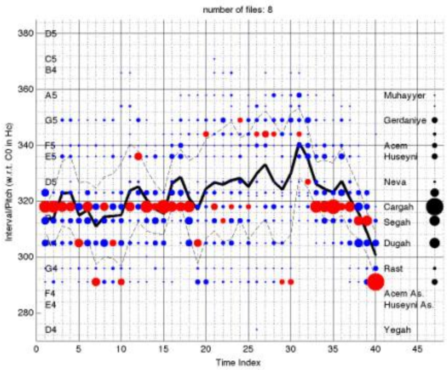
*Muhayyer*



*Hüseyni*



*Saba*



*Bestenigar*

As explained in theory books, *Hüseyni* shares the same scale with *Muhayyer* but have different melodic direction. *Muhayyer* is a descending *makam*, and it starts from upper tonic, pitch *muhayyer* (A). Second prominent pitch is *neva* (D) and then *hüseyni* (E). *Hüseyni makam* has an ascending–descending melodic line. *Hüseyni* opens with the pitch *hüseyni* (E). The lower parts of the progression are very similar and both *makamlar* have the same finalis, pitch *dügah* (A). It is clear from the representations that two *makamlar* mainly differ in the initial part of the progression and the relative emphasis levels of pitches *neva* (D) and *hüseyni* (E).

Considering the lower row of Figure 5, representations for *makam Saba* and *Bestenigar*: both *makamlar* begin with the emphasis of pitch *çargâh* (C). The main differences are: *Bestenigar makam* uses a larger dynamic range, from *muhayyer* (high-A), down to the tonic *ırak* (low-F sharp), the finalis (of both the overall progression and some of the melodic lines throughout the progression) is different [*dügah* (A) for *makam Saba* and *ırak* (low-F sharp) for *Bestenigar*] in these *makamlar*.

In our private communication with the masters of Turkish *makam* music, they found these figures very informative. It is interesting to observe that the average contour follows the structure defined for *seyir*. This is not always easily observed for individual pitch contours (of pieces).

## 4. Conclusion

In this text we have introduced a representation that can be automatically obtained from a collection of scores to be used in studies targeting *seyir* analysis. To our information this is one of the initial attempts to provide a computational approach for long-term melodic contour analysis. Our tool (developed in Matlab) is available upon request from the author and can be used on the open collection SymbTr to study long-term melodic progression characteristics for Turkish makam music as demonstrated here.

### *Acknowledgement*

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## References

AYANGIL, Ruhi (2001), "21. Yüzyıl Eşiğinde Türkiyede Müzik Kuramı Çalışmaları", *Musikişinas*, 5, pp. 72–81.

AYDEMIR, Murat (2010), *Turkish Music Makam Guide*, Istanbul, Pan Yayıncılık.

BOZKURT, Bariş (2008), "An Automatic Pitch Analysis Method for Turkish Maqam Music", *Journal of New Music Research*, 37/1, pp. 1–13.

BOZKURT, Bariş (2012), "Features for analysis of Makam music", in SERRA, Xavier, RAO, Preeti, MURTHY, Hema, and BOZKURT, Bariş (eds), *Proceedings of the 2nd CompMusic Workshop, July 12–13, Istanbul, Turkey*, Barcelona, Universitat Pompeu Fabra, pp. 61–65.

EROY, Ozan (2010), "Tekirdağ Bölgesi Çingene Müziklerinde Kullanılan Ezgi Yapılarının İncelenmesi", MS Thesis, Kırıkkale University.

GEDİK, Ali Cenk, IŞIKHAN, Cihan, ALPKOÇAK, Adil, and ÖZER, Yetkin (2005), "Automatic Classification of 10 Turkish *Makams*", *Proc. Int. Cong. on Representation in Music & Musical Representation*, İstanbul.

GÖNÜL, Mehmet (2010), "Nevres Bey'in Ud Taksimleri Analizi ve Ud Eğitimine Yönelik Alıştırmaların Oluşturulması", PhD. Thesis, Selçuk University.

GÜRMERİÇ, Şefik (1966), "Ders notları, [printed lecture notes]", *İBK Türk Müziği Bölümü Talebe Cemiyeti Neşriyatı*, 1.

KARADENİZ, M. Ekrem (1980), *Türk musikisinin Nazariye ve Esasları*, Ankara, İş Bankası Yayınları.

KARAOSMANOĞLU, Mustafa Kemal (2012), "A Turkish Makam Music Symbolic Database for Music Information Retrieval: SymbTr", in *Proceedings Int. Society for Music Information Retrieval (ISMIR)*, Porto.

SÜMBÜLLÜ, Hasan Tahsin, Albuz, Aytekin (2011), "Türk sanat müziği dizilerinin bilgisayar destekli makamsal analizi", *Uluslararası İnsan Bilimleri Dergisi*, 8/1, pp. 145–198.

ŞENTÜRK, Sertan (2011), *Computational Modeling of Improvisation in Turkish Folk Music using Variable-length Markov Models*, Georgia, Georgia Institute of Technology.

ÖZTÜRK, Okan Murat (2011), "Turkish Modernisation and Makam Concept: Some determinations on two musical systems", *ICTM Yearbook*.

TOUMA, Habib Hassan (1971), "The Maqam Phenomenon: An Improvisation Technique in the Music of the Middle East", *Ethnomusicology*, 15/1, pp. 38–48.

YENER, Suat (2004), "Bilgisayar Destekli Analiz Yoluyla Geleneksel Türk Sanat Müziği Hicaz Taksimlerinde Kalıplaşmış Ezgilerin Araştırılması", PhD Thesis, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü Güzel Sanatlar Eğitimi Bölümü Müzik Öğretmenliği Bilim Dalı.

YENER, Suat, AKSU, Cahit (2004), "Türk Halk Müziği Ezgilerindeki Türk Müzik Dokusunun Bilgisayar Destekli Analizi", *Atatürk Üniversitesi Güzel Sanatlar Enstitüsü dergisi*, 13, pp. 127–137.

Olivier LARTILLOT[1]

# A COMPREHENSIVE COMPUTATIONAL MODEL FOR MUSIC ANALYSIS, APPLIED TO *MAQAM* ANALYSIS


## Abstract

We introduce a new computational framework for music analysis decomposed into a set of modules. Each module addresses a core aspect of music analysis and offers some innovative breakthrough compared to the state of the art. In order to overcome the limitations of local segmentation, we propose an alternative paradigm based on hierarchical local grouping. New mechanisms for ornamentation reduction based on local grouping enable to build a syntagmatic network for the search for ornamented patterns. We propose an approach for modal analysis based on comparing local contexts (defined by current and recent notes, and taking into account ornaments reduction) with all possible modes and key scales. We show how this could be applied in particular to the analysis of *Maqam* music. Pattern mining is applied to the search for motives, for mode-related patterns as well as metrical analysis. The integration of the modules into a single framework enables to model interdependencies, which play a major role in music.


[1] Olivier Lartillot is Academy of Finland research fellow at the University of Jyväskylä. He develops computational models and tools for music analysis, both from the audio and the score domains, such as *MIRtoolbox* and *MiningSuite*. He collaborates with Mondher Ayari on the design of cognitive models for music analysis that take into consideration the impact of cultural knowledge. He participates in particular to the *CréMusCult* project funded by the French research agency ANR.