A CULTURE-SPECIFIC ANALYSIS SOFTWARE FOR MAKAM MUSIC TRADITIONS

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ABSTRACT

Computational analysis of traditional music recordings often requires culture-specific problem definition and methodologies. Our previous efforts were directed towards developing technology for computational analysis of Turkish makam music which shares many common features with other maqam/makam traditions such as Arabic and Persian traditional music. This study presents an interactive tuning analysis tool developed with sufficient flexibility for parameter settings. We demonstrate that the tool can be effectively used for tuning analysis of Turkish music, Arabic music and Persian music once the appropriate settings are supplied by the user, using the interface of the tool.

1. INTRODUCTION

Each music tradition in the world has distinct melodic, rhythmic and timbral characteristics as well as semantic and cultural understandings (Tzanetakis et al., 2007). Any study done on a music culture needs to have a careful consideration of these musical concepts and how they are related to each other. Until recently, computational methods and tools were mainly aimed at studying euro-genetic musics (Serra, 2011). These approaches typically fail to address the research questions and the related computational tasks involving other music traditions (Bozkurt, 2008; Gulati et al., 2015). This brings a necessity to introduce culture-specific problem definitions and create novel methodologies to solve them.

On the other hand, computational research tools aimed at analyzing or modeling common musical concepts may be developed with flexibility to a certain extent. Such a feature is crucial in comparative studies between music traditions, where the methodologies should be capable of showing the similarities and/or differences between each music tradition consistently.

In this paper, we present a music analysis software that can be adjusted according to the musical properties of the studied music tradition(s). We focus on the so-called "tuning analysis" task, which is an important step in the melodic analysis of many music traditions. In this task the performed melodic intervals in one or more audio recordings are extracted and analyzed. The obtained model(s) can then be used for several related research problems such as tonic identification (Bozkurt, 2014), melodic mode recognition (Gedik & Bozkurt, 2010; Koduri et al., 2014), comparison of music theory and practice (Bozkurt et al., 2014) and expression analysis. The developed software mainly differs from similar tuning analysis software (such as TARSOS (Six & Cornelis, 2011)) by the flexibility of applying user specified culture-specific settings.

As a proof-of-concept we develop a toolbox named *MakamBox* and a separate settings creation tool. The settings tool is used to adapt the *MakamBox* to the culture-specificities of the studied music. We show that the toolbox and the setting tool can be used to analyze various music traditions such as Turkish-makam, Arabic-maqam and Persian music traditions.

The rest of the paper is organized as follows: in Section 2 previous problem definitions and related studies are briefly introduced, in Section 3 the methods useful for analyzing Turkish makam music are stated and in Section 4 the software implemented in this study is described in detail.

2. RELATED RESEARCH

There are considerable amount of MIR studies on euro-genetic music culture. However, the existing MIR methodologies are inadequate to analyze other music cultures due to certain characteristic differences (Serra, 2011). These characteristic differences have been discussed in recent studies. To illustrate: Indian art musics do not utilize descriptive scores, which can be used to analyze the musical traditions (Koduri et al., 2014). Arab-Andalusian music possess a special and unique musical richness as it has been influenced by several political and geographical developments throughout the history (Chaachoo, 2011). In Central African music there is no reference tuning, standardization of pitch frequencies and fixed pitch intervals (Moelants et al., 2006, 2007). Consequently, unlike the discrete pitch space representation in euro-genetic music, Central African music has continuous pitch space representation.

In this context, Turkish makam music holds a special position since it is a junction point for several different music traditions (Bozkurt et al., 2009) It has many similarities with other makam traditions, which are still alive in Middle East, some parts of Asia and Northern Africa, and contains many of aforementioned features of traditional music cultures (Bozkurt et al., 2014). Moreover, there are already comprehensive studies on makam histogram templates extraction (Bozkurt, 2008), tonic identification (Bozkurt, 2014), makam recognition (Gedik & Bozkurt, 2010), tuning analysis (Bozkurt et al., 2009), eval-

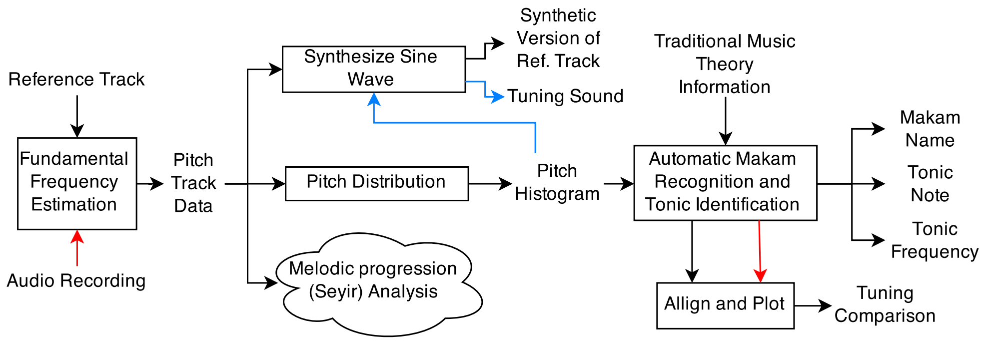


Figure 1: Block Diagram of *MakamBox*

uation of theory-performance mismatch and representation of pitch organization.

3. MELODIC ANALYSIS TASKS CONSIDERED FOR TURKISH MAKAM MUSIC

For the computational analysis of music traditions, several methods are needed to explore different aspects of the music. Mainly, analyzing the melodic and rhythmic features of a music culture provides a substantial amount of information. For this purpose, audio recordings, related metadata and machine readable scores can be used (Uyar et al., 2014). After the relevant data is obtained from the sources, various characteristics of the tradition can be studied. In this section, the methods used for analysis of Turkish makam music are briefly described.

Melody extraction is the first step of the analysis related to the melodic aspects. The result of the process is the pitch-time series data (pitch track). The pitch track provides important information about the audio recording such as the tuning (Bozkurt, 2012), the melodic progression (Şentürk et al., 2014) and embellishments (Özaslan et al., 2012). By using a pitch track, the pitch histogram can be obtained. Pitch histogram is computed as a distribution of the all pitch values in a recording.

A generic information about the scale features of a collection can be attained, by computing a pitch histogram from multiple audio files having a common characteristic. The pitch hierarchy and the melodic progression rules of the each makam result in certain distribution of the pitches. This approach has been used in many studies previously (Akkoç, 2002; Bozkurt, 2008; Karaosmanoğlu & Akkoç, 2003; Şentürk et al., 2013; Tzanetakis et al., 2003; Zeren, 2003). For instance, by combining the theoretical information and the pitch histograms of a group of recordings from a certain makam, the makam template histogram can be obtained. Makam template histograms of Turkish makam music theory can be computed by supervised learning as described in Bozkurt (2008). Automatic makam and tonic detection method provided by Bozkurt (2008) is based on matching the overall histogram of a certain audio recording with makam histogram template.

Pitch histograms have been used to analyze the tuning in makam music recordings in Bozkurt (2008); Bozkurt et al. (2009); Gedik & Bozkurt (2010). The comparison between two aligned histograms which are computed from two recordings in same makam is quite useful to understand tuning approach of different experts. In addition, pitch histograms can be used to compare analysis of student performance to reference track.

The tonic together with the *ahenk* [1] information provides information about the tuning used in a recording. This knowledge is important because there are several reference frequencies for tuning (e.g A ≈ 440 Hz for Mansur *ahenk*, D ≈ 440 Hz for Bolahenk *ahenk*) in practice of makam music tradition. If a user wants to practice by playing over a recording, a tuning difference between the user's instrument and the recording can be encountered. In such cases, key transposition of the recording is needed. The transposition can be performed by pitch shifting the recording with an amount of frequency difference between the estimated tonic and theoretical tonic frequency specified by the *ahenk* information and the makam.

Melody extraction methods may be inaccurate in some conditions. Some methods work well on monophonic recordings whereas they are not reliable on polyphonic recordings (Şentürk et al., 2014). In addition, some octave errors on the pitch track effects the accuracy of the pitch distribution. Synthesizing sine wave using a portion of pitch track and listening both original recording and synthetic version are quite useful to test accuracy of estimation. Furthermore, synthesizing sound using histogram peaks is helpful to tune the instrument as used in a reference track.

4. TOOLS

4.1 Analysis Software

To increase the usability of the existing computational studies of TMM, *Makam Aracı* has been developed for the musicians and the musicologists in the MATLAB [2] environment. *Makam Aracı* consists of some implementations of Turkish makam music studies. The toolbox has been used

[1] Diapasons are called *ahenk*s in Turkish Makam Music, which roughly specifies the length of ney that will serve as the reference mapping between frequencies and notes (similar to specifying that a score should be interpreted using a Bb instrument).

[2] http://www.mathworks.com/products/matlab/

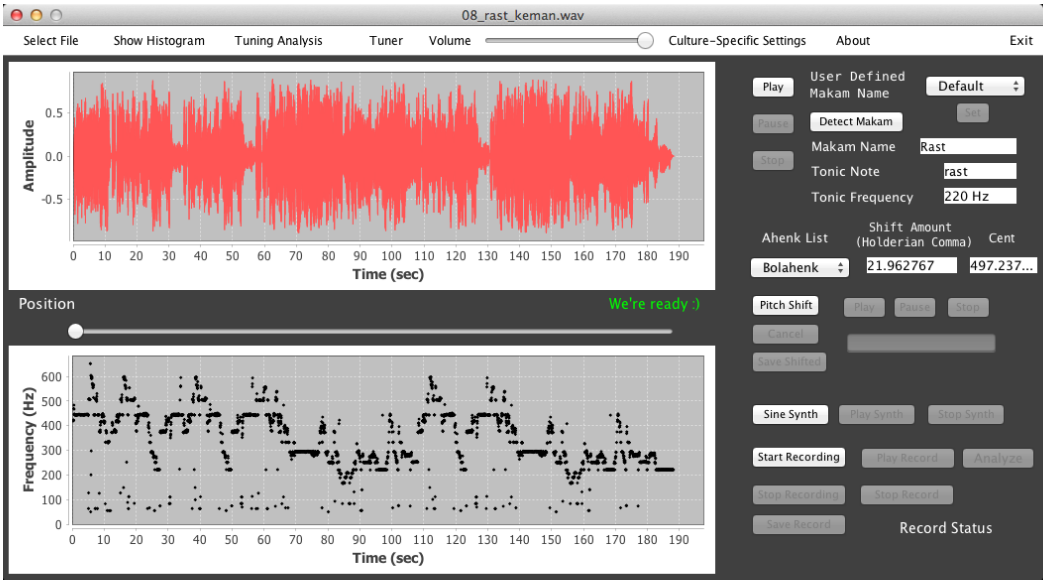


Figure 2: Screen capture of *MakamBox*, Culture-Specific Analysis Software

in several thesis studies in conservatories or musicology departments (Ekşi, 2011; Özek, 2011; Tan, 2011). Moreover, the methodologies implemented in this toolbox can be effective used with some adaptations for other makam music traditions (such as Arabic and Persian) by taking into consideration of the cultural similarities of Middle East, Asia and Northern Africa.

Although it is quite useful, *Makam Aracı* is not designed as a standalone application. It requires extra configuration steps (e.g. compilation of the YIN (De Cheveigné & Kawahara, 2002) algorithm, a need of MATLAB environment). In addition, *Makam Aracı* can be only used for the Turkish makam music culture due to hard-coded culture-specific music theory information.

To cope with these limitations and difficulties we have re-implemented *Makam Aracı*. We name the new software as *MakamBox*. *MakamBox* is developed in Java[3] to be able to deploy easily to researchers and musicians. The origin of our idea is to develop platform-independent software which does not require additional installation (excluding Java Virtual Machine, Java Runtime Environment or JRE).

Another advantage of *MakamBox* is the flexible analysis capabilities on different music cultures and traditions. As a consequence, all hard-coded information about TMM is removed from the software. Then, a new function that helps the user to load culture-specific settings file to software is added. The discussed culture-specific setting file which can be created via the newly developed tool, contains overall information (note and makam names, template histogram for each makam, *ahenk* information) about specified traditional music theory.

A snapshot of *MakamBox* is shown in Figure 2. The waveform and the pitch track of the reference recording are presented in the main window. The user can zoom in and out both of the graphics and loop-play the zoomed part. Moreover the estimated pitch track can be synthesized using a sine wave. The user can listen to the synthesized pitches corresponding to the peaks of the pitch histogram. The synthesized peaks can also be used a reference to tune musical instruments.

[3] http://www.java.com

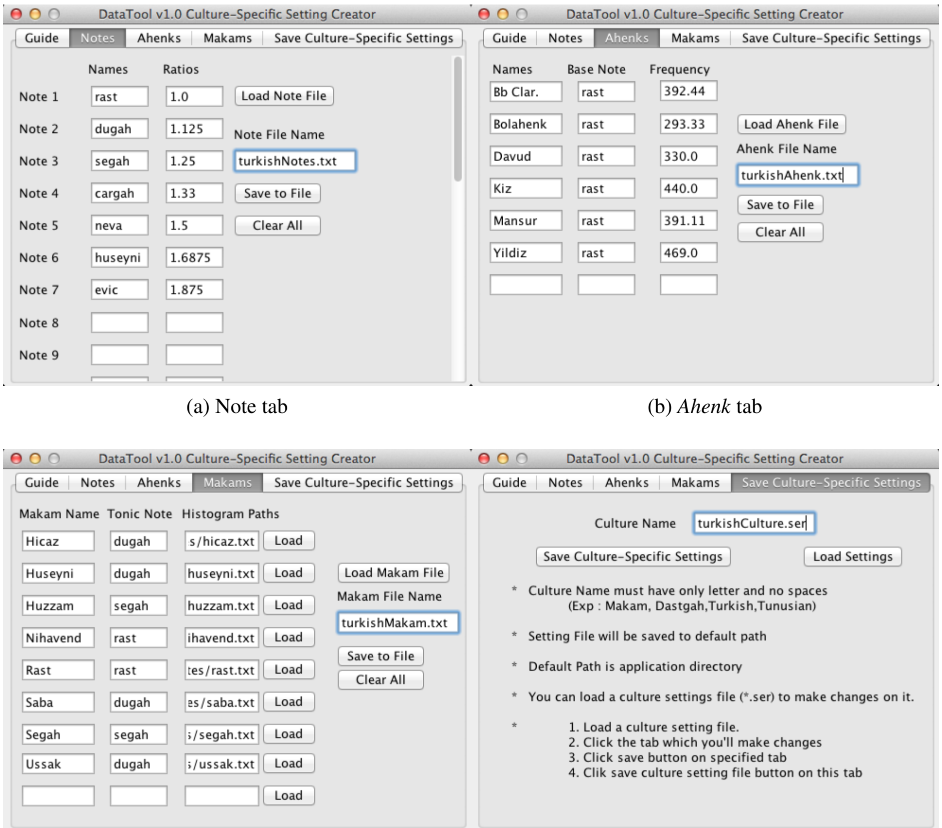
12TET Note Names	Frequency Ratios
C	1.0000
D	1.1225
E	1.2599
F	1.3348
G	1.4983
A	1.6818
B	1.8877
C (octave)	2.0000

Table 1: Note names and frequency ratios for 12TET

4.2 Culture-Specific Settings Creation Tool

DataTool is a software which is developed to create the settings file. *DataTool* needs 3 types of information. First one is about note information in traditional music theory. In this part, the user specifies the name of notes and frequency ratios with respect to the first note. This information serves as a theoretical reference, which helps initialization of intonation analysis. For example, frequency ratio of A5 with reference to A4 is 2. Frequency ratios of notes in 12 tone-equal-tempered (TET) and Turkish Makam Music (according to Arel theory (Arel, 1968)) are listed in Table 1 and Table 2 . On the notes tab in the software, *Save To File* button saves the notes names and frequency ratios to a text file which user can specify the name of the file. The snapshot of this part is shown in Figure 3a.

Second part is the *Ahenk Settings*. User will specify the *ahenk* name, reference note of each *ahenk* and frequency of the reference note. This data will be used for key trans-



(a) Note tab (b) *Ahenk* tab

(c) Makam tab (d) Culture-specific setting file tab

Figure 3: Screen captures of *DataTool* software

TMM Note Names (8 of 24)	Frequency Ratios
Rast	1.0000
Dügah	1.1250
Segah	1.2500
Çargah	1.3333
Neva	1.5000
Hüseyni	1.6875
Eviç	1.8750
Gerdaniye	2.0000

Table 2: Note names and frequency ratios for TMM (according to Arel)

position (when pitch shifting needs to be applied). *Save to File* button saves the *ahenk* names, reference notes and their frequencies to a text file which user can specify the name of the file. The snapshot of this part is shown in Figure 3b.

Third part is the *Makam Settings*. For each makam, a template histogram file is needed, which is computed/learned from recordings using another tool described in Bozkurt (2008). The user needs to specify the text file path containing the histogram. Also, each makam has a tonic note information, called *karar perdesi*. The shifting amount to transpose to user-specified *ahenk* with this note is calculated automatically. *Save to File* button saves the makam names, tonic notes and histogram file path to a text file which user can specify the name of the file. The snapshot of this part is shown in Figure 3c.

At the end of the process, the user needs to save all settings with given name to a Java SER [4] file. *Save Culture-Specific Settings* button saves the overall information about music culture to SER file, which user can specify the name. It will be used to set culture specific features of the *MakamBox*. There is also a *Load Settings* button. By clicking *Load* button the user can make some changes on settings file, which is created before. The snapshot of this part is shown in Figure 3d.

5. CONCLUSION

In this study, we presented an intonation analysis tool that can be adapted easily to various makam music traditions.

A new software, *DataTool*, is developed to expand the analysis capabilities of *MakamBox* on different music cultures and traditions. Interested readers are invited to author's web page [5] to watch our demonstration videos about creating culture-specific settings file and its usage.

[4] The file name extension which is used mostly for Java serializable object

[5] www.miracatici.com/makambox

6. ACKNOWLEDGMENTS

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