Distribution based computational analysis of makam music

By Barış Bozkurt,
Bahçeşehir University, Istanbul

“Makam world” (needs re-painting)
Let the music speak for it-self

• Earliest sources of recorded material:
  – Tanburi Cemil Bey (1873-1916): a virtuoso being constantly imitated still today

  Çoban Taksim
  – Roots: Nature, folk music, dance music as well as Ottoman urban music

  Hüzzam taksim (violincello (Western inst.))
  – Modern interpretations of his compositions

  – International scene: Turcs with Greeks
  – Various forms in today’s Istanbul
  – In the Arab world

Modernization(?!), continuation?
Mesud Cemil Bey (1902-1963)

Continues his age’s tradition but also introduces new concepts:
- The choir lead by a chief (Western)

Today one of the most common forms of making music

Plenty of professional (state funded) and amateur choirs exist today
Today’s various settings
To fix or not to fix, that’s the only problem

Phytagoras (570 B.C.)
Tuning Theories
Al-Kindi (800-873)
Use of the 3/2 operator to define frequencies ratios

Safiüddin Urmevi (1224?-1294): Kitab-ül Edvar
Maragah Abdülkadir (1350?-1435)
Nayi Osman Dede (1650?-1730)
Kantemiroğlu (1673?-1723)
Abdulbaki Nasır Dede (1765?-1820)

17 notes in an octave

The success of this repeated theory in representation of the practice is highly questionable!
Albert Bobowski: a foreigner stayed in Topkapi Palace, used Western notation (1650) to write Ottoman music. Thanks to him, he helped preservation of many pieces.
Dimitrie Cantemir (Kanemiroğlu) (1673-1723)

Begining of the 20th century, time of rapid changes
- Study of theory, notation and repertoire

First official state conservatory: Darülelhan (1917-1927)

Oral -> Written

Important part of today’s repertoire

Next conservatory after 1927: Let’s make a guess: 1976
Continuation of theory and practice: Tekke’s

20th century theoreticians got their education from these people.

Closed/banned in 1925

Rapid changes in 1925-1930

- No official body for music education for makam music
- Conservatories for Western music education
- Westernized theory and notation for makam music
- Ottoman music banned on radio: 1934 (for 8 months)
- Tekke’s banned

What is left? Who carries the tradition?

Folk music, small circles of people, radio, amateur choires, music for everyday life (taverns, weddings, etc.)

Conservatories after 1976
Notation used in the 20th-21th century (Arel Theory)

A combination of Phytagorian tuning, 53Tet and Western music notation.

DISCUSSIONS CONTINUE!

Problem definition

- A Westernized theory used with patches
- No audio recordings before 1915
- Historical writings which mainly repeat each other and contain vague descriptions
- Changes in music practice are hard to study in detail
- Oral education chain is almost totally broken
- ...
- Yet music is alive in various forms, sometimes mixed with other genres
THE(?) tool for computational studies: distributional analysis

- Pitch class histograms
- Pitch histograms
- Distributions of:
  - makams used in different centuries
  - intervals used by a composer
  - number of songs in each distinct makam
  - Etc.

Pitch class histograms

Used to study:

- composer specific characteristics of tunes
  (done manually in the past)
- makam recognition (recently) or similarity between makams
Pitch histograms

- An effective tool for tuning analysis, automatic tonic detection
- Useful in automatic makam recognition

**Melograph (f0) → Histogram**

**Histogram construction**

$$Hf_0[n] = \sum_{k=1}^{K} m_k$$

$m_k = 1, f_k \leq f_0[k] < f_{k+1}$

$m_k = 0, otherwise$

**53Tet:** Logarithmic division of an octave into 53 equally spaced intervals.

**Choosen for easy comparison to existing theories.**

Resolution of the highest resolution tuning system proposed for Turkish music: 159tet (Yarman, 2008)

**Holderian comma** is also referred as: “comma”, “turkish comma”, “arabic comma”, etc. It often means “a bit” for a musician.
The diapason system called Ahenk. Like Eb, Bb instruments. The most frequently used is “Bolahenk”: Neva-Re-D=220Hz.

<table>
<thead>
<tr>
<th>NEY TYPE / AHENK</th>
<th>LENGTH (mm)</th>
<th>D² (mm)</th>
<th>A=440 cpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boldhunk</td>
<td>1044-1040</td>
<td>39-40</td>
<td>neca</td>
</tr>
<tr>
<td>Đerel</td>
<td>925-956</td>
<td>35.5-36</td>
<td>corazah</td>
</tr>
<tr>
<td>Şab-Olk* Şah</td>
<td>858-884</td>
<td>33-34</td>
<td>reğah - huvetik</td>
</tr>
<tr>
<td>Menmar</td>
<td>789-906</td>
<td>30-31</td>
<td>diqah</td>
</tr>
<tr>
<td>Ezi</td>
<td>702-715</td>
<td>27-27.5</td>
<td>rost</td>
</tr>
<tr>
<td>Yoldax*</td>
<td>639-663</td>
<td>25-26.5</td>
<td>asuk</td>
</tr>
<tr>
<td>Hörhaham</td>
<td>598-611</td>
<td>23-23.5</td>
<td>ausen qins</td>
</tr>
<tr>
<td>Şıgırیدe</td>
<td>573-585</td>
<td>23-23.5</td>
<td>qins</td>
</tr>
<tr>
<td>Boldhunk-Niyfat*</td>
<td>529-553</td>
<td>20-20.5</td>
<td>qapah</td>
</tr>
</tbody>
</table>

These are not precise in frequency either.

Notes -> fingering, not frequency

- Freedom of the player, regional variations in intervals
- Use of non-standard instruments (and mismatches in the construction of different types of instruments: Kanun(72Tet), Ney(? by ear), Tanbur(? by ear))
- More notes ... Mainly 17 tone system used for centuries, then came 24 tone....then 32, 48... ->79 tones in an octave(2009)!!?
Tonic detection and Makam recognition can be achieved via template matching

Was also used later for Indian music

Makam histogram template construction

The AEU system scale intervals: [0 5 17 22 31 35 44 53] Hc

Given a recordings pitch distribution, align the two distributions

Examples
Testing the Tonic Detection on Synthetic Signals (from MIDI)

<table>
<thead>
<tr>
<th></th>
<th>CrossCorr.</th>
<th>City Block</th>
<th>Euclidean</th>
<th>Intersection</th>
<th>Bhattacharyya</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RAST</strong> (24 songs) Mean Tonic F0(Hz)</td>
<td>110.05</td>
<td>109.59</td>
<td>109.51</td>
<td>109.59</td>
<td>109.61</td>
</tr>
<tr>
<td>Std (Hz)</td>
<td>0.42</td>
<td>0.16</td>
<td>0.19</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>MaxDist(Hz)</td>
<td>1.12</td>
<td>0.26</td>
<td>0.34</td>
<td>0.26</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>SEGAH</strong> (22 songs) Mean Tonic F0(Hz)</td>
<td>276.62</td>
<td>274.71</td>
<td>274.44</td>
<td>274.71</td>
<td>274.16</td>
</tr>
<tr>
<td>Std (Hz)</td>
<td>0.48</td>
<td>0.6</td>
<td>0.5</td>
<td>0.6</td>
<td>0.43</td>
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<tr>
<td>MaxDist(Hz)</td>
<td>1.18</td>
<td>1.27</td>
<td>0.95</td>
<td>1.27</td>
<td>1.23</td>
</tr>
<tr>
<td><strong>Overall</strong> (150 songs, 9 makams) Mean-Std(Cents)</td>
<td>56.39</td>
<td>2.75</td>
<td>54.62</td>
<td>2.75</td>
<td>2.42</td>
</tr>
<tr>
<td>Max-MaxDist(cents)</td>
<td><strong>579.9</strong></td>
<td><strong>7.96</strong></td>
<td><strong>583.01</strong></td>
<td><strong>7.96</strong></td>
<td><strong>7.72</strong></td>
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<tr>
<td># false tonic peak det.</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Tests on 118 real recordings:
# false detections 1 1 1 1 2

We studied the theory-practice mismatch on 9 most frequently used makams (covers 75% of the repertoire), on taksim recordings of selected masters, comparing measurements with representative theories from 13th century to today.


Future work: separate histograms for descending and ascending lines
These are not only glissando’s but tendency to lower pitch of certain notes in descending passages

Makam recognition via simple template matching

The evaluation results of the makam recognition system.

<table>
<thead>
<tr>
<th>Makam type</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>R</th>
<th>P</th>
<th>F-measure</th>
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<tbody>
<tr>
<td>hicaz</td>
<td>14</td>
<td>150</td>
<td>2</td>
<td>6</td>
<td>70</td>
<td>88</td>
<td>78</td>
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<tr>
<td>rast</td>
<td>14</td>
<td>151</td>
<td>2</td>
<td>5</td>
<td>73</td>
<td>88</td>
<td>79</td>
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<tr>
<td>segah</td>
<td>17</td>
<td>149</td>
<td>3</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>kürdili h.</td>
<td>10</td>
<td>145</td>
<td>11</td>
<td>6</td>
<td>63</td>
<td>48</td>
<td>55</td>
</tr>
<tr>
<td>huzzam</td>
<td>10</td>
<td>152</td>
<td>6</td>
<td>4</td>
<td>71</td>
<td>63</td>
<td>67</td>
</tr>
<tr>
<td>nihaend</td>
<td>14</td>
<td>143</td>
<td>11</td>
<td>4</td>
<td>78</td>
<td>56</td>
<td>65</td>
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<tr>
<td>hüseyni</td>
<td>10</td>
<td>146</td>
<td>6</td>
<td>10</td>
<td>50</td>
<td>63</td>
<td>56</td>
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<tr>
<td>uğşak</td>
<td>15</td>
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<td>9</td>
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<td>60</td>
<td>62</td>
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<tr>
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<td>16</td>
<td>150</td>
<td>1</td>
<td>5</td>
<td>76</td>
<td>94</td>
<td>84</td>
</tr>
<tr>
<td>Mean</td>
<td>13</td>
<td>147</td>
<td>6</td>
<td>6</td>
<td>68</td>
<td>68</td>
<td>68</td>
</tr>
</tbody>
</table>

**Distance Measure:** City-Block(L-1 norm),

**Test method:** Leave one out
Confused Makams

**Human performance**: not measured (like any other cognitive phenomenon)

Average Turkish listener should be around 1/9: by chance

Interested Turkish music listener should be around %60 percent

Professional musicians: close to %100

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Highly open to further improvement:

i) Hierarchical classification

ii) Adding temporal features: typical melodies, overall progression

*Seyir (%80): but very vaguely described*

iii) Classification from spectral features like choroma features

**Hüseyni taksim from 4 different musicians**
Our new direction: distributional -> temporal

• “Seyir: progression” is at least as important as tuning (they work together)
• We need to study it in various resolutions: melodic atoms and overall progression in a piece
• Modulations constitute important part of the beauty