Analysis and classification of the Persian musical modes

Peyman Heydarian

Centre for Digital Music, Queen Mary, University of London

The Persian Intervals

- Vaziri defined Sori (♯: half-sharp) and Koron (♭: half-flat) quartertones in 1913
- Officially, there are 24 equally distant Quartertones
- In practice, only 13 of them (or their transpositions) are used:

E - F - ♯F - #F - G - #G - A - ♭B - B - C - ♯C - #C - D

- A quartertone's position depends on the performer's mood, the melody and the mode

Actual Intervals (in cents)

Whole tone:	204
Semitone:	90
Small neutral tone (n):	135
Large neutral tone (N):	160
Plus tone (P):	270

The Rhythm

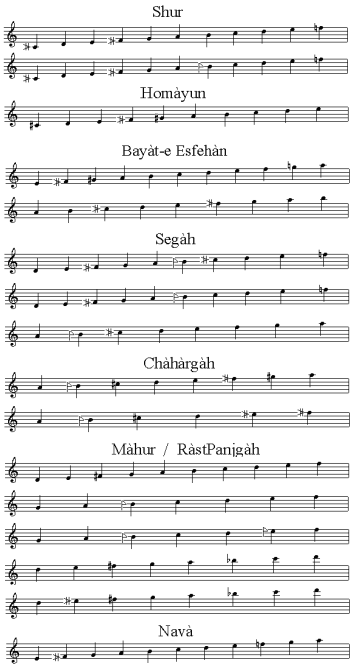
- Free-rhythmic
- 2/4, 4/4, or 6/8.
- Complex like 5/8 and 7/8

The Modal system

Persian music is based on a system of 12 main modes, called the Dastgàh: Shur, Abu' Atà, Bayàt-e Tork, Afshàri, Dashti, Homàyun, Bayat-e Esfehàn, Segàh, Chahàrgàh, Màhur, RàstPanjgàh, Navà

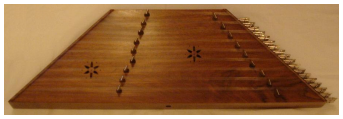
The Composition

- Performance starts with an opening section: Daràmad
- Tonal centre moves upward during modulations
- Forud, a cadential phrase, brings mode back to the initial

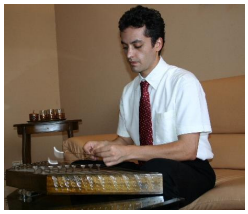


The Santur (Hammered Dulcimer)

- Santur is a Persian instrument
- Was taken to other countries: India, China, Thailand, Greece, Germany, Austria, Poland, Hungary, US, England and Scotland
- Is a direct ancestor of Piano
- Tone range:
  C3 (130.8 Hz) to F6 (1396.9 Hz)

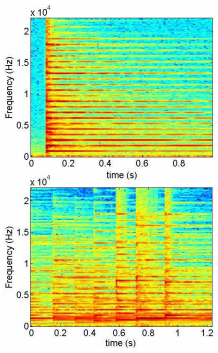


- Resonating body: Walnut wood
- White Strings: Stainless Steel
- Yellow Strings: Brass
- String holders: Metal
- Tuning pegs: Metal
- Bridge: Walnut wood and a rolling metal
- Sticks: Walnut or Narenge
- Tuning hammer: Metal



Performing the Santur

Spectrum of an A4 note and a two-octave A minor arpeggio



Towards the mode classification

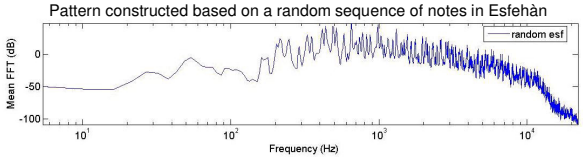
Human does this task by either of these ways:

- Perceptually: based on the emotions a song conveys
- By melody / theme identification, i.e. by direct matching of song with a known pattern
- Through intervals, frequency of note occurrences and order of them. So the first step can be determining the tuning system

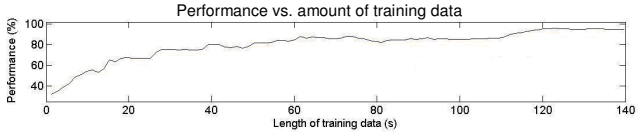
Spectral averages can be used to find the tuning

- Signal is windowed with 75% overlap
- FFT is calculated for each frame
- Average is calculated over all frames
- Reference patterns are calculated for each class during the training process (3 classes in this research)
- Spectral average is calculated for test samples too
- Manhattan distance and Cross-correlation are used as similarity measures
- Works well while the tone-range and no. of occurrence of notes are similar for signal and the respective pattern
- Order of feature space is high
- It is dependent on instrumentation and harmonic content

Pattern constructed based on a random sequence of notes in Esfehàn



Performance vs. amount of training data

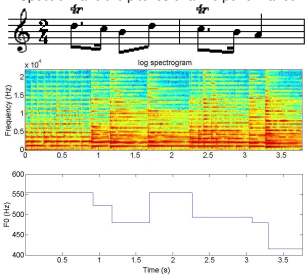


Pitch Tracking algorithm

A pitch tracker based on Tolonen et al. is used

- A pre-whitening is done to remove the short-time correlations. This flattens the spectrum
- Signal is divided into two frequency Bands over and below a cross frequency of 1000 Hz
- Generalized Autocorrelation is performed over each frequency band
- The results are summed up to make the summary autocorrelation function (SACF)
- A post-processing is performed to remove the tone partials
- SACF is rectified
- It is expanded in time by a factor of 2, 3 or more and is subtracted from the rectified SACF
- The past two steps are done with different time expansions to remove 2nd, 3rd, … partials
- The result is called the enhanced SACF (ESACF), which unveils the signal periodicities

Spectrum and the pitches of a live performance



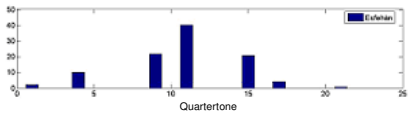
- Onset detection is performed prior to pitch tracking to bypass the transients
- Sound of Santur is pitched percussive so HFC (High Frequency Content) is used
- Transfrom-domain ACF is computationally efficient and can be used for real time applications
- Spectrum can be compressed non-linearly
- SACF is calculated by the following MATLAB command:

$$SACF = real\left(IFFT(abs(FFT(x_l).^{\wedge} p + IFFT(abs(FFT(x_h).^{\wedge} p)\right)$$

Pitch Histograms are used to find the tuning

- They can be constructed based on music repertoire or training samples
- A folded pitch histogram lets map all notes to a single octave
- Dimension of feature space is less
- Calculation cost is reduced
- Works well on samples of different instruments

Pitch Histogram based on written music in Esfehàn



Future work

- Extend the database to include all Persian modes and samples from other close cultures
- Implement other features like chroma and other similarity schemes
- Find the mode through intervals that don't exist in a mode performance
- Consider the order of notes
- Find the mode through a melodic approach
- Follow the modulations to completely describe a performance
- Develop new standards and symbols for non-western music

References

[1] Heydarian, P., Reiss, J.D., "The Persian Music and the Santur Instrument", ISMIR05 conference, London, UK, 2005.
[2] Tolonen, T.; Karjalainen, M., "A computationally efficient multipitch analysis model", IEEE Trans. on Speech and Audio Processing, Vol. 8, Issue 6, Nov. 2000 pp. 708 – 716.