A DATABASE FOR PERSIAN MUSIC

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ABSTRACT

The lack of a proper database has been a major obstacle for the analysis of Non-Western music. To pave the way for research on Eastern music and particularly on Persian music, we have decided to create a database for the Persian music on the Santur instrument. This database consists of single notes and melodies from two Santurs, a 9-bridge and an 11-bridge. The database will be used to construct and analyse the Dastgàh, which are the Persian music scales. This database is tailored to music processing tasks such as note and scale recognition and identification of the melody. Furthermore, it will assist in the analysis of acoustical properties of the Santur. This paper describes its construction, as well as initial analysis results.

Keywords: Non-western Musicology, Persian, Iranian Music, Santur, Database, Dastgàh, Quartertone, Interval.

1 BACKGROUND

Persian music, regardless of the Geographical borders, has influenced various Eastern musical cultures in Central Asia, Middle East, Northern Africa and Southern Europe. The musicians and musicologists in Persia have played a significant role in this trend [1].
The Persian Intervals and Modes are very similar to those of various cultures like Kurdish, Azeri, Guilaki, Màzandaràni, Baluchi in Iran and Turkish, Arabian and Greek music abroad. So, any analysis on Persian music may be extended to a wide range of cultures.

This section provides the background material on Persian Intervals, Modes and the composition.

1.1 The Persian Intervals

There are different views for the Intervals in Persian music:

- A 24-Quartertone interval octave for Persian Music was firstly suggested by Ali Naqi Vaziri [2] and has been widely used since the early 20th century.
- A 22-tone octave was proposed by Mehdi Barkeshli according to the theories suggested by the medieval musicologists like Farabi and Ormavi.
- Considering some intervals between a semitone and a whole tone, in addition to the 12 semitones in tempered Western music. Also there is an interval; which is greater than a whole tone [3].

Vaziri was interested in finding a way to apply the Western harmony rules to the Persian music [4]. He suggested a division of the octave into 24 equal Quartertones in analogy with Western tempered music and defined the Sori (𝄲) and Koron (𝄳) symbols to show half-sharp and half-flat quartertones [2]. This system is widely used by musicians. An ASCII-like version of the symbols is in use where "p" shows the Koron, and ">" shows the Sori. Here we use “q” to show the Koron, and “s” to show the Sori.
In practice, Sori and Koron are not exactly half-sharp or half flat, and can reside anywhere between two semitones. Their position depends on the mode, the melody, and the performer’s mood. Only few quartertones exist in each Persian Mode. Not all the whole tones are divided by quartertone intervals, nor is the position of a quartertone unique. So, only a few quartertones exist in each Persian Scale. All the twelve Dastgàh in Persian music (explained in section 1.2) can be performed with 13 principal notes, 7 of which are the diatonic notes, 3 are semitones and 3 are quartertones [4]. The seven diatonic notes are now called with their international names:

Do Re Mi Fa Sol La Si

The 13 principal notes with which all the Persian Dastgàh can be played on an 11-bridge Santur (Sec. 1.2 and 1.4) are:

Mi Fa 𝄲Fa #Fa Sol #Sol La 𝄳Si Si Do 𝄲Do #Do Re

It should be noted that two consecutive quartertones are very rarely used for trills or as ornaments.
The system proposed by Vaziri is widely used by the musicians, while the 22-tone scale suggested by Barkeshli in 1940 has never been popular.

A preferred option was suggested by Farhat [3]: Considering some intervals between a semitone and a whole tone, and an interval greater than a whole tone to the 12 semitones in tempered Western music.

1.2 The Persian Dastgàh system

Persian music is based upon a modal system, which is called the Dastgàh system. The precise classification is a matter of debate for Persian musicologists, but a twelve Dastgàh system may be used to capture most structure: Shur, Abu' Atà, Bayàt-e Tork, Afshàri, Dashti, Homàyun, Bayàt-e Esfehàn, Segàh, Chahàrgàh, Màhur, RàstPanjgàh, and Navà [3, 5].

There is a tonal centre or centre of pitch gravity for each Dastgàh, which is called the Shàhed. Each Dastgàh has a number of derivatives, called Gushé. Moving from a Dastgàh to Gushé is the usual way for modulation in Persian music. Most of the time, it occurs with a change

in the Shàhed, but sometimes it may change the tuning too. Some of the Gushé are independent, but when called through another Dastgàh, will play the role of a Gushé. For example the Delkash Gushes of Bayàt-e Esfehàn is absolutely a Shur from the fifth higher interval.

Performance in each Dastgàh starts with an opening section, which is called the Daràmad. Then, modulations to other modes (Gushé) occur, during which the Shàhed note gradually moves upward. Finally, a Cadential phrase called the Forud, brings the mode back to the main mode of the Dastgàh.

In terms of rhythm, the urban Persian music consists of either free-rhythmic pieces (Avàz) or rhythmic songs, typically in 2/4, 4/4, or 6/8. Complex rhythms like 5/8 and 7/8 are mostly used in the ethnic music.

1.3 The Persian Composition

Persian music is often dichotomised into urban music (music of the large cities) and ethnic music (music of the different ethnic groups living in smaller cities, villages, and mountainous areas). The first uses more ornamentations and free rhythms. The second uses simple melodies, which are more preserved and are closer to the ancient tradition. Both follow the same intervallic distances and the same modes (sec. 1.2 and 1.4). They rely to a large extent on improvisation.

There are three instrumental forms and one vocal form in urban music. The instrumental forms are Pishdaràmad, Chàhàrmezrab, and Reng. Pishdaràmad was invented by a master of the tar, Darvish Khàn, and was intended as a prelude to the Daràmad which is the opening section of a Dastgàh. It may be in duple, triple, or quadruple time, and it draws its melody from some of the important Gusheh of the piece.

Chàhàrmezrab is a solo piece with a fast tempo, and is usually based on the melody immediately preceding it. The third instrumental form is the Reng, which is a simple dance piece that is usually played at the conclusion of the Dastgàh. The vocal form is called Tasnif. It has a design similar to the Pishdaràmad, and is usually placed right before the Reng. The Persian music is mainly unison, where the instruments in an ensemble play the melodic scheme and relies highly on the improvisation [3].

1.4 The Santur

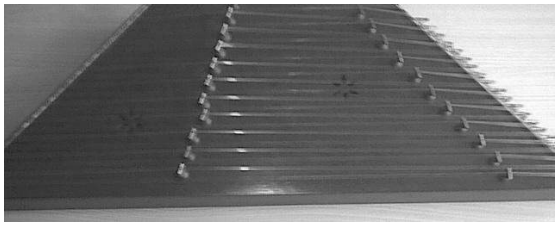
1.5.1 The history

The Santur is a trapezoidal string instrument, played by a pair of delicate hammer sticks. This instrument originated in Iran, and was later brought to India, China, Thailand, Greece, Germany (and other countries), where it is called Santoor, Yang-jin, Khim, Santouri, Hackbrett respectively. It is often referred to as a dulcimer in English. The Santur is one of the most popular instruments in Persia. In a typical Persian ensemble, the Santur sits in the middle and assumes a leadership position.

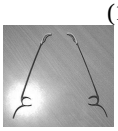
1.5.2 The Santur structure

The hammer sticks, or Mezràb, are held between the index and the middle fingers and are used to hit the strings. The Mezràb are usually coated by a piece of cotton or leather. The body of the Santur is made of walnut and the Mezràb are made of either walnut or Narenge (a citrus wood). Figure 1 shows a Santur and its peripherals.

Four strings are vibrated for each note. They are pulled between the string holders (figure 2-a) and the tuning pegs (figure 2-b), and sat on a bridge (figure 2-c) between these two ends. The notes can be tuned by turning the tuning pegs, using a tuning key which is also used as a hammer to hit the tuning pegs. The bridges are movable and can continuously change the pitch of a note by several whole steps.



(1-a)

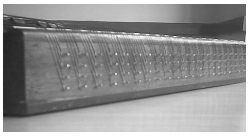


(1-b)

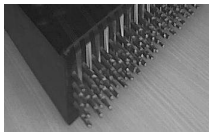
(1-c)

Figure 1 a) Santur b) Sticks (Mezràb) c) Tuning Key

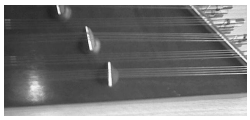
There are two[1] flower-like sound holes (figure 2-d) on the soundboard of Santur. They serve to enhance the sound quality, and influence the timbre.



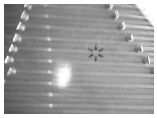
(2-a)



(2-b)



(2-c)



(2-d)

Figure 2 a) Bridges (Kharak) b) Sound holes

Modern Iranian Santurs most often consist of 9 bridges, although 11 and 12-bridge Santurs can be found too.

There are three regions for Santur notes. The first octave notes, or yellow notes, are on the right side of Santur and are made of brass. The second Octave notes, denoted as white notes, are in the centre and made of stainless steel. The extension of the second octave notes pass over the bridges and terminate on the string holders in the left end. These are called behind-the-bridge notes. An 11-bridge Santur has a tone Range from C3 (130.8 Hz) to F6 (1396.9 Hz). The fundamental frequency (F0) of the 11-bridge Santur notes can be calculated reference to a known tone, f_1 using $f_2 = f_1 \times 2^{(d/24)}$ where d represents the distance in quartertones of f_2 from f_1. Table 1 shows the F0 for Santur notes, using the above formula.

The fundamental frequency of the string is a function of its length l, string pulling force F, string material constant μ and a constant K, as given by Eq. (1).

$$f = \frac{K}{2l}\sqrt{\frac{F}{\mu}} \qquad (1)$$

The resonance body of a Santur is hollow, but there are wooden columns that keep the instrument from dis-

[1] Sometimes there is also a round sound hole in the front or rear vertical wood sheet of Santur.

ruption. They bear the force exerted by the strings over the bridges on the upper surface of Santur.
All Dastgàh may be played on a Santur in different keys. For example, figure 3 shows the tuning system and the intervals for an 11-bridge Santur. AbuAtà, Dashti, Bayàt-e-Tork and Afshàri which are all derivatives of Shur, have the same tuning.

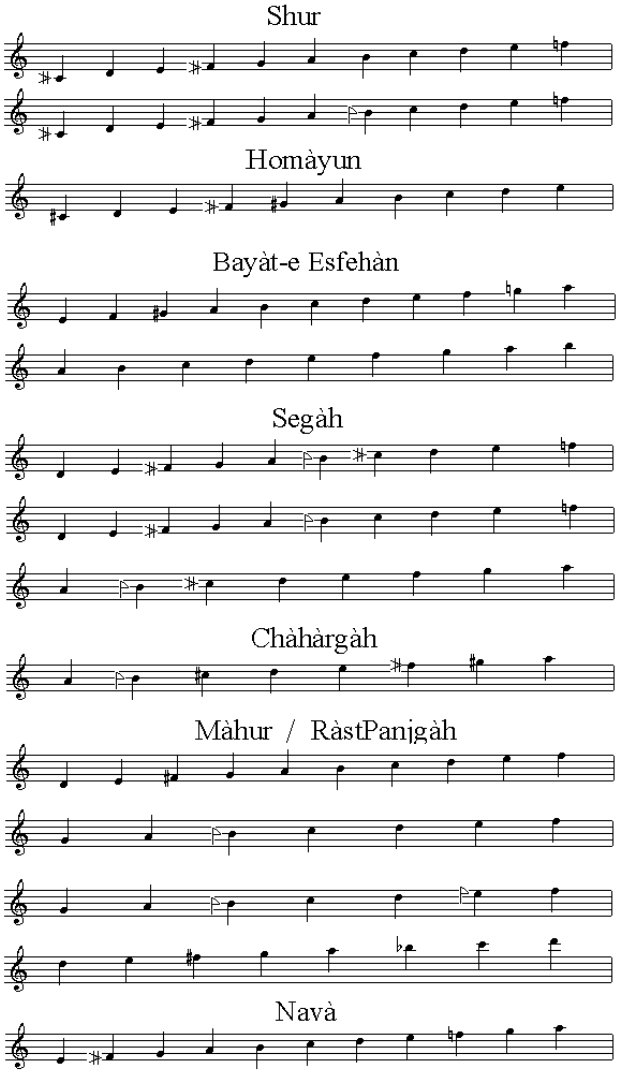


Figure 3 The tuning system on Santur[1]

2 THE DATABASE

The sound was recorded using a computer with sound card, a preamplifier, A/D, and two microphones placed in right angles. Stereo samples of 16-bit precision at 44.1 kHz sampling rate where recorded. The samples were performed by a trained musician. To provide a database for F0 analysis, 10 samples for each of the notes in Persian music from E4 to E5 was recorded:

E4 F Fs F#4 G4 G#4 A4 Bq4 B4 C5 Cs5 C#5 D5 E5

The samples have been played in three different conditions:

- 4 strikes with sticks with a thick coating
- 4 strikes with sticks with a thin coating
- 2 Strikes with sticks without any coating

Two different tunings were used for each quartertone to show their flexibility. For example the Fs in Bayàt-e Esfehàn is slightly higher in pitch than the same note in Homàyun (figure 3).
Then, for the analysis of the Dastgàh, melody or other long-term structures, some melodies were played in Bayàt-e Esfehàn (in E and A) on an 11-bridge and in Màhur (in F) on a 9-bridge Santur. The performance was improvisatory based on contemporary Persian music. For example the 3rd Interval below the tonal centre in Bayàt-e Esfehàn is a Major third (F-A) rather than being a quartertone less (Fs-A).

Table 1 F0 for Santur Notes

Note	Fundamental Frequency (Hz)
C#3	138.6
D3	146.8
F3	164.8
Fs3[2]	179.7
G3	196
A3	220
Bq3	239.9
C4	261.6
C#4	277.2
D4	293.7
E4	329.6
F4	349.2
Fs4	359.5
F#4	370
G4	392
G#4	415.3
A4	440
Bq4	479.8
B4	493.9
C5	523.2
Cs5	538.6
C#5	554.4
D5	587.3
E5	659.3
F5	698.5
Fs5	718.9
G5	784
A5	880
B5	987.8
C6	1046.5
D6	1174.6
E6	1318.5
F6	1396.9

2.1 Analysing an A4 note and a two-octave arpeggio

Figure 4 shows the logarithm of the Spectrum of an A4 note (F0=440 Hz). They show the variation of harmonic content through time. The amplitude of a harmonic component may change due to the resonance

[1] More information on the Modes can be found in [3, 5].

[2] Note that Sori and Koron are not exactly a quartertone over and below the note. The amount of these combinational marks depends on the mode, the piece and the performer's desire.

characteristics of the strings, the instrument body and the room acoustics.

Figure 5 shows the harmonic content of a 1024 point frame of the same signal in logarithmic scale. To bypass the transient, the analysis window for figure 5, starts at sample no. 4500. The F0 and the major harmonics can be seen.

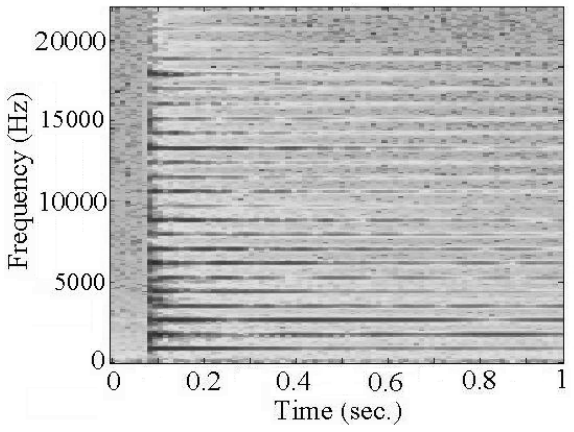


Figure 4 Spectrum of the note A4

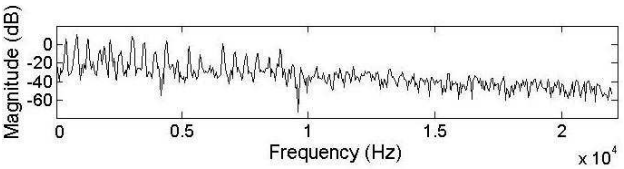


Figure 5 Frequency domain representation of A4.

The same portion of the signal has been analysed by Empirical Mode Decomposition (EMD) [7]. The signal has been decomposed to 6 modes and one residue (figure 6). The first IMF, contains the 6th, 16th, and 20th harmonics of the tone A4; IMF2 contains the 2nd harmonics; IMF3 the 4th harmonic; IMF4 the fundamental frequency; IMF5 half the fundamental frequency; and IMF6 one-fourth of that; the residue shows an increasing trend. Existence of half-pitch in the signal can be interpreted as the sympathetic vibration of the A3 strings. The quarter-pitch may be created by the superposition of the other vibrations. The amplitudes show the contribution of each mode in the main signal.

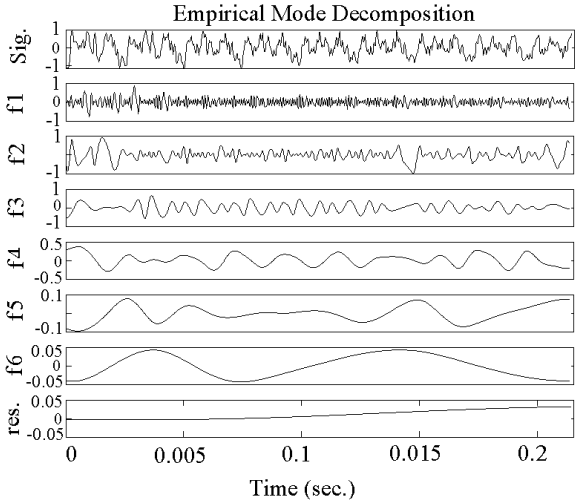


Figure 6 Decomposition of the sample in figure 1: The signal, its 6 IMFs and the residue

In Figure 7 the Spectrum of a two-octave A4 minor arpeggio is shown. An array of the following notes was played: A3-C4-E4-A4-C5-E5-A5 Fundamental frequencies for the array of notes are 220, 261.6, 329.6, 440, 523.25, 659.25 and 880 Hertz respectively (table 1). A 1024 point window has been used. The change in the harmonic content can be seen.

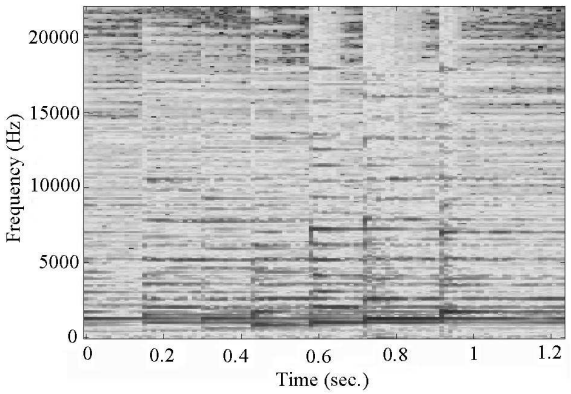


Figure 7 Spectrum of a two-octave A4 minor arpeggio.

3 CONCLUSION

In this paper, Persian music, the Santur instrument and a Database for Persian music were explained.

The Database consists of samples of single notes and improvisations in Màhur and Bayàt-e Esfehàn Modes. It can be used either for testing transcription algorithms or for the analysis of long-term structures such as rhythm and melody. Future work will include recording more individual samples and performances of other Dastgàh by different musicians, on different instruments and orchestral music.

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