Generative Improvising in Shur: an approach to generative Persian traditional music

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Abstract:

*Our goal is to aesthetically analysis Persian traditional music which is been generated by genetic algorithm technique. A survey on general music philosophy, in this special case, Persian traditional music philosophy and regarding to its unique rules such as micro tones , improvisations ,semi-atonality and etc, shows that traditional optimization algorithms are not appropriate for generating Persian traditional music. Therefore through an investigation in evolutionary algorithms, we considered using genetic algorithm as our music generator system. In order to produce Fitness Function of Genetic Algorithm we utilize Persian traditional music concepts such as **Dastgậh, Gushe, Shahed tone** and etc, and Persian traditional music unique rules. Due to the extent of Radif which is the base of Persian traditional music, Shur, as one of its twelve Dastgậhs (mode) is chosen as genetic algorithm state space. We choose Shur for its capability to mark Persian traditional music tone through its unique scale and its significant role in Radif as omm'ol alhan (= mother of tones).Having Fitness Function and initializing the first generation of genetic algorithm which is derived from a transformed accidental event in real world as our system input, we move toward finding an optimum tone by reproduction of generations. In this paper the genetic algorithm system output is analyzed in presence of Persian traditional music aesthetics.*

Introduction:

The dependency of traditional Persian music composition on motifs and melodic particles derived from Radif, was the origin of our idea for composing a piece of music using these motifs through a computer program.To reach to a pure traditional music we tried to realize our idea respecting the traditional methodes of music teaching in Iran. Infact, composing in these methodes happens after many years of learning Radif. So, firstly, we had to make a Radif database to teach computer the motifs. Then, using a sentence by sentence analyzing of Radif, we derived rules that were supposed to be learned by practising it. In order to get even closer to a biological approach of learning, we set up a genetic alogorithm procedure to start the composing. While, Radif database is its musical motif knowlage, fitness function made by the mentioned derived rules is its composing technic and an accidental input is its motivator.

Persian traditional music philosophy:

The structure of the Radif is complex and its history can in part be uncovered by a comparison of its versions and components.But listening to the Radif in its various versions, one may be struck by the degree to which different gushes and Dastgahs present themselves in a variety of scalar patterns, motifs, and rhythmic types while at the same time providing a sense of strong stylistic unity. Dastgahs and Gushes differ, but the radif sounds very much like a single unified work, in a style not easily confused with Arabic or Turkish classical music, or with the folk and tribal traditions of the Middle East—to say nothing of the musics of South Asia (Nettl, 1992: 63).

If there is a general stylistic unity in the Radif overriding the diversity of rhythms and modes, it is in

good measure based on ornamentation and phrasing, areas that we can only touch upon in this group of studies. Even more specific to the Radif is a group of techniques of treatment of motifs and gestures. In contrast to at least some non-metric music in Arabic traditions, the radif as a whole is perhaps best characterized by its dependence on a set of short melodic particles, which may (but not always quite accurately) also be called gestures or motifs. The composition techniques are quite unified. Typically, one short motif is presented and briefly developed in some way, sometimes separated from others by non-motivic and musically more generalized materials, followed by new motifs similarly treated or by the reappearances of motifs presented earlier. The techniques by which these motifs are developed include repetition, melodic sequence, extension, augmentation, and contraction. And there are also characteristic combinations of these techniques, such as repetition followed by upward transposition further followed by a second transposed version given in extended form. These techniques appear distributed throughout the Radif and are equally present in all of the dastgahs. Most important, they play a significant role in the performance of improvised avaz and in composed works based on the radif. It is to a substantial extent the dependence on motifs and their brief development that give the radif, and the Iranian classical tradition, its unique character (Nettl, 1992: 63-64).

Persian traditional music concepts:

Radif: The combination of pieces that form the whole Persian traditional music, are called Radif. However Radif is not a complete defined set of pieces, but it is an ideal melodic idea for improvisation (Farhat, 2007: 45). This melodic idea has not been learnt or used directly. In fact, during many years of its practicing and through an applied experience, a performer will be able to learn how to use them. On the other hand, just an experienced listener will be able to distinguish them (Farhat, 2007: 45). There are several Radif versions in Persian traditional music, which are classified into two major groups:

One group is written for the vocalists which is called vocal Radif (Radif-e-Avazi) and the second group is written for instruments that is called Instrumental Radif (Radif-e-Sazi).

In another classification each version is distinguished by the name of its assembler. Some notable versions of this classification are: Mirza Abdollah's Instrumental Radif, Ostad Davami's Vocal Radif, and etc.

Dastgah: Dastgah is usually translated into "mode" while this term can not properly define Dastgah's concepts. Dastgah is a set of pieces which are traditionally collected under a unique name (Dastgah's name) (Farhat, 2007: 41). These pieces, which are called Gushehs, have some similar properties but are in different modes. In another words, Radif contains a variety of modes grouped under 12 names. Among them, seven groups are called Dastgahs, for their independent spirit and five groups are called Avaz. Each avaz is assossiated with one Dastgah. The 7 dastgahs are: Shur, Segah, Chahargah, Rast panjgah, Homayun, Nava, and Mahur.

There are 4 avaz assossiated with Shur, the most important Dastgah in Persian traditional music, Dashti, Bayat-e-tork, Abu ata, and Afshari. The last one belongs to Homayun.

A group of musicians believe that this kind of classification is not correct. They claim that if we consider a relationship between Afshari and Shur, then using the same reasons we can relate Nava and Shur too (khaleghi, 1999: 252-253).

However most of musicians have come to an agreement over this kind of classification and therefore we use it in this paper too.

Gusheh: is a general name for each piece of Dastgah's reparatory. Each Dastgah has a different number of Gusheh. Gushehs have different lengths, different weights, and different roles. Some of them offer melodic ideas for improvisation beginning and some for its end. There are some Gushehs that are not mentioned in any Radif versions but are used widely in folklore performances. Some Gushehs are used in some regional parts of Iran and have been unknown for the other parts. Some Gushehs are created during the composing process.

Daramad: Daramad is a Gusheh by which a Dastgah begins. Daramad is the most important Gusheh in every Dastgah and presents the main idea of that Dastgah. Proceeding Gushehs have different modes from Daramad (Farhat, 2007: 46). For the finishing piece (Forud) we have to return back to this idea.

Tetra-chord: Persian traditional music despite its western form is not based on firm scales. In order to

show Dastgah characteristics, we make use of concepts like tetra-chords and in some cases penta-chord.

Final: Final's role is like tonic note in western music definition. A Piece ends in Final. Final doesn't appear necessarily in the beginning, it indicates the place where a piece character is going to be introduced or recalled. All the other tones in a mode are described in relation with Final.

Aqaz (begin): aqaz is a note where improvisation starts. (Farhat, 2007: 49).

Ist (stop): In some special cases instead of ending in Final the tune pauses on Ist. This ending is temporary and at last the tune returns to its Final (Farhat, 2007: 49).

Shahed: In most of the Persian modes this note has a different more important role than he other notes. It can be the same as Final or not. We call it Shahed (Farhat, 2007: 49).

Moteqaier (variant): There is a varying note in some modes. For example in some modes Eb and Ep appear alternatively. These notes should not be mixed up with third degree below the Final which it's pitch rises less than a semi-tone when it's going to resolve on second degree below the Final and then on Final (Farhat, 2007: 49).

Forud: Forud is a melodic cadence with a constant pattern which varies in each improvisation. In a Dastgah, Forud plays an important role (it can have numerous patterns). Forud is the joint element of different Gushehs, while most of them have independent modes. In some cases Forud is the unique methode for relating *Gusheh*s in a *Dastgah.* This is why Gushehs are gathered under a unique name. Foruds can be as short as several notes or as long as an independent Gusheh (Farhat, 2007: 50).

Oj: The traditional method of using Gushehs in Dastgah is from low-pitched to high-pitched. Therefore Daramad is in first tetra-chord. When pitch rises gradually to its highest range it is Called Oj. Oj literally means the maximum point.

Microtone: when an interval is less than a semitone it is called microtone. This kind of interval is not used in Persian traditional music alone but an interval may rise or lower by a microtone (Farhat, 2007: 51).

Coron: a symbol that lowers the pitch of a note by a microtone. We show it by "p" like Ep as Mi coron.[9]

Sharp and **Flat**: these terms are similar to western music we show them by "#" and "b".

Pish-dang: is a tetra-chord which is preceding the first tetra-chord.

Pas-dang: is a tetra-chord which is preceding the second tetra-chord.

Naghme: literally means a musical piece, we use it to indicate our generated music.

Choosing state space:

In order to have a smaller state space which leads in to a more rapid analysis and a faster procedure, though Avazes have too short lengths, we had to select a Dastgah in Radif.This Dastgah must contain all the characteristics of the traditional Persian music spirit and accent, in this way, Mahur and Homayun with their similarities to the western major and minor scales are ignored (khaleghi, 1999: 305). Rast-panjgah is more appropriate for modulation and doesn't have a unique spirit (khaleghi, 1999: 303). Therefore we selected Shur, Segah, and Chahargah.

Among these three Dastgah, Shur is the most important and the most expended Dastgah which reflects the best the Persian music spirit. It is said that Iranians who are not familiar with any kind of traditional music, murmur in Shur either.Shur is known as the mother of tunes in Persian traditional music.

So, we selected Shur as our state space. Shur divides into two ranges itself: low-pitched and high-

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[9] Also we have Sori, which is a symbol that raises the pitch of a note by a microtone. We show it by ">" like E> as Mi Sori. this accidental is not used in this paper

pitched. Low-pictched part and high-pitched part are very similar in movement so we decided to choose low-pitched which is more expended already. Also Shur has rhythmic Gushes, however these are pieces that are generated just using ideas and concept which are shown in non-rhytmic parts.

So we ignore all rhythmic parts and concentrate over none-rhytmic, low-pitched parts of Shur.

G Shur tone range and role:

Pish-dang= Bp C D Ep F G

First tetra-chord=F G Ap Bb C Dp

Second tetra-chord=C Dp Eb F G Ab (Ap)

Pas-dang=G Ab (Ap) Bb C Dp

Daramad to Rahab are in first tetra chord in these range Ap is Shahed and F is the Ist.

In Salmak and Oj shahed changes to C.

Shahed in Gharache range is Eb and C is the Ist.

Shahed in Razavi range is F and C is the Ist.

Shahed in Hoseini range is G and C is the Ist.

F is the Aqaz note.

Dp is the Motaqier note.

Building fitness function by finding Radif rules:

Sentence analysis:

Daramad:

Daramad is the first Gusheh of Shur and it reveals the spirit of Dastgah and introduces new notes to the listeners.

1.   Plays on Final and Shahed, uses a passage from first degree below Final to third degree above the Final to stabilize[10] Shur spirit. This passage or similar passages are essential to make listeners' ears familiar with the accent of Shur.

2.   As completing first sentence it shows the third degree[11] tone.

3.   Shows last note of first tetra-chord, hesitates a bit more on second degree, and come back to Final by a melodic form which is shown in the next step.

4.   Completes third sentence, with a bit more emphasize on 4th degree.

5.   It's like third and 4th sentence, but emphasize goes to all degrees of first tetra-chord.

6.   Emphasizing on all degrees of first tetra-chord, and sounds Shahed and in this case the leading-tone for Final.

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[10] When we say a tone or a spirit is stabilized we mean that it is familiar to listener's ear
[11] When not mentioned above the final or below the final we mean above the final.

7.   Preparing for a Forud by emphasizing on F (the aqaz that shows Shur spirit) and G (Final) return to G by a perfect fourth jump. This kind of returning to Final is common in Persian traditional music and is called "bird wing".

Panje-she'ri:

Panje-she'ri is in fact a second Daramad for Shur

1.   It's like first sentence of Daramad and the difference is about its emphasize on third degree tone of first tetra-chord, since in the following sentence third degree is the note which the most emphasize will be over it.

2.   For the first time hesitation goes on third degree of first tetra-chord. This is done by using a pattern similar to previous sentence (like a serial counterpoint).

3.   Hesitates on Final to bring back the previous spirit, which is going to be forgotten when the new tone is heard. A rapid return to a stabilized spirit after using none stabilized tone is a normal form in Persian traditional music.

4.   Sentence 4 is just the same as what is heard in Daramad until the end of Gusheh.

Kereshme:

Generally Kereshme is a type of Gusheh which is much more free and it uses some ranges that are not familiarized yet.

1. Up to here, Shur spirit and important tones like Shahed and Final are introduced. In the following part the rest of notes will be shown.

So a melodic pattern begins with these tones and spirits, in second sentence this pattern continues to third sentence where a short emphasize goes on 4th degree of first tetra-chord, which returns rapidly in third sentence to the start pattern. Now listener's ears are ready for emphasizing on 4th degree.

2.   Sentences 5, 6, and 7 follow preceding patterns.

3.   In sentences 8 and 9 emphasizing on 4th degree completes.

4.   After making a so called Oj in previous sentences with a known pattern, it returns to third and second degree and at last with a continuous movement which breaks rhythmic spirit of Gusheh to the Final.

5.   Sentences 11, 12, and 13 are exactly like sentences 5, 6, and 7 to fade away Oj spirit.

6.   Sentences 14 to 16 are melodic movements to show some available intervals.

7.   The last two sentences are exactly like Daramad.

Rahab:

Rahab is the 4th and the last Daramad for Shur. It doesn't introduce new things; it just indicates new patterns to be used in what is shown in the preceding Gushehs,

1.   First and second sentences show two melodic ideas which can be used to go from Shahed to Final.

2.   Third sentence is a melodic pattern which is repeated to make it familiar, since this pattern would be used in the following sentences.

3.   Using the introduced pattern in the third sentence from 4th sentence to the end of Gusheh, we make use of other tones of tetra-chord: first on second degree, then 4th, then third, and after all on Final.

Oj:

Second tetra-chord is heard in Oj for the first time. Please note that it is a type of Gusheh and should not be confused with the concept of Oj in Persian traditional music.

In Oj, Ap is still the leading-tone but Shahed changes to C. Also, in Oj, Bb introduce as an "rest point" for Forud.

1.   Introduces C and immediately returns to F for preserving the spirit.

2.   After introducing C, with a similar pattern, goes to C and doesn't return. This movement stabilizes

the C tone.

3. Returns to Final with a melodic pattern in which the most emphasize is on C. Now, we return back to our previous spirit, knowing that a new note is also added to what we had before.

4. Now, in sentences 4 and 5 we introduce C as a Shahed of Gusheh .

5. Introduces Bb, the third degree, as a rest point for Forud.

6. Again, goes to C, Gusheh's Shahed, not for an introduction purpose, but for a commonly usage of this tone. In another words, after introducing all essential notes, from this point we can start using them to show the melodic idea.

7. In sentences 9, 10, and 11, it shows a melodic idea for Forud.

8. In sentences 12 and 13, it returns to the leading-tone and then to the Final.

Mollanaazi:

Mollanazi is a melodic Gusheh which uses the introduced idea to form a piece.

1. Emphasizing on C, Bb, and A, it shows an idea which is similar to what we have in Daramad. It is used for utilizing tetra-chord range in a downward movement.

2. Second and third sentences suggest a melodic idea for Final in which F and C are heard more. F is for preserving Shur's spirit and C is Gusheh's Shahed.

3. Sentences 4, 5, and 6, start a Forud by emphasizing on Bb and moving toward Ap and C.

Naghme-ie-avval and **naghme-ie-dovvom**:

These two Gushehs are only melodic. They only use introduced items to suggest ideas that can be used in improvisation

Zirkesh-e-salmak:

Zirkesh-e-salmak is used for Forud,

1. First three sentences present a pattern in which the pitch of third degree below the Final rises by a microtone to make a better Forud on Final.

2. Second three sentences are just like the first three sentences, except that the second group is a bit different in the number of notes and the way they are used.

3. Sentences 7 to 11 are like the first three sentences. Their movement through Final is straighter and its elements are longer.

4. Also sentences 12 to 15 are used for Forud, their difference is in using F in Forud procedure.

5. The 16th sentence's form is like its previous 3 sentences and together with the last three sentences it forms a complete Forud.

Salmak:

Salmak is more like an Oj and introduces a few more new concepts.

1. The first three sentences are used to reach C, in this way F, the third degree of the second tetra-chord, and Eb, the second degree of the second tetra-chord is shown, but this does not make them familiar.

2. Sentences 4 to 8 suggest two melodic ideas for Forud.

Golriz:

Golriz is a Gusheh for entering into Hoseini from Daramad range. In Hoseini Ap lowers using Microtone and Shahed and Ist changes.

1. Sentences 1 to 5 are a simple Forud to Final.

2. Sentences 6 and 7 are a passage for entering into Hoseini tone. This is done by lowering Ap with the help of a microtone, and stopping on Hoseini's Shahed.

3. 8th sentence stabilized the Shahed.

4. Sentences 9 and 10 prepare the mode for the last Forud.

5. The 11ᵗʰ sentence using a prepared passage in the two latest sentences goes toward C which is Hoseini's Ist

6. Then it moves toward Hoseini's Shahed.

Majles-Afruz:

Majles-Afruz is a rhythmic Gusheh to stabilize Hoseini and to return to Daramad range.

1. The First five notes use a rhythmic pattern and emphasize on stabilization of Hoseini.

2. Sentences 4, 5, and 6 Introduce F and stop on G, which is Hoseini's Shahed.

3. Sentence 7 is an important passage to return back from Hoseini to Daramad range.

Ozzal:

Ozzal is for introducing Pish-dang.

1. In the first sentence, it introduces pish-dang.

2. But in the rest of Gusheh, it doesn't have anything new and just repeats the previous patterns.

Safa:

Safa is for entering to Hoseini's Oj from Daramad.

1. The first two sentences just remind the Pish-dang spirit.

2. Emphasizing on Eb and F together with rising Ab by a microtone, it moves toward Hoseini's oj.

Bozorg:

Bozorg is for entering Razavi. From this Gusheh, movement toward Final Forud begins.

1. Using F, Razavi's Shahed, exactly after G which is Hoseini's Shahed, in the first 6 sentences, it prepares the spirit for entering into Razavi.

2. Making use of a passage it completely enters into Razavi and stops on C to make a cadence-like for Kuchak.

Kuchak:

Kuchak goes from Razavi to Hoseini.

1. The first two sentences emphasize on F to stabilize Razavi's spirit.

2. The third and the forth sentences prepare the spirit for entering into Hoseini.

3. Last sentence is the common way for moving toward Hoseini.

Do-beyti:

Do-beyti is a melodic Gusheh in Hoseini:

1. The First sentence emphasize on Hoseini's G, also on F to form an accent.

2. From the second sentence up to the end, it moves toward C to make a cadence-like for the beginning of Khara.

Khara:

Khara is just like Do-beyti but in Razavi.

Qajar:

1. In the first sentence it moves toward C which is Oj's Shahed.

2. The next two sentences are similar, but they do this from G despite the first sentence which moves from F.

3. Moves toward G to complete Forud in Hazin

Hazin:

1. The first four sentences stabilized Oj's Shahed.

2. In the next two sentences it pauses on Bb to prepare Forud.

3. In the last sentences it completes Forud by rising Dp using a microtone.

Rules derived from sentence analyzing:

1. For introducing Shur's spirit to the listener's ears, we should use a passage containing F and Bb.

2. We can only use a note after familiarizing and stabilizing it.

3. We can only stabilize a note after shortly intrducing it.

4. If we pauses and/or emphasize on a non-stabilized note, we should rapidly show the last familiar spirit again.

5. To stabilize a newly used note we can use sentences with the same melodic patterns, like the ones that are before the sentence which contains this note.

6. Pausing on a previously introduced note stabilizes it.

7. For performing the last Forud we have two basic methods: firstly, to raise the pitch of a third degree down of Final using a Microtone or secondly, to use a descending jump from Bb to G. Using Final as the last note will have the same result but not as impressing as these two methods.

8. For preparing a better Forud, sometimes the melody has to pause on Bb.

9. A Dorrab[12] in a sentence or a passage beginning gives a more emphasized sentence or passage. It is used in the passages that are designed to introduce or recall the accent or spirit of Dastgah.

Functions derived from the obtained rules:

Shownfirmsearch (generated naghme, population index, desired note):

This function searches throughout the entire generated naghme and locates the places where each note is introduced, stabilized, and/or used. It uses rule 6 to find out these terms

This function is used to simulate rules 2, 3, 6, 7, and 8.

Passagesearch (generated naghme, population index, desired notes, passage range):

This function searches throughout the entire generated naghme, and finds passages containing given notes. It also gives ascending or descending order of passage and indicates the first note's plucking method.

This function is used to simulate rules 1, 7, and 9.

Melodyformsearch (generated naghme, population index, desired sentence, beginning, and end index of desired passage in sentence):

This function searches throughout the entire generated naghme, and finds the passages which are similar to the given passage.

This function is used in shownfirmsearch () function to simulate rules 4 and 5. Due to the limited processing power of the PC in which the program runs, and a need for a higher processing power, this function is omitted and rules 4 and 5 are ignored.

Ojforudsearch (accidental input):

This function analyzes accidental input and output where a forud is likely to happen.

This function is used to simulate rules 7, and 8.

Other functions:

RDBbuilder (input radif data file):

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[12] A plucking technic in which a note's length is divided into three parts and played together, the three particle durations are ¼, ¼, and ½ of its original length.

Because of the Persian music special notation, a coding char was written to encode Radif's note to codes that is possible for a machin to compile. This function builds Radif database from radif data file.

RDBsearch (desired note, radif database, note length)

This function searches throughout the Radif database and outputs Dastgahs, Gushes, and sentences in which a note with a desired note length exists. By considering zero as the desired note length, this function ignores note length filter for founded items.

Sequence (generated naghme, population, tempo), playit (note value, tempo), and FC (note value):

These functions are written for sampling an approximate audible output for the best fitted generation. This output is just for estimating the real output. The actual outputs of this program are notes that should be played by a Setar player.

Reproducing functions:

Elit (generated naghme, elite factor):

This function copies the best fitted members of the current generation to next generation.

Crossover (generated naghme, elite factor, crossover factor)

This function crosses over the best members of the current generation to reproduce the next generation. These are the members that are not as proper as the other members which have been copied in to the next generation,

Mutate (generated naghme, elite factor, crossover factor, radif database, accidental input length)

This function mutates remaining members and copies mutated members in to the next generation.

Correctfitness (generated naghme, radif data base, accidental input) and Fitnesscheck (generated naghme)

These functions are written for generating fitness report of the current generation to work with a genetic algorithm.

Making an accidental input from a real world:

In order to provide an accidental input firstly, we take a wave sound and import its frequencies (for making a suitable pattern for our special case we make use of the absolute values of the frequencies):
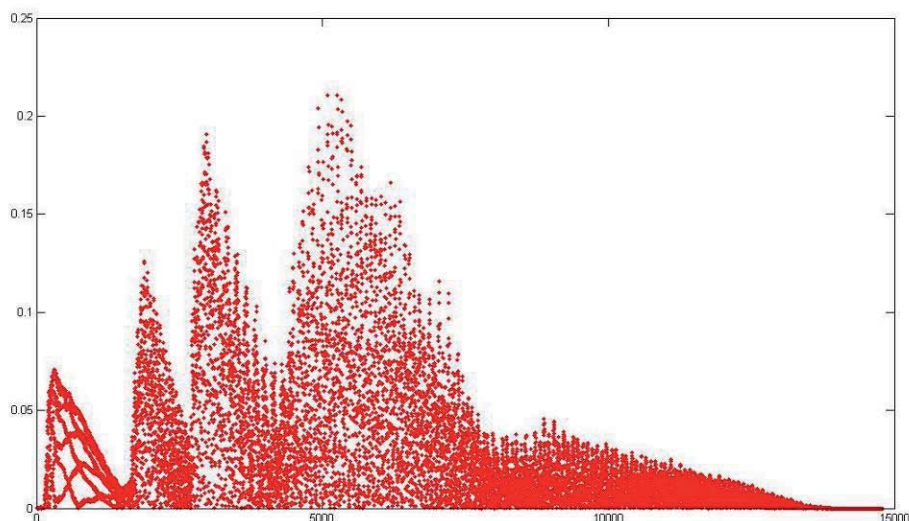
Figure 35

Then in an assumed range of frequencies we fit the values to the maximum points.
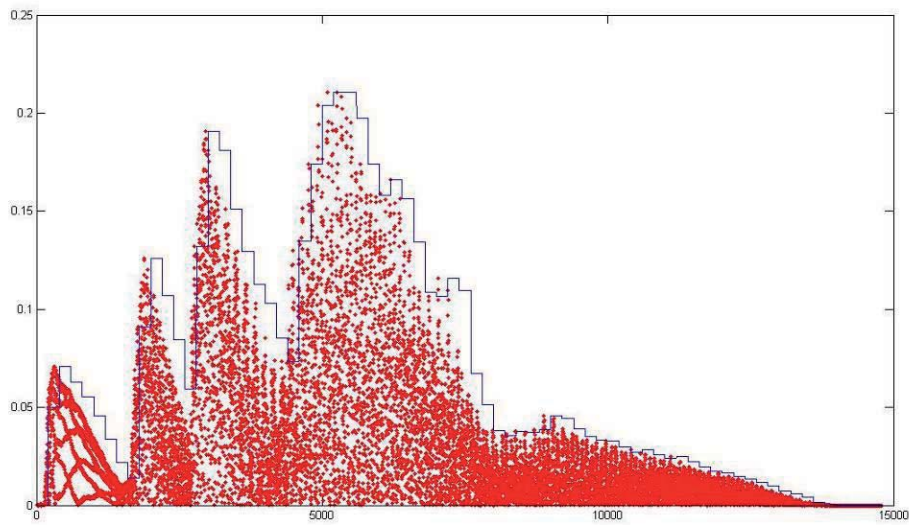
Figure 36

Then we use an algorithm which is similar to the first-order hold algorithm, in order to calculate the plotted values in figure 3 and 4.
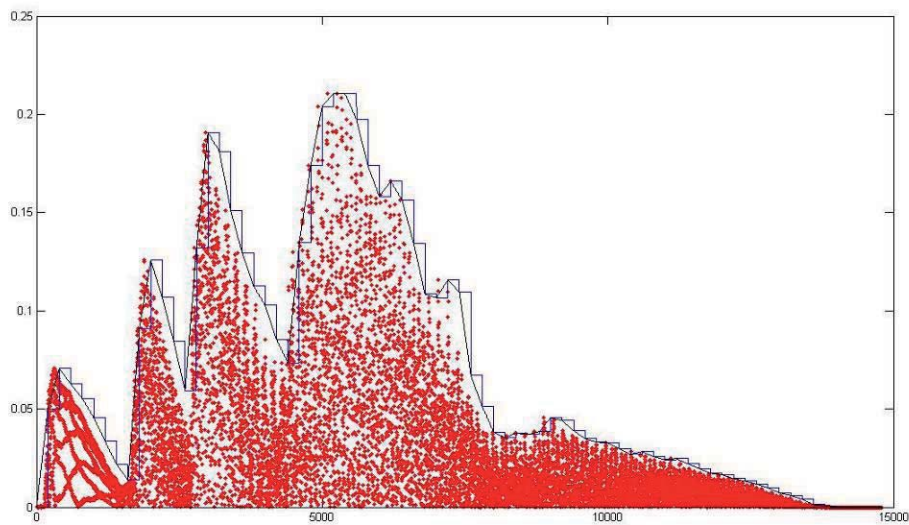
Figure 37
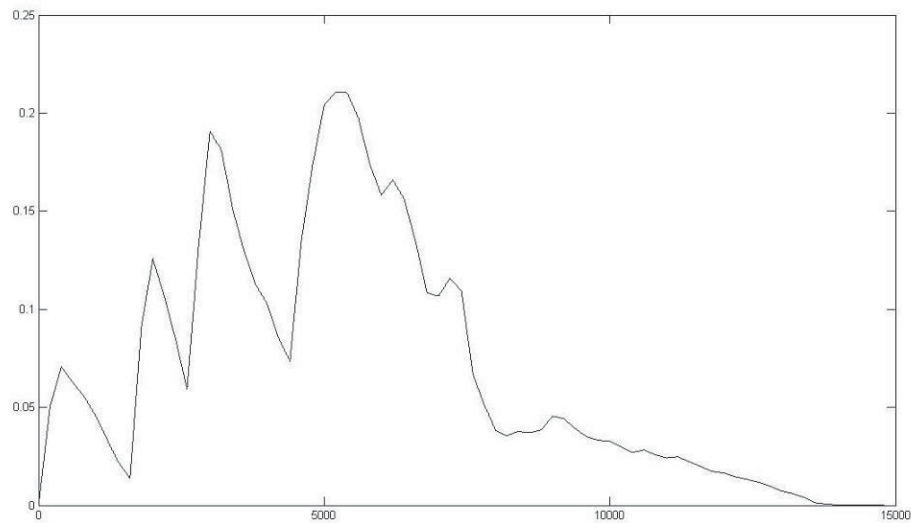
Figure 38

These values make our input pattern. In order to produce the first generation, we scaled these values to a special range of frequencies that our available notes which are founded in Radif database were able to support them.

Then, through determining the length of our output, we scale the accidental input length. Now each produced value indicates the note that must be picked up at each moment. For having a more effective randomize selection of an assumed note we can choose it from a range of determined notes in which there are two more notes with higher and lower pitches. Now, we randomly select a note out of these three notes.

In the next step, we looked for sentences inside our database that were containing this note. At last we accidently selected a sentence and added it to our generated input.

Aesthetics:

Since, there is not a defined term for aesthetic analysis in traditional Persian music, to analyise a piece of music, it is common that somone with a trained ear listens to the composed piece and judges it is how far or how near to the traditional persian music. As well we had followed a same method here and asked a proffesionall Setar (an Iranian instrument) player to hear generated pieces. As a result, it was said that generated pieces are similar to improvisitions which were heard before. And also some kinds of movements are found in generated pieces that were not heard before.

Unfortunately, due to the low proccessing speed of the computer used for running the program, none of the generated pieces reached to the global optimum state.

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Appendix a: Note coding

1.Length	#	2.note	#	3.accidental	#	4.octave	#
Whole tone	1	A	1	Natural	1	1 (A=55Hz)	1
half note	2	B	2	Flat	2	2 (A=110Hz)	2
quarter note	3	C	3	Sharp	3	3 (A=220Hz)	3
eighth note	4	D	4	Coron	4	4 (A=440Hz)	4
sixteenth note	5	E	5	Sori	5	5 (A=880Hz)	5
thirty-second note	6	F	6	Double bemol	6	6 (A=1760Hz)	6
sixty-fourth note	7	G	7	Double sori	7	7 (A=3520Hz)	7

5.Plucking	#	6.Articulation	#	7.Articulation	#	8.First articulation accidental	#	9.Second articulation accidental	#
....	1	>	1	>>	1	Natural	1	Natural	1
...	2	Tr	2	<<	2	Flat	2	Flat	2
..	3	.	3	Π	3	Sharp	3	Sharp	3
				U	4	Coron	4	Coron	4
				>>.	5	Sori	5	Sori	5
				.>	6	Double bemol	6	Double bemol	6
						Double sori	7	Double sori	7

Etc.	#
Dastgah	$
Gushe	+
Sentence (begining and end)	/
Note (begining and end	-
Repeat beginning	*2
Repeat end	*

Example: first sentence of Daramad of Shur:

$1+1.1/-461330000-471300000-414400000-422400000-*2-414400120-471300000-*-414400210-514400000-414400210-271310000-/

Appendix b: A sample output

541400000-552400000-541400000-552400000-541400000-552400000-541400000-552400000-
541400000-552400000-541400000-552400000-541400000-552400000-541400000-552400000-
341410000-561400000-552400000-541400000-231410000-514400000-522400000-431400000-
544400000-522400000-431400000-544400000-522400000-431400000-544400000-422400000-
544400000-431400000-552400000-544400000-531400000-422400000-544400000-531400000-
522400000-414400000-531400000-522400000-514400000-471300000-414400000-471300000-
414400210-471310000-522400000-414400210-471310000-214400000-522430000-431400000-
514430000-422400000-571330000-414400000-561330000-271310000-531400000-531400000-
531400000-431400000-431400000-431400000-431400000-531400000-522400000-531400000-
444400210-544400000-431400220-322400440-452400110-452400110-244410000-422400000-
444400120-444400120-231410000-422400000-431400140-431400140-222400000-322410240-
531400000-222410240-561400000-554400000-544400000-561400000-554400000-444400000-
561400000-554400000-544400000-561400000-561400000-461400240-554400000-571400000-
571400000-471400210-461400240-454400240-444400210-331400000-571400000-471410000-
571400000-571400000-471410000-571400000-571400000-471410000-571400000-571400000-
471410120-571400000-561400000-471410120-571400000-561400000-471410120-571400000-
561400000-571400000-512500000-571400000-522500000-512500000-471400000-461400000-
271400000-552400000-241410000-541400000-552400000-541400000-552400000-541400000-
552400000-541400000-552400000-541400000-552400000-541400000-552400000-541400000-
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231400000-431430000-444400000-431400000-222400000-561400000-552400000-541400000-
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552400000-541400000-552400000-541400000-552400000-541400000-552400000-541400000-
552400000-541400000-552400000-541400000-252410000-514400000-522400000-531400000-
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261410000-252410000-261410000-452400000-461400000-571400520-571400000-561400000-
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431430000-352430000-344430000-331430000-561400000-571400000-512500000-561400000-
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452400110-452400110-244410000-422400000-444400120-444400120-231410000-422400000-
431400140-431400140-222400000-422400000-431400000-444400000-431400000-444400000-
431400000-444400000-431400000-444400210-544400000-531400000-322410000-514400000-
522400000-531400000-544400000-531400000-544400000-544400000-531400000-522400000-
514400000-522400000-531400000-531400000-522400000-414400210-414400000-371310000-
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422430000-431400000-422400000-331410140-331410220-222400440-544400000-531400000-
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444400120-231410000-422400000-431400140-431400140-222410000-522400000-514400000-
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522400000-514400000-522400000-514400000-522400000-514400000-422400000-531400000-
522400000-514400000-571300000-414400120-414400120-271300000-522430000-431400000-
514430000-422400000-571330000-414400000-561330000-271300000-414400000-471300000-

414400000-471300000-414400000-371310000-314410010-371310000-314410010-471300000-522400000-414400210-271310000-322410240-531400000-222410240-431400140-431400140-222410000-214400210-544400000-431400140-431400140-222410000-214400210-422400000-414400000-422400000-414400000-422400000-314410000-322410000-314410000-322410000-414400000-422400240-531400000-422400240-214410000-422400240-214410210-522400000-414400210-271310000-414400210-471310000-522400000-414400210-471310000-214400000-561400000-552400000-561400000-552400000-552400000-544400000-552400000-544400000-544400000-531400000-544400000-531400000-531400000-522400000-531400000-522400000-522400000-514400000-522400000-514400000-514400000-571300000-214400210-514400000-522400000-522400000-571300000-514400000-522400000-522400000-571300000-514400000-522400000-522400000-514400000-522400000-531400000-531400000-522400000-531400000-531400000-522400000-331410140-531400000-522400000-514400000-571300000-414400120-414400120-271300000-