The notion of Ethos in Arabic music: computational modeling of Al-Urmawi's modes (13th Century) in Csound

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ABSTRACT

The notion of ethos in Arabic music is outlined in this paper through the writings and thoughts of al-Kindi, Ziriab, Ikhwan al-Safa, Avicenna and Saffiyu al-Din al-Urmawi. The approach developed by al-Urmawi in his book "The book of cycles" will be studied and the ties woven between 13th Century modes and their ethos will be underlined. Al-Urmawi was the first Arabic theorist who defined a relationship between musical modes and their emotional influence on people's perception according to a classification in three categories: bravery, peaceful and sad characters.

A computational model of these modes will be proposed using an object library developed in a Csound environment. A computational model of Saffiyu al-Din al-Urmawi's intervallic system will be performed and the twelve cycles he defined in his book will be classified according to their ethos.

The modeling of some of the idioms pertaining to Arabic music, such as the homophonic aspect of musical rendition, or ornamentation, will be addressed.

Intrinsic units of the object library: UDO (User Defined Opcodes), function tables, Opcodes (operation codes), loops and conditions will be explained.

Finally, the possibility of studying the effect these modes create on people will be considered.

1 Introduction

The notion of ethos in Arabic music has always been ever-present. Terms in ancient writings such as "ta'thir" (influence), or "hal" (state) refer to the relation between ethos and music. In the 13th Century, Saffiyu al-Din al-Urmawi "was the first to make an attempt at drawing up the ethos of the modes[1]" [1].

In order to study this influence of music and modes on the individual following the thoughts of al-Urmawi, it is essential to reproduce the modes described in his book while respecting some of the idioms of Arabic music of his time.

First, this paper will propose details on the notion of ethos through the writings and thoughts of Arabic theorists ranging from the 9th to the 11th Century. It will especially highlight the classification of modes according to their ethos in al-Urmawi's book in the 13th Century.

Then, within the framework of the creation of an object library in Csound, this paper will propose a computational model of the twelve modes described by al-Urmawi, following a model representative of its non-tempered musical scale.

It will then try to model some of the idioms in Arabic music such as its homophonic nature or Arabic techniques of musical rendition based on ornamentation.

Finally, this paper will explain how this object library works.

2 The notion of ethos in Arabic musical spirit

The notion of ethos was ever-present in the writings and thoughts of Arabic theorists. On this matter, Philip D Schuyler wrote [2]: "Middle Eastern theorists, like the Greeks before them, recognized that each mode had a certain ethos[2]". Farmer [3] noted: "The doctrine of the ethos (ta'thir) was now definitely linked up with music. This old Semitic idea had been strengthened by the doctrines of the Sabi'a of Harran and the theories of the ancient Greeks and Byzantines." C. Poché [1] defined ethos as "the relation between musical and extramusical". Then he made the connection with maqâm: "that is to say the relation between maqâm, the individual, the world surrounding him, and the cosmos[3]."

In the 9th and 10th Centuries, the notion of ethos was present in the writings of al-Kindi, Ziriab, Ikhwan al-Safa and al-Farabi[4]. In the 11th century, Avicenna (Persian philosopher and scientist, 980-1037) was one of the first Arabic theorists who took a radical stand on this issue: "finding a relation between the state of the sky, the states of the soul and musical intervals is no longer an issue[5]" [4].

In the 13th Century, the notion of ethos returned with Saffiyu al-Din al-Urmawi, who classified the 12 modes of his time according to their influence on the listener.

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[1] Personal translation.

[2] P.D Schuyler also noted that: "In Baghdad, philosophers and mathematicians, like al-Kindi and al-Farabi, began to apply Greek theory to the study of music."

[3] Personal translation.

[4] For example, al-Kindi linked music and astrology, Ziriab went further, and developed a system of twenty-four modes – one for every hour of the day. Just like in al-Farabi's writings, the word "ta'thir" (ethos) can often be found in the writings of Ikhwan al-Safa.

[5] Personal translation.

The Arabic Maqâm must first be defined.

2.1 Maqâm

The word maqâm means mode in English and "place" in Arabic. It started to mean, in the 18th Century, the location of an area on the handle of a musical instrument and describes a series of intervals grouped by genre or by family (jins) [1].
The word jins, or set in English, describes a distribution of melodic cells, intrinsic to each maqâm, in trichord, tetrachord and pentachord.
Maqâm can therefore be defined as a series of genres built according to an ascending or descending horizontal line and defined on a predefined acoustic scale with a melodic sequence featuring modal properties.
Below is an instance of maqâm called Bayati, with its endogenous melodic cells and its variants. The jins Bayati in D is a fundamental cell used as a returning point for each modal exploration; when the second cell is a Hijaz, the maqâm changes aspect and is then called Bayati Churi (see Figure 1).

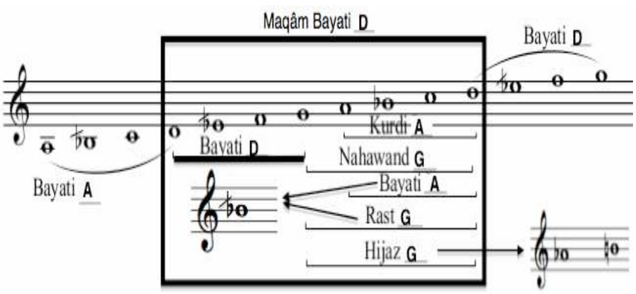

Figure 1. The Bayati mode, its jins and its variants.

In this example, the main jins is Bayati with the fundamental D note and represents the main sound register. The second sound space can be the Kurdi A jins, Nahawand G, Bayati A or Rast G. When the 2nd sound space is a Rast G, the instrumentalist can explore Bayati D and Rast G jins but also Bayati A jins one octave below and Bayati D one octave above. The Kurdi A and Nahawand G genres have the same notes but include the fundamental A and G notes. Regarding Hijaz G, notes that change are A-Flat and natural B. Bayati A and Rast G jins have in common the B expressed in quarter tone (symbolized by crossed b)[6].

2.2 The notion of ethos in Arabic musical thought in the 13th Century

A distinct relation between the mode and its emotional nature appear in al-Urmawi[7]'s writings. In his book “Kitab al-adwar” (The book of cycles) he defined twelve modes[8] and listed their ethos in a precise manner:

- ‘ussaq, nawa and busalik : Character of strength, courage and bravery[9].
- Rast, nuruz, ‘iraq and isfahan: peaceful character and peace of mind.
- Bozorg, rahawi, zirafkand, zangualah and husayni: sad character.

Poché [1] pointed regarding the Hijaz mode, the relation of which to ethos in particular was not established by al-Urmawi in his book, characterized by its interval in augmented second: "Regarding augmented second: oral tradition in Turkey as well as Greece and in the Arabic world teaches us that this interval favors a better sleep and this is the reason why it can be found in many lullabies in that geographical areas[10]."
The modes described by Saffiyu al-Din are based on an intervallic system of the time which was the subject of several chapters in his book.

3 Musical and computational modeling: an object library in Csound

In order to propose a representation of Saffiyu al-Din al-Urmawi's thought concerning ethos and modes, this paper will first model the intervallic system described in his book, then will model modes of his time while focusing on the subtleties of Arabic musical rendition: homophonic aspects and ornamentation.
The model proposed in this section will not only serve to understand the working mechanisms of the Arabic music system, but also to reproduce it via Csound in line with an analysis/synthesis perspective or even of emulation[11].

3.1 Modeling the intervallic system described by al-Urmawi in Csound

Unlike the transformation Arabic music experienced following the Cairo Congress of Arab Music (1932), especially when a tempered scale of 24 quarter tone was adopted [5], Saffiyu al-Din al-Urmawi's scale remains authentic and keeps intrinsic idiosyncratic elements of the Arabic musical language. Here is its scale (numerical ratio) and its modes[12] (Figure 2) [6]:

[6] The crossed b symbols express the microtones according to the acoustic scale on which the maqâm is performed. For instance, in the case of a tempered scale the relevant note is lowered by one tempered quarter tone.

[7] Saffiyu al-Din al-Urmawi (1216-1294) was a renowned musician and writer on the theory of music.

[8] In his book, Al-Urmawi uses the words “adwar” which means cycle and “shadd” which means, literally, to pull. This suggests visualizing intervals on the handle of a string instrument. In this paper, the words maqâm and mode will be used hereinafter.

[9] He proposed the character of Turks, Abyssinians, Blacks and mountain dwellers as examples.

[10] Personal translation.

[11] Not only can we consider the simulation of the Arabic music phenomenon but also the possibility of emulation with the aim of recreating or transforming it. The notion of emulation was used and adapted by the AFIM workgroup (Sound Visualization) in an artistic perspective: "Artistic emulation of sound". See activity report proposed by Anne Sedes at: gtv.mshparisnord.org/IMG/pdf/rapportGTVisualisation.pdf

[12] For instance, to obtain a Pythagorean major third, two major tones must be added: $9/8 \times 9/8 = 81/64 = 3^4/2^6$.

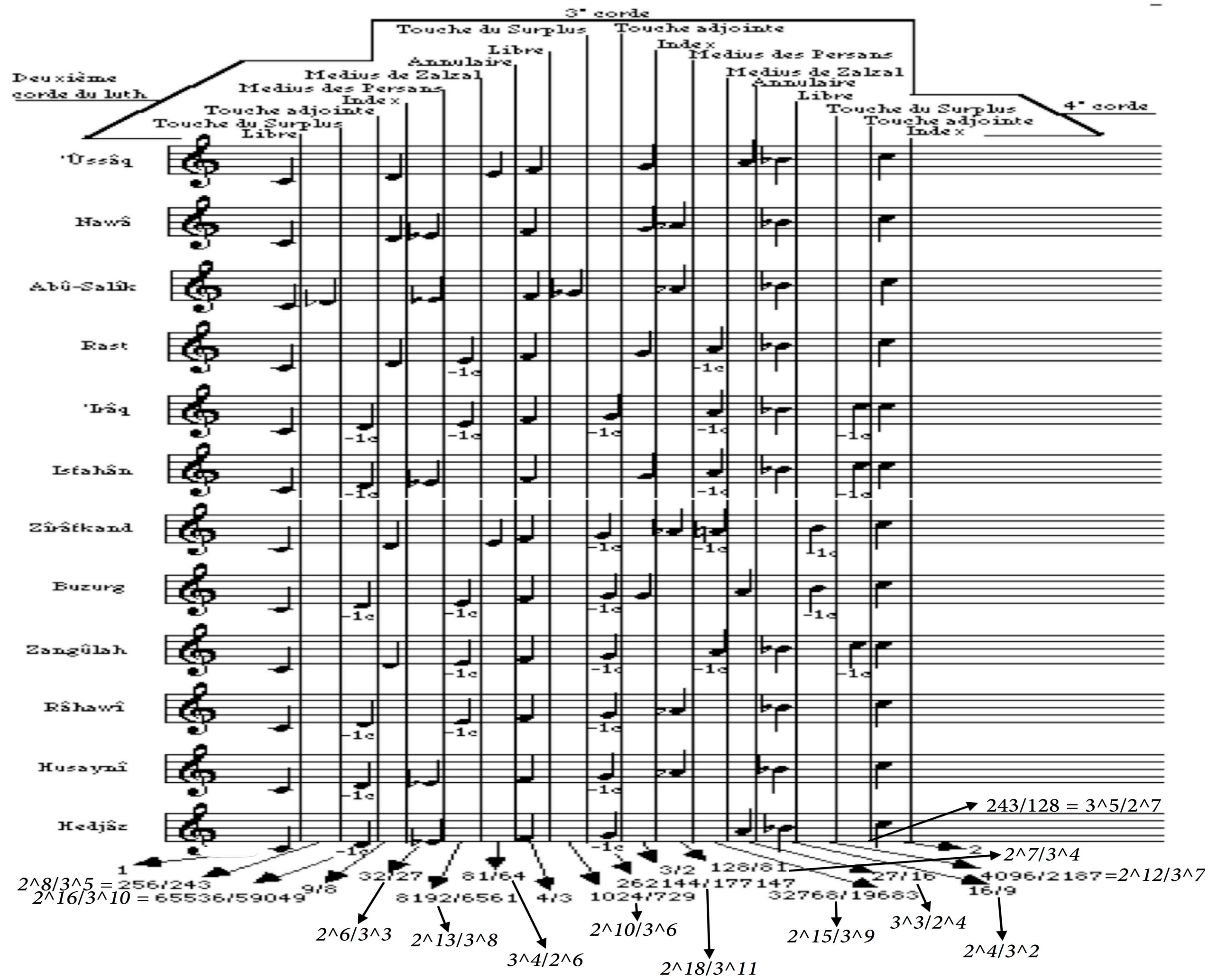

Figure 2. Al-Urmawi's modes and intervallic scale

This work proposes to use pitch-class in order to model this system in Csound.

3.1.1 Using Pitch-class

The frequency of a musical note can be calculated according to the non-tempered scale of Saffiyu al-Din in the following manner:

$$\mathcal{F}_n = \mathcal{F}_{fn} \text{ X } \mathcal{N}r_n \quad (1)$$

$\mathcal{F}n$ represents the frequency of note n, $\mathcal{F}_{fn}$ represents the frequency of the fundamental note and $\mathcal{N}r_n$ represents the numerical ratio of interval corresponding to the note n.

In Csound, Pitch can be expressed in frequency or pitch-class. A pitch-class is made of a whole number corresponding to the octave and of a decimal part representing the twelve musical notes in equal temperament (according to the Opcode used). For instance, for a C3, the pitch-class is 8.00, 8.03 for a D#3, 8.04 for an E or 9.00 for a C4. To reproduce a tempered quarter tone on the E note, for instance, simply lower it by half: 8.035

On a non-tempered scale, it only takes to convert the pitch-class of a fundamental note in frequency, to multiply it by the numerical ratio determining the interval then to convert it again in pitch-class.

It must be noted that the conversion of a frequency to a pitch-class in Csound is not direct, unlike the opposite.

Here is a code example for the maqâm Rahawi:

```
#define DOFIRSTNOTE #pchoct(octcps(cpspch(8.00)))#
isib13 = $DOFIRSTNOTE * (16/9)
ilab13 = $DOFIRSTNOTE * (128/81)
isolnegonec13 = $DOFIRSTNOTE * (262144/177147)
ifa13 = $DOFIRSTNOTE * (4/3)
iminegonec13 = $DOFIRSTNOTE * (8192/6561)
irenegonec13 = $DOFIRSTNOTE * (65536/59049)
```

3.1.2 Using function tables

The *ftgen* Opcode allows us to create a table referenced by a chosen number that will be named depending on the maqâm involved and which allows us to stock eight pitch-classes corresponding to the musical notes of an octave.

Here is an example of code relative to the maqâm Rahawi:

```
giRahawi13 ftgen 119, 0, 8, -2, 9.00, isib13, ilab13, isolnegonec13,
ifa13,iminegonec13, irenegonec13, 8.00
```

3.1.3 *Classification of modes according to their ethos:*

After having modeled the intervallic system described by al-Urmawi, a base with the twelve modes of his time, classified according to their ethos, is obtained (Figure 3):

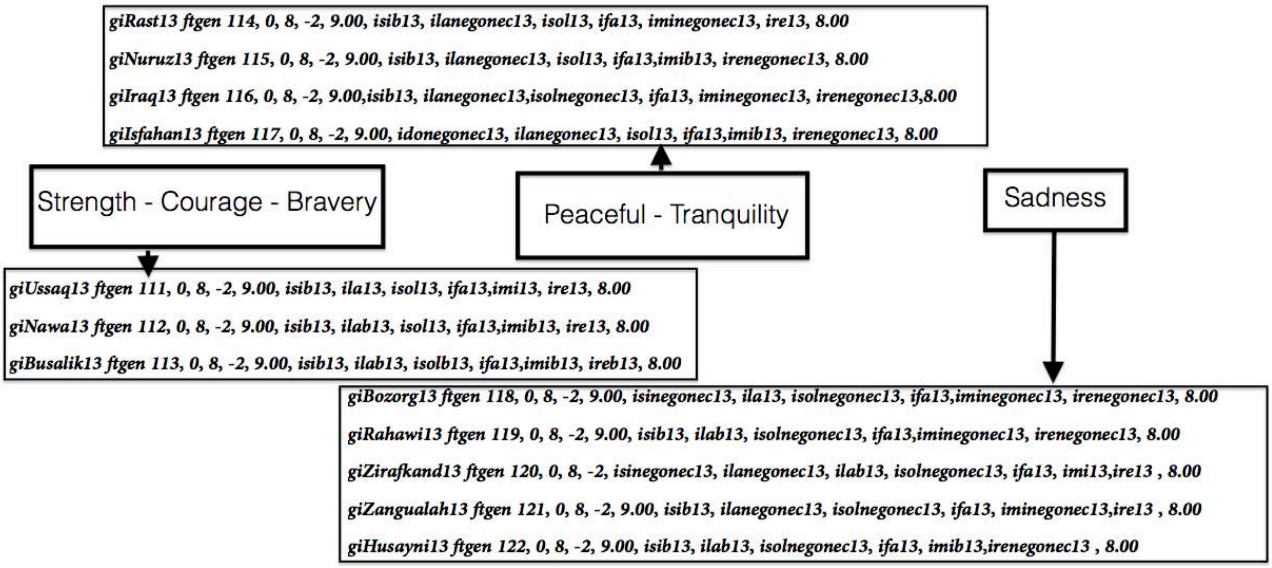

Figure 3. Classification of the twelve modes according to their ethos.

In order to represent the notion of ethos in Saffiyu al-Din's work, not only do we need to model his intervallic system and modes, but also the Arabic musical rendition, by taking into account its main features such as its homophonic character, its ornamentation and other musical rendition techniques.

3.2 Modeling subtleties typical of Arabic musical rendition

3.2.1 *The homophonic aspect of Arabic musical rendition*

Musical creation in Csound goes through two phases: from instruments of the orchestra, generated by operation codes (*Opcodes*), and according to events in the score part. We chose to work with the Opcode *pluck*, which produces a sound with a naturally decaying plucked string, based on the Karplus-Strong algorithms.

Taking the homophonic nature of a musical piece into account means creating successive events [13], belonging to a perspective of horizontal writing.

3.2.2 *Ornamentation in Arabic musical rendition*

As far as ornamentations are concerned[14], modeling is done automatically using UDOs (User Defined Opcodes) in order to generate the macro-ornaments[15].

Below is an example of how a macro-ornament works (Figure 4):

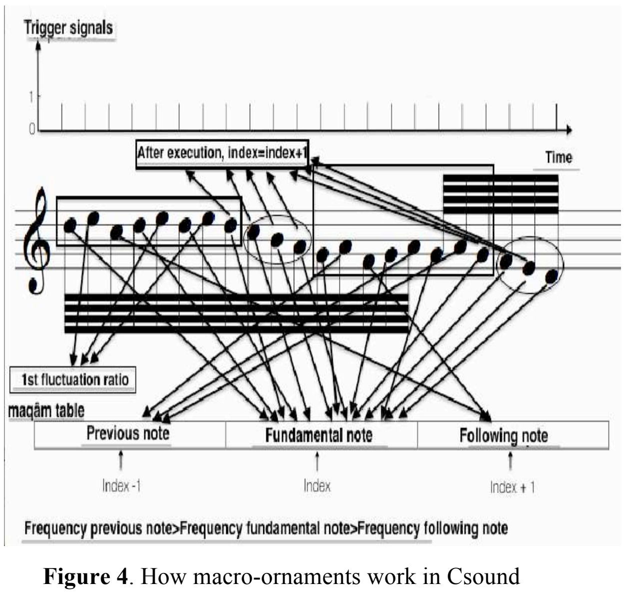

Figure 4. How macro-ornaments work in Csound

The isochrony of events generated by macro-ornaments is done automatically with the *metro* Opcode[16].

Fundamental notes are notes extracted from the maqâm table on which specific fluctuations must be applied, respecting the macro-ornament framework, which creates four melodic parts. The change of root is done by incrementing an index counter

Dynamics and phrasing effects are added to this working principle with decreasing sound intensity and a reproduction of the legato with marked picks in the case of the first and last events.

[13] As far as Csound is concerned, event will mean the onset of a sound hereinafter

[14] On ornaments in Arabic music, al-Faruqi wrote: « Ornamentation for the Arab artist, therefore, is not an addendum, a superfluous or extractable element in his art. It is the very material from which his infinite patterns are made. "

[15] A macro-ornament is the result of the motivic overlapping of micro-ornaments.

[16] The notion of emulation is illustrated here by the isochrony of events.

To provide further details, this example can be divided into four parts:

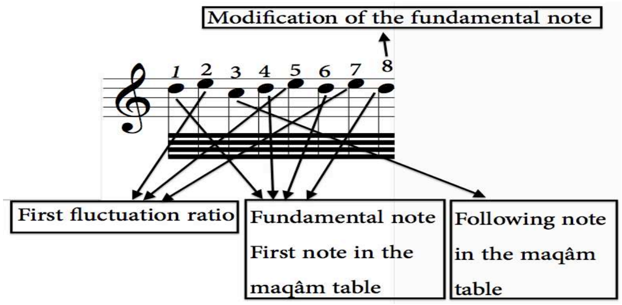

Figure 5. First phase of the macro-ornament

During that first phase, the notes number 1,4,6 and 8 represent the fundamental note which is the first note of the maqam table. That table includes 8 notes forming a descending scale. In that example and after transposition, a process that will be detailed further, the notes in the table are: D, C, B, A, G, F, E and D.

Consequently, the fundamental note here is D, the first fluctuation rate is given in the score and the following note corresponds to the C note. In the end of this first phase, the following note becomes the fundamental note: After execution of note 8, index = index + 1.

Below, 2nd part of the macro-ornament:

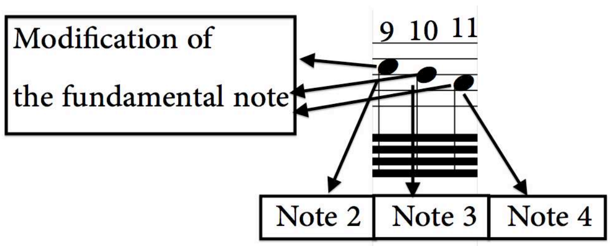

Figure 6. Second phase of the macro-ornament

After execution of the notes, the fundamental note changes: the 9th note corresponding to the 2nd note of the maqâm table is the C note, the 10th note becomes a B and the 11th becomes an A corresponding to the 4th note of the table.

The 3rd phase works in the same manner as the 1st phase:

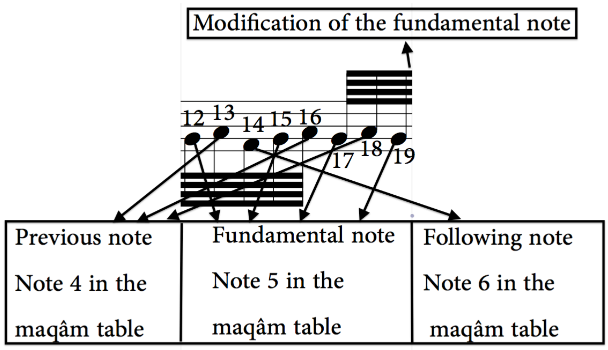

Figure 7. Third phase of the macro-ornament

The 12,15,17 and 19 notes correspond to note number 5 (note G for instance). The ornamentation is performed as a fluctuation applied to the fundamental note thanks to the following and previous notes to form a micro-ornament [7]. Notes 13,16 and 18 correspond to the 4th note in the table: note A.

The note number 14 is the following note which becomes the fundamental note after execution of note 19.

As far as the last phase is concerned, the process is the same as the 2nd part:

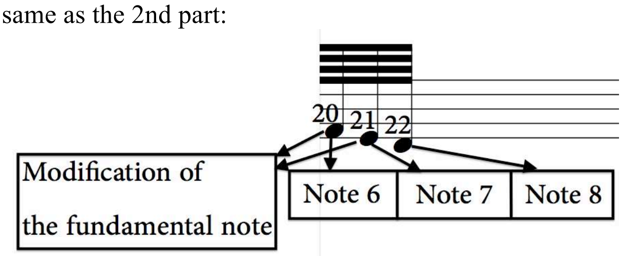

Figure 8. Last phase of the macro-ornament

This example serves as a model for other macro-ornamentations.

Starting from a pitch-class in the score, a macro-ornament runs the contents of the table of a given maqâm. However, if the pitch-class of the score does not correspond to the first pitch-class of the table, the macro-ornament must generate automatically update the other values.

The *semitone* function serves to calculate a factor to raise or reduce a frequency by a given number of semitones.

Considering X as the number of semitones, the following mathematical formula applies:

$$X = ((PC_{T'} - int(PC_T)) + ((int(PC_T) - int(PC_S)) \text{ X } 0{,}12) - (PC_S - int(PC_S))) \text{ X } (-100) \quad (2)$$

$PC_{T'}$ is the first pitch-class of the table, PC_S is the pitch-class of the score and int represents the extraction of a whole number from a pitch-class.

Here is the code of the macro-ornament illustrating the whole operating process described previously:

```
opcode macroornement11, 0, kkkkkkkkk
klegato init p10
kmetro init 0
kindextable init 0
kamplitude init p4
kmetronome metro (1/0.06)
if kmetronome == 1 then
kfrequence table kindextable , p14
kmetro = kmetro +1
kamplitude = kamplitude - (p3/10)
if kmetro == 8 || kmetro == 9|| kmetro == 10|| kmetro == 11|| kmetro
== 19|| kmetro == 20|| kmetro == 21 then
kindextable = kindextable +1
elseif kmetro == 13 || kmetro == 16 || kmetro == 18 then
kfrequence table kindextable - 1 , p14
elseif kmetro == 2 || kmetro == 5 || kmetro == 7 then
klegato = 0.1
kfrequence = kfrequence + p12
elseif kmetro == 3 || kmetro == 14 then
kfrequence table kindextable + 1 , p14
elseif kmetro == 22 then
klegato = p10
endif
kfrequencerep table 0, p14
if kfrequencerep > p5 then
koctave = int(kfrequencerep)-int(p5)
kintable = kfrequencerep - int(kfrequencerep) + (0.12 * koctave)
kintp = p5 - int(p5)
```

```
ktone = kintable - kintp
kdiff = -ktone*100
ktranspose = semitone(kdiff)
elseif kfrequencerep < p5 then
koctave = int(p5) - int(kfrequencerep)
kintable = kfrequencerep - int(kfrequencerep)
kintp = p5 - int(p5) + (0.12 * koctave)
ktone = kintp - kintable
kdiff = ktone*100
ktranspose = semitone(kdiff)
else
ktranspose = 1
endif
kcycle = cpspch(kfrequence)*ktranspose
kcycle1 = octcps(kcycle)
kcycle2 = pchoct(kcycle1)
event "i", 2, 0, .06, kamplitude, kcycle2, kcycle2, p7, p8, p9, klegato
endif
endop
```

3.2.3 UDOs call procedure

3.2.3.1 Control instrument

The control instrument enables the selection of a UDO depending on the *p11* p-field defined in the score. It assigns a value to the name of the macro-ornament in order to be called from the score: It also transfers the entry values to be used and updated.
Below is an extract of code in the control tool:

```
instr 1
ktrigger init p11
if (ktrigger == 1) then
macroornement1 p4, p5, p6, p7, p8, p9, p10, p12, p13
ktrigger = 0
elseif (ktrigger == 2) then
macroornement2 p4, p5, p6, p7, p8, p9, p10, p12, p13
ktrigger = 0
;etc…
elseif (ktrigger == 14) then
macroornement14 p4, p5, p7, p8, p9, p10, p14
endif
endin
```

3.2.3.2 The controlled instrument:

Although the instrument controlled in the orchestra plays an execution role, the result of multiple interactivity and conveyance between functional units driven by the controlling instrument, it also plays a more direct execution role. Juggling between these processes serves to accomplish the work. This second role as autonomous instrument favors the melodic sequence, whether ornamented or not, creating as such a kind of fluidity giving a general framework to the work. Here is its source code:

```
instr 2
kvib lfo p8, p9, 3
kgliss linseg cpspch(p5), p3/3,cpspch(p6)
kenv linen ampdb(p4),p3*p10 , p3, p3/4
kgliss=kgliss + kvib
asig pluck kenv, kgliss, cpspch(p7), 0, 1
out asig
endin
```

Pitch treatment is based on *kvib* and *kgliss* with a low frequency oscillator to reproduce fluctuations and glissandos, drawing a series of line segments between the spots specified. The effects of the phrasing are reproduced with an envelope that applies a motive of an attack and of decay as line segments obtained with the Opcode *linen*.

3.3 General operation of the library

The event in the score sends control parameters either to the control instrument that transfers them later to the object library, which updates them and dispatches send to the instrument controlled to perform them with this new data, or directly towards the latter to reproduce the sound occurence (Figure 9):

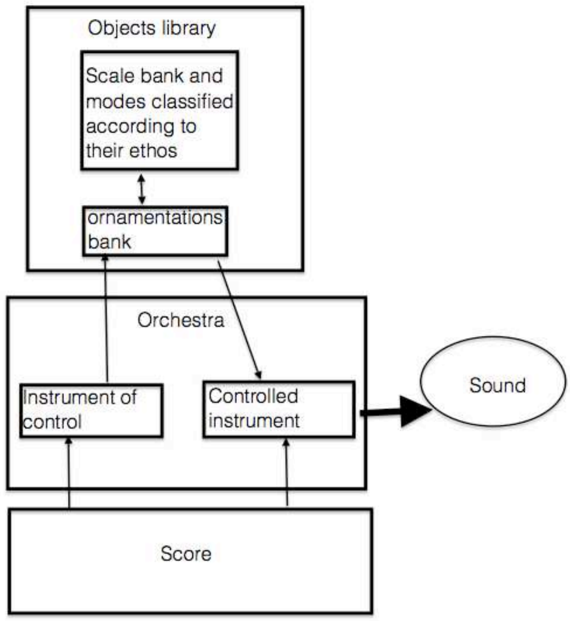

Figure 9. General operation of the object library in Csound.

4 Conclusion

This paper first dealt with the notion of ethos thanks to a historical approach through the thought of al-Kindi, Ziriab, Ikhwan al-Safa, Avicenna and Saffiyu al-Din al-Urmawi. We underlined the classification of modes according to their ethos in “The book of cycles”.
In order to feel concretely the modes described by al-Urmawi in the 13th Century and their ethos, a computational model of the non-tempered intervallic system and modes of his times was created in Csound while taking the subtleties of Arabic musical rendition into account.
This work will now serve to compose Arabic music according to “The Book of Cycles” in Csound and will enable a direct link between the modes and the notion of ethos described in the 13th Century.
In other words, this library will allow us to rethink the ethos, not only when listening, but also in the composition process: priority can be given to such or such mode, according to the melodic passage, depending on its poten-

tial influence on the listener during the act of musical creation.

At the moment, the library is limited to the use of Opcode pluck, which gives a specific idea of the way micro-intervals, ornamentations and other subtle Arabic musical features work. The sound results are reminiscent of the way Arabic strings work, such as the Ud (lute).

A widening of the instrumentarium will be considered in the future, thanks to sound synthesis for more dynamism and variation in timber. At first the difficulty at that level will be to consider the creation of UDOs for each instrument to be studied according to a logic of musical execution relevant for each instrument. The implementation of hybrid sounds was considered in order to exploit the potential of sound synthesis. That phase will permit completion of other musical rendition forms such as heterophony for instance.

Deeper control of execution speed will be implemented while keeping a fixed tempo or slightly faster tempo in the case of micro/macro-ornaments.

In the future, the creation of musical demonstrations via this library is considered in order to determine the impact and the feel on groups of listeners to establish a comparative study of the ethos defined by Saffiyu al-Din al-Urmawi.

The suggested model will be transposed on other software platforms such as languages designed for algorithmic composition (such as SuperCollider, CommonMusic, OpenMusic or PWGL).

Acknowledgments

Thanks to Anne Sèdes, my director of research.

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