

TONAL SIGNATURES

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ABSTRACT

We present in this paper an original approach of the use of tonality for composition and improvisation, developed by the French flute player, composer and improviser Malik Mezzadri. The main concept is about finding a minimal group of notes which acts as a *signature* of a given scale in the major-minor tonal system. We will first define the notion of tonal signatures in the tonal system and expose its principles. Among the possible way to solve our problem and find all the *tonal signatures*, we define some constraints and we use a constraint solver implemented in *Open Music*[1], a computer assisted music and composition environment. We provide some examples of original compositions along with improvisation playing based on the tonal signature concept. Malik Mezzadri's music counts already a rich discography with players from the international jazz scene.

1. TONAL SIGNATURES

1.1 In the context of major-minor tonal system

Tonal signatures are subsets of notes singled out from the tonal system. We consider the major-minor tonal system as referred and characterized by the three following main modes (Table 1 and Figure 1) :

Table 1. The main modes of major-minor tonal system

Modes	Intervallic structure
Major	$[T, T, H] T [T, T, H]$
minor	$[T, H, T] T [T, T, H]$
harmonic minor	$[T, H, T] T [H, T \& H, H]$

In Table 1. the letter T represents a whole tone interval, the letter H a half tone interval, and $T \& H$ represents one and a half tone interval. The brackets indicate the construction of the two diatonically disjoints tetrachords; they are the fundamentals to build the heptatonic scales of the major-minor tonal system. By transposing the three previous modes over the twelve chromatic tempered notes, we built the whole set of scales of our considered tonal system. We end up here with 36 scales.

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Figure 1. The major, minor melodic and harmonic minor modes of the tonal system (here given in C)

1.2 Definition

The notion of tonal signature starts with a simple idea. In the context of western classical and improvised music, the tonal system plays an important role. To a certain extent, from free jazz to main stream improvised music, and towards experimental improvised music fields, it is often possible to use extended scales that are still making reference to the notion of center or tonality. Depending on the playing, on the speed and on the compositions, different degrees of complexity give a more or less clear readability, or intelligibility, of the tonal center, even if modified by fast modulation changes. Malik Mezzadri has been looking for a minimal principle to deal with the readability of this center, something that would act as a minimum of information needed to understand the tonal center for someone who does share this cultural and musical background. Shouldn't a principle of minimalism also imply simplicity? The Tonal Signatures embrace the idea that the French flute player was initially expressing and experimenting intuitively with his musicians in his compositions, before formalizing it. We define the tonal signature concept as the following :

Definition 1 : A tonal signature is the smallest set of notes which belongs to one and only one transposition of a mode of the major-minor tonal system.

Definition (1) makes this group of notes, by the condition of unique existence, and if proved, an exclusive *signature* of the considered transposed mode, a given scale, among the whole thirty six possible scales. A tonal signature does not contain enharmonic ambiguities, which means that the set of sounds handled in one tonal signature is also unique and specific of the mode and its own specific transposition. We can reformulate definition (1) in a slightly more mathematical way :

Definition 2 : A tonal signature of a scale S is a minimal subset of notes in S that is not contained in any scale S' different from S .

Let us explain why the notion of minimality makes sense. For a given scale S , a *typical* set T of S is any subset of S that is not contained in any other scale different from S . Obviously, any set T' such that $T \subset T' \subseteq S$ is also *typical*. So, it makes sense to look for *minimal typical* sets. Such sets are what we call tonal signatures. The main questions we now have are : How many tonal signatures do exist ? How do we find them ? How can we use them for composition and improvisation ? Can we extend the tonal signature concept with other musical modes ?

1.3 Finding tonal signatures

We use the computer assisted compositional environment *Open Music*[1] to look for the solutions of the tonal signature problem. To elaborate the research of the minimal *typical* subsets, we define some constraints (Figure 2) to generate the subsets of notes among the 36 tonal scales defined in §1.1 and to look for unique belonging property to the reference scale (Figure 3). For example, if we consider the scale of C major as the reference scale, we want to find what are the smaller and typical subsets of notes that only belong to C major. We used the *Screamer*¹ constraint solver to express the constraints and find the solutions.

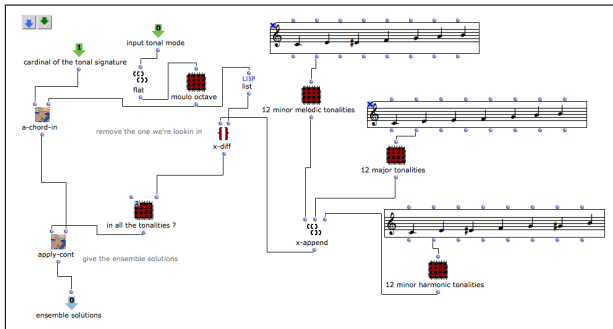


Figure 2. constraint definition in *Open Music* with *Screamer* solver to find a tonal signature

We end up with seven tonal signatures (Table 2) with their structures in semi-tones related to the given tonic. In Table 2 and note examples are given for the C tonic.

We use the following convention for names : M for the major mode, h for the harmonic minor mode and m for the ascending melodic minor mode, followed by a figure before the tonic letter to label the solution if more than one.

The *Screamer* constraint solver builds its own search tree and we don't have too much control of how it looks

¹ Screamer is an extension of Common Lisp that adds support for non-deterministic programming. Screamer consists of two levels. The basic nondeterministic level adds support for backtracking and undoable side effects. On top of this nondeterministic substrate, Screamer provides a comprehensive constraint programming language in which one can formulate and solve mixed systems of numeric and symbolic constraints.

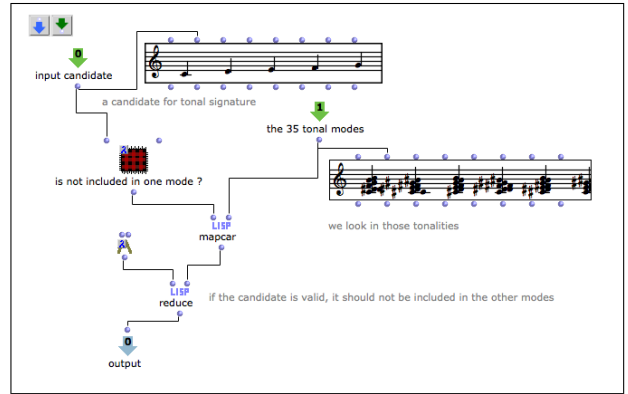


Figure 3. Constraint rule expressing unique belonging property of a candidate signature in the set of scales

Table 2. the 7 tonal signature structures

Modes	Structure	C tonal signature	name
Major	0, 4, 5, 7, 11	C, E, F, G, B	MC
minor	0, 3, 5, 9, 11	C, Eb, F, A, B	m1C
	3, 5, 7, 9, 11	Eb, F, G, A, B	m2C
	2, 3, 9, 11	D, Eb, A, B	m3C
harmonic min	0, 3, 8, 11	C, Eb, Ab, B	h1C
	0, 7, 8, 11	C, G, Ab, B	h2C
	2, 7, 8, 11	D, G, Ab, B	h3C

for the solution. But as it gives us the solutions and because the set of scales and subsets is not too large, we can cope with this. We are implementing a new version with the *Gecode*² constraint solver as this library is now available in *Open Music* and also in the *C language*. This is interesting as we can also use the solver motor in a real time environment like *Max5*³ to request solutions on demand with nearly no time headroom. This option has also the advantage to enable the use of other scales and constraints as we will see later.

It is nonetheless possible to prove mathematically the existence of the tonal signatures by considering the problem as an appropriate set covering model [2] which belongs to the class of integer linear programming problems. Arbitrary set covering problems are NP-complete [3], but [4] prove in this more general case that a fast and direct algorithm solves the tonal signature problems.

2. A COMPOSITIONAL APPROACH

We now focus on the use of the tonal signatures. Tonal signatures provide both material for composition and for improvisation. To stay with the same minimalistic approach as their definition, we hardly ever use the tonal signatures $m1$ and $m2$. $m3$ is a smaller signature so we privilege this one and skip the larger ones. In this compositional context we only use five tonal signatures : M , $h1$, $h2$, $h3$ and $m3$, and we now notate the minor tonal signature $m3$ as m (Table 3).

² <http://www.gecode.org/>

³ www.cycling74.com

Table 3. context of 5 minimal tonal signatures

<i>Modes</i>	<i>Structure</i>	<i>C tonic</i>	<i>name</i>
Major	0, 4, 5, 7, 11	<i>C, E, F, G, B</i>	MC
minor	2, 3, 9, 11	<i>D, Eb, A, B</i>	mC
harmonic minor	0, 3, 8, 11	<i>C, Eb, Ab, B</i>	h1C
	0, 7, 8, 11	<i>C, G, Ab, B</i>	h2C
	2, 7, 8, 11	<i>D, G, Ab, B</i>	h3C

2.1 Some musical implications

One of the first implication of the use of tonal signature is the diminishment of the functional possibilities of the harmonic material of the tonal system. The tonal system is strongly rooted in the western culture, and we can understand easily it without going through the abstract or philosophical ideas of its evolution. A function from the tonal system is a musical construction that is inclined to underline or undertake the reference system in which the music takes place.

The favorite subject of tonal system is itself. The music that grew up in this context organized itself in structures and tools as a tautology of its own views. The tonal system is indeed almighty, and organizes the musical materials so as to maintain its supremacy. It is a fact in the classical period that even the more subtle harmonic transitions are speaking by themselves of the tonality of the composition. And so it is inside the western cultural musical background, people became soaked with tonality and knew it intuitively, unconsciously : for a non musician, it is often not difficult to organize a small melodic phrase that makes reference to a tonal mode. It is not new that the tonal system creates a hierarchical music where no subset of the scale can pretend to the same rights as the whole reference scale has.

With the tonal signatures, we nevertheless achieve the building of subsets that do share the same functional prerogatives as their ensemble of reference : being clearly identifiable to their reference scale. The C major mode for example, is nothing else than the C major mode within the tonal system, whereas a singled out triad of C major would not be evidence of the C major mode, as it could be evidence of another mode. We need a combination of several triads to recognize what is the C major mode. The *MC* tonal signatures is enough to restore this information. In fact, any tonal signature restores the identity of the mode it belongs to. As it is now a minimal information, we might nevertheless find ourself a bit lost or disturbed to the listening to some incomplete parts of a scale, even if they should retain the whole information of the mode ! We might explain that by the fact that the tonal signatures retains, as described in §1.2, the *minimal* and *typical* melodic structure of a tonality, but implicitly is retains less of its harmonic structure. We still have the minimal information to understand the notes belonging to a mode, but we have less information to restore all the harmonic qualities of the same mode among the whole tonal system.

2.2 Resolutions with tonal signatures

With the tonal signatures, we create a paradoxical situation where we hold harmonic ambiguities, or rather non complete harmony, together with unambiguous melodic information. In this new situation, we are strangely in between modality, from melodic consideration, and tonality, from harmonic consideration. In this context, we propose two ways to use the tonal signatures to compose musical forms : one is an afferent or inward *resolution*, the other is an efferent or outward *resolution*.

2.3 Afferent movements of the tonal signatures

We mean with afferent movements to use the tonal signatures in their own particularity but retaining the link they have with the tonal system. We can make a comparison with the dodecaphonic serialism attitude : Arnold Schoenberg often used his musical material in afferent way, inserting it in forms and structures of the tonal system. Conversely, Anton Webern deduced forms and structures from the musical materials and its inner rules, as if the form was a consequence of the dodecaphonic series and its inner arrangement. We note that the *functional* use of the tonal signature inside the tonal system claims a kind of serial existence : to achieve its *function*, a tonal signature must be explicit and all of its note have to be used.

2.3.1 Common notes : sequence vs progression

The project and record [5] has been realized with the afferent techniques use of the tonal signatures. The approach was to use tonal melodies from the cultural repertoire and to harmonize it only with tonal signatures. To achieve this, we match the mode the parts of the melody makes reference to, and we proceed to the writing of the sequence of tonal signatures. We insist on the term *sequence* and not *progression* : *progression* is like chord changes and would emphasize or point a tonality within the *chain* of the musical material, while the term of *sequence* implies to keep the maximum of common notes in respect with the given melody. Besides, to keep a musical touch and feeling of the harmonization, choices are done intuitively so that the foreign notes brought implicitly or *per se* with the tonal signatures don't disturb too much the melodic constraint. The first musical tunes written with this system are "Z" in [6] and "Vienne" in [6]. The former undertakes harmonic realization of the tonal signatures, while the later undertakes melodic realization; the original harmony is of a classical tonal implementation.

2.3.2 Tritone resolution

Another possibility for afferent use of tonal signatures is tritone resolution. This time we can consider progressions, as we deal with functional quality of the chaining tonal signatures. We build progressions on the tritons resolution inside a tonal signature towards the next one, so that they also share, or not, the most possible common notes with the tonal reference of this resolution. We have considered the two easier resolutions with semi-tones. For example $(E\#, B) \Rightarrow (F\#, A\#)$, and $(F, B) \Rightarrow (E, C)$. A

composition where this principle is used is the piece *XP26* in the project [7]. Here is, from the (F, B) triton and its tonal en-harmonies, the set of tonal signatures that contain its resolutions :

1. $MF\#, MC$
2. $m1C\#, m2C\#, m3G, m3Db$
3. $h1Bb, h1E, h2Bb, h2E, h2B, h2F, h3B, h3F$

We got interested in applying tonal signatures to the triton resolution because it is a subject of discussion since ages, and as such is a subject of importance that cannot be ignored.

2.4 Efferent mode of the tonal signatures

We develop here other ideas to use the tonal signatures. The tonal signatures are coming from a tonal context, from a deductive and *conservative* approach, which involves *minimal* means to retain functional data relative to the three subsets of the tonal system. But the tonal signatures are not so familiar to listen to. If we play an *h2* tonal signature, even looping this *information*, it would still be difficult for an average listener to identify it with certainty to its reference mode. We can nonetheless make the most of this remark! We can use this material in a efferent way, knowing that the *information* it holds would have few or maybe no interferences with other *information* from another context. Moreover, the tonal information of a tonal signature would also be restored in a new context, in a more subtle way which can stimulate a lot the cultural memory of the listener.

2.4.1 Talea color

The chosen approach in this project is realized in reference to the *Talea Color* of the *Ars Nova* period. The melodic material or *color* is rhythmically organized with a given temporal cycle or *talea*.

In the first record of [6], the tonal signatures are used as a polyphonic material without contrapuntal treatment, but rather like monoliths. The score is built from a bass line which acts as an attractor for the tonal signature, chosen for its harmonic role or in respect to common notes. We can build this way a polyphony of tonal signatures, which makes a musical topology on top of which improvisation can unfold. Rules for music ranges are added to constrain the scoring, and these combinations tends to make the composition, as an example is given in (Figure 4), resemble a kind of cellular automata process .

2.5 Tonal signatures among Messiaen's modes

The meeting with Olivier Messiaen's modes of limited transposition is very stimulating. They are a main domain of application with tonal signatures in the efferent mode. The limited transposition modes of Messiaen, notated *LTMM*, are a logical consequence of the tempered system, maybe even more than the dodecaphonic system. We can see Messiaen's modes as a gradual chromatic development of the tonal system. The *LTMM* are subsets of the chromatic

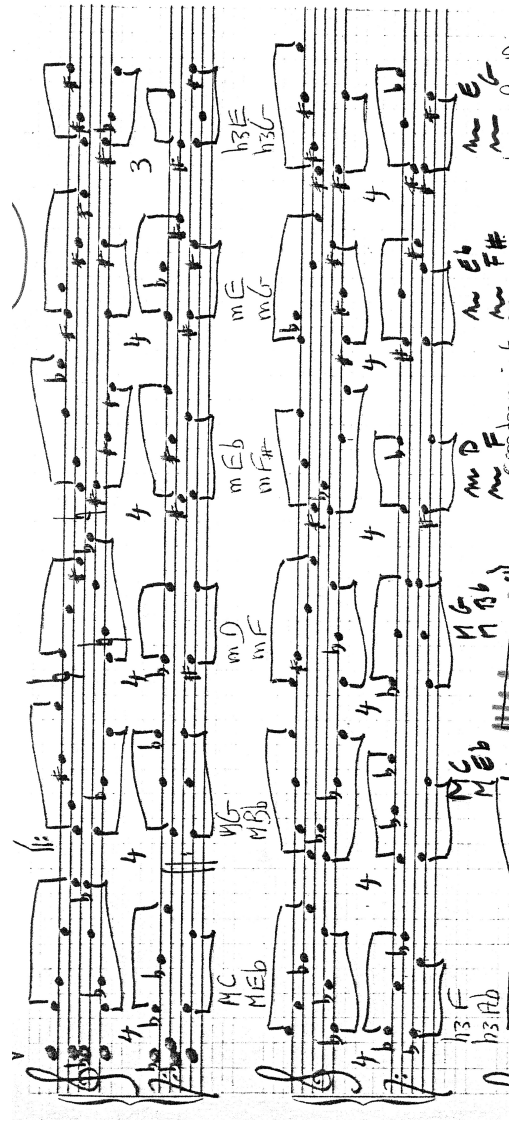


Figure 4. polyphony of tonal signatures within constraint of tessitura given as a chord at the start of the stave

scale, and because of their inner symmetry, they remove polarity of notes, as found in tonal system, and replace it with polarity of axes. From the seven *LTMM*, we only consider the third and the seventh mode (Figure 5), as they contain all the others, considering all the transpositions. If we look for tonal signatures in limited transposition modes *M3* and *M7*, we now find the same intervallic structured signatures in one mode, i.e. at least one transposition of the same signature is found in the modes (Table 4). From this very singular observation, we can now consider the possibility to go back to the idea of progressions, and not merely sequences. We can reformulate the same idea : from the tonal system context where we have tonal signatures with notes, we arrive in the *LTMM* context to sign progressions with tonal signatures, that we can call *progression signatures*.

3. CONCLUSION AND FUTURE PERSPECTIVES

Mixing tonal signatures concept within context of Messiaen's modes is opening some new material and intuitions for new compositions and improvisations. We can use the tonal signatures also in more conventional forms, as *Canons* or *Counterpoints* (Figure 6). We will remind that in Messiaen's mode context, where there is by symmetric construction no more tonic function, the tonal signature concept fits very well, because it does not make a classical hear reference to one scale, as sometimes it also misses tonic or triad. Then the real difficulty begins for the musicians, as one needs to build reflex and a new musical thinking mind with this musical material, to digest it, so as, from a new compositional language it becomes also a natural language to improvise and play with.



Figure 5. Limited transposition modes of Messiaen : CM3 and CM7

Table 4. Tonal signatures in Messiaen's mode

LTMM	Tonal signature inside LTMM
CM3	MEb MG MB m1Eb m1G m1B m2Db m2EB m2F m2G m2A m2B m3Db m3F m3A h3C h3E h3Ab h1C h1Eb h1E h1G h1AB h1B h2C h2Eb h2E h2G h2AB h2B
CM7	MDb MD MG MAb m1C m1D m1EB m1F# m1Ab m1A m2C m2D m2E m2F# m2Ab m2Bb m3C m3Eb m3E m3F# m3A m3Bb h1C h1Eb h1F1 h1A h2C h2C# h2F# h2G h3C h3C# h3E h3# h3G h3Bb

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Eleonore [om]

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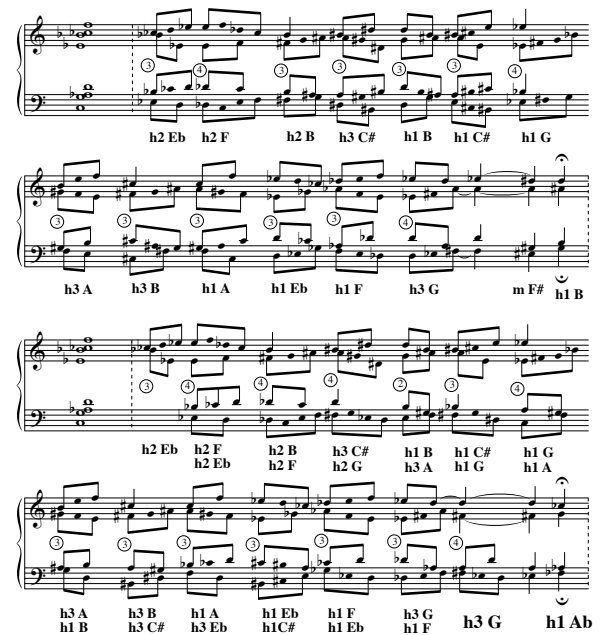


Figure 6. Four voices counterpoint, polyphony of tonal signatures mixed within Messiaen modes's context

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