

Retentional Syntagmatic Network, and its Use in Motivic Analysis of Maqam Improvisation

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Abstract

In this paper is defined a concept of *Retentional Syntagmatic Network* (RSN), which models the connectivity between temporally closed notes. The RSN formalizes the Schenkerian notion of *pitch prolongation* as a concept of *syntagmatic retention*, whose characteristics are dependent on the underlying modal context. This framework enables to formalize the syntagmatic role of ornamentation, and allows an automation of motivic analysis that takes into account melodic transformations. The model is applied to the analysis of a maqam improvisation. The RSN is also proposed as a way to surpass strict hierarchical segmentation models, which in our view cannot sufficiently describe the richness of musical structure. Instead of *separability*, we propose to focus instead on the *connectivity* between notes, modeled with the help of RSNs.

1. Introduction

In this paper is defined a concept of Retentional Syntagmatic Network (RSN), which models the connectivity between temporally closed notes.

Section 2 gives basic rules for the construction of a RSN out of a score, and shows in particular that the complexity of the network is significantly limited thanks to the use of a concept of syntagmatic retention, related to Schenkerian pitch prolongation. Two main applications of RSNs are developed in the next two sections. Section 3 shows how a comprehensive closed pattern mining throughout the RSN enables to detect repetitions –with variations such as ornamentations– of motivic patterns. Section 4 considers RSNs as a productive change of paradigm within the topic of melodic segmentation.

Throughout the paper, the concepts are illustrated with the analysis of a transcription of the first part of a improvisation by the Nay flute master Mohamed Saâda on the *Mhayer Sîkâ maqam* (Lartillot & Ayari, 2011).

2. Retentional Syntagmatic Network

2.1 Definitions

The RSN is a graph made of edges, called syntagmatic connections, that connect couple of notes perceived as successive.

The *syntagmatic surface* is the whole series of notes defining the monody under study. There is always a syntagmatic connection between two notes that are immediately successive in the syntagmatic surface, forming therefore a syntagmatic chain.

For notes n_i and n_j that are not immediately successive, the syntagmatic connection between n_i and n_j is drawn when the succession of the two notes can be perceived, such that the succession n_i, n_j can be integrated in a monodic line $\dots n_i, n_j \dots$, called syntagmatic path. In other words, combination of horizontal lines, typical of contrapuntal music in particular, are modeled as syntagmatic paths throughout the RSN.

2.2 Syntagmatic retention

A syntagmatic connection between two notes of same pitch, and more generally a syntagmatic chain made of notes of same pitch, are also perceived as one single “meta-note”, called *syntagmatic*

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retention, related to that particular pitch, such that each elementary note is considered as a repeat of the meta-note on a particular temporal position. This corresponds to a basic principles ruling the Schenkerian notion of *pitch prolongation*.

Since successive notes of same pitch are considered as repeats of a single meta-note, any note n of different pitch that comes after such succession does not need to syntagmatically connect to all of them, but can simply be connected to the latest repeat preceding that note n . Similarly, a note does not need to be syntagmatically connected to all subsequent notes of a given pitch, but only to the first one. The actual note to which a given note is syntagmatically connected will be called *syntagmatic anchor*.

This enables to significantly reduce the complexity of the RSN: instead of potentially connecting each note with each other note, notes only need to be connected in maximum to one note per pitch, the syntagmatic anchor, usually the latest –or the soon-to-be– played note on that particular pitch. The RSN can therefore be simply represented as a matrix where each column is a note, and each line is a pitch, as shown in Figure 2.

2.3 Scope of syntagmatic retention

The definition of the RSN is highly dependent on the specification of the temporal scope of syntagmatic retentions. In other words, once a note has been played, how long will it remain active in memory so that it get connected to the subsequent notes? What can provoke an interruption of the retention? Can it be reactivated afterwards?

One main factor controlling syntagmatic retention is modality: the retention of a pitch remains active as long as the pitch remains congruent within the modal framework that is developing underneath. Once the pitch conflicts with a subsequent modal state, its retention is deactivated.

We propose to illustrate these ideas through the analysis of the *Mhayer Sîkâ maqam* (Lartillot & Ayari, 2011), which, as any maqam mode, is made up of the juxtaposition of *ajnas* (plural of *jins*), as shown in Figure 1. A *jins* is defined as a group of 3 to 5 successive notes such that one (or two) of those notes is considered as pivotal, i.e., melodic lines tend to rest on such notes.

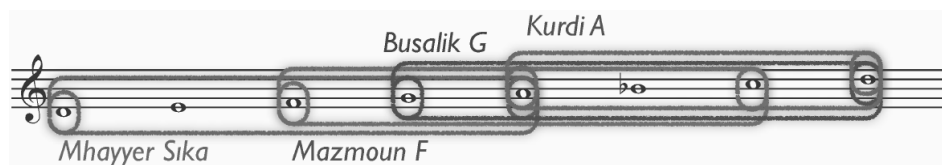


Figure 1: Modal scheme of the Mhayer Sîkâ maqam developed in the improvisation shown in Figure 3.

The modal analysis of the improvisation could be described as a succession of *ajnas*, showing clear transitions from one *jins* to the other. Yet multiple *ajnas* can be considered as active at a same time, and the most active *jins* can be considered as defining the dominant characteristic at that instant. We proposed a model that infers numerical scores for each *jins* for each successive note in the improvisation (Lartillot & Ayari, 2011). The score of each *jins* can be used to infer the syntagmatic retention of previous pitches. This is under investigation in current works.

In this paper, we propose to simply infer the syntagmatic retentions through a manual and intuitive method. In the RSN of the improvisation, shown in Figure 2, the retention of each different pitch is considered separately. For a given pitch p , we listen to each successive note, from the first occurrence of that pitch p to the end of the piece, and for each note n , we imaginarily superpose to the sound of note n to the sound of pitch p . If the combination sounds congruent (both their superposition and their succession p, n), we consider the retention of p as still active, if its sound incongruent, the retention is interrupted.

A tentative RSN related to the *Mhayer Sîkâ maqam* is shown in Figure 2.

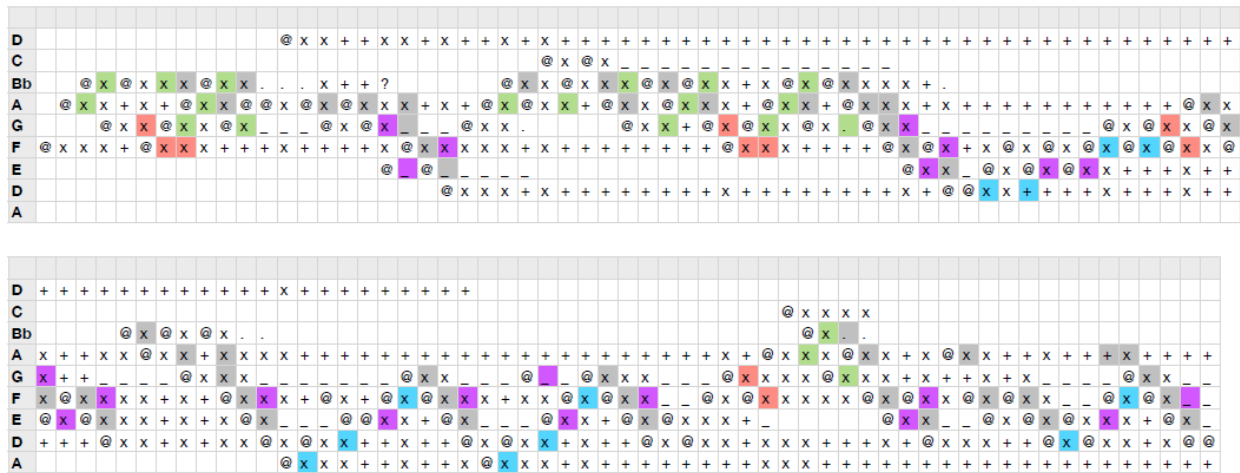


Figure 2: RSN related to the transcription of the improvisation on *Mbayer Sika maqam* shown in Figure 3. Each successive column of the matrix is a successive note in the transcription. Lines develop syntagmatic retention of pitches, the top line corresponding to the highest pitch. Actual notes are indicated with '@'. Syntagmatic retentions are shown by 'x'-crosses, which indicate that the current note (column) can be syntagmatically connected with the pitch related to the line. '+' is similar, simply adding that the syntagmatic anchor has already been used by a previous note. Other signs indicate other degrees of syntagmatic connections that have not been fully formalized yet. Syntagmatic connections shown in the motivic analysis in Figure 3 are highlighted in this matrix using the same color code.

3. Motivic pattern mining in the RSN

3.1 Ornamentation and reduction

An ornamentation of a motif generally consists in the addition of one or several notes –the ornaments– that are inserted in between some of the notes of the initial motif, modifying hence the composition of the syntagmatic surface. Yet, the ornamentation is built in such a way that the initial –hence reduced– motif can still be retrieved as a particular syntagmatic path in the RSN.

The challenge of motivic analysis in the presence of ornamentation is due to the fact that each repetition of a given motif can be ornamented in its own way, differing therefore in their syntagmatic surface. The motivic identity should be detected by retrieving the correct syntagmatic path that corresponds to the reduced motif. Motivic analysis is hence modelled as a search for repeated patterns along all the paths of the syntagmatic network (Lartillot: 2010).

We proposed a method for comprehensive detection of motivic patterns in strict monodies, based on an exhaustive search for closed patterns, combined with a detection of cyclicity (Lartillot: 2010). That method was restricted to the strict monody case, in the sense that all motifs are made of consecutive notes. The closed pattern method relies on a definition of specific/general relationships between motifs. In the strict monody case, a motif is more general than another motif if it is a prefix, or a suffix, or a prefix of suffix, of the other motif². The application of this comprehensive pattern mining framework to the analysis of RSNs requires a generalization of this notion of specific/general relationships that includes the ornamentation/reduction dimension.

3.2 Application to the analysis of a maqam improvisation

Figure 3 shows a theoretical analysis of a transcription of the first part of a improvisation by the Nay flute master Mohamed Saâda on the *Mbayer Sika maqam* (Lartillot & Ayari, 2011). The lines added in the score show occurrences of motivic patterns. Two main patterns are induced, as shown in Figure 4:

² The additional problem of multidimensionality of the musical representation is here ignored to simplify the explanation.

- The first line of Figure 4 shows the main pattern that is played in most of the phrases in the improvisation, and based on an oscillations between two states centered respectively around A (added with Bb, and represented in green) and G (with optional F, and represented in red), concluded by a descending line, in black, from A to D. This descending line constitutes the emblematic patterns related to the *Mhayyer Sîkâa maqam*, and can be played in various degrees of reduction through a variety of different possible traversals of the black and purple syntagmatic network.
- The second line shows a phrase that is repeated twice in the improvisation – plus another more subtle occurrence—and based on an ascending (blue) line followed by the same paradigmatic descending line aforementioned.
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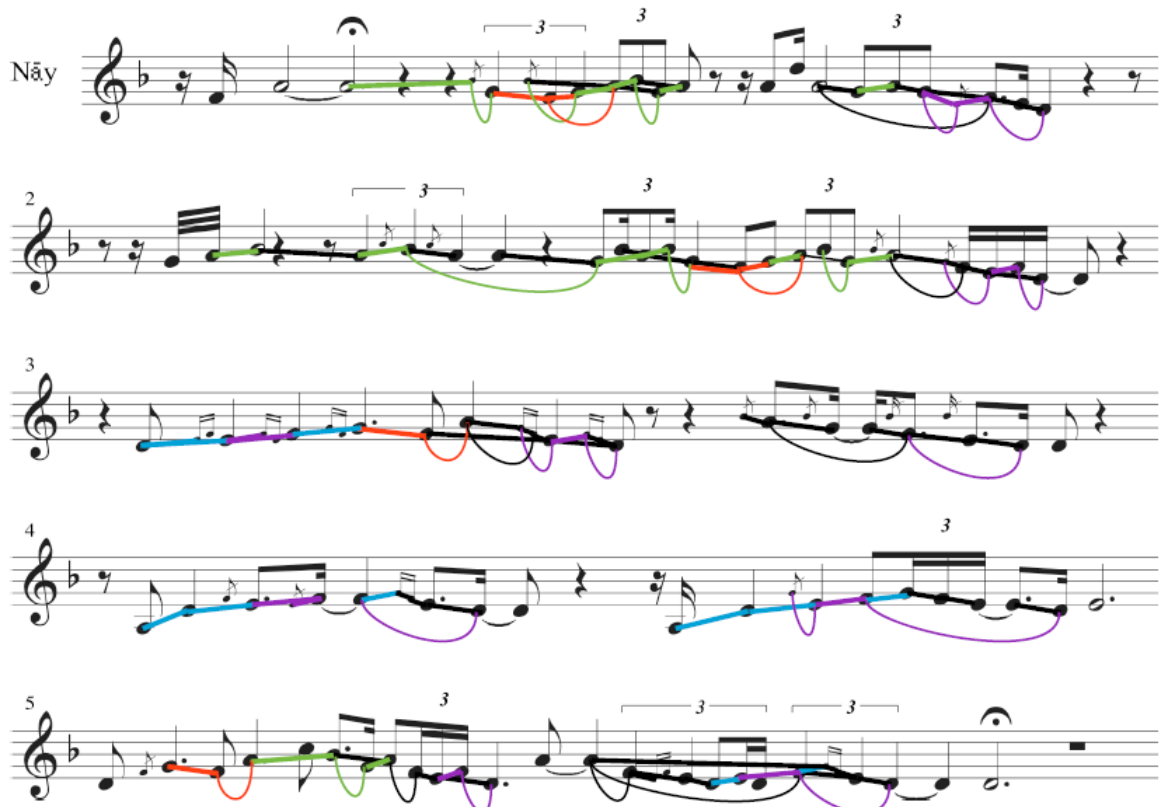


Figure 3: Transcription and motivic analysis of the first part of an improvisation by the Nay flute master Mohamed Saâda on the *Mhayyer Sîkâa maqam* (Lartillot & Ayari, 2011). The lines added in the score show occurrences of motivic patterns, described in Figure 4.



Figure 4: Motivic patterns inferred from the analysis of the improvisation shown in Figure 3.

This detailed analysis of the transcription shows how parallel motivic understanding can be

drawn on a same musical passage. For instance, the second grace note Bb at the beginning of the improvisation can be understood:

- as a simple ornamentation of the subsequent note G, following the logic of the previous ornamentation Bb-A,
- as part of a green pattern Bb-G-A,
- as part of a black descending line Bb-A-G-F-E-D.

The algorithm is under development. In order to offer a compact representation of the results, as shown in the figure, some additional mechanisms need to be added, such as the detection of internal cycles within a pattern, as indicated by the repeat bars in the representation of the first pattern in Figure 4.

4. Beyond Gestalt segmentation

4.1 Separability of segmentation models

In formalized and computational approaches of structural analysis of music, one core mechanism consists in decomposing the stream of music into segments and, in multi-level hierarchical models, segments are themselves decomposed into subsegments and so on. This corresponds in particular to the Grouping Structure in the GTTM (Lerdahl & Jackendoff, 1983) or to Tenney and Polansky (1980)'s model. Applications to polyphony have been considered similarly as a decomposition of the polyphonic flow into segments of streams (Lerdahl, 1989; Rafailidis et al, 2008).

This hierarchical segmentation of music face two major limitations:

- This forces one single hierarchical understanding of the structural organization of the musical material. Refined motivic analyses often show how particular musical elements can be organized in various ways, and that such structural polysemy can be easily understood by the listener.
- Such compartmentation conceals the rich interconnection that could be drawn between notes that belong to different clusters. In hierarchical segmentation models, segments are represented in the upper level by reducing their content into one single note: the interconnection between neighbor segments is represented by an interconnection between the anchor note of each segment. This solution allows indeed interconnections rising above the strict taxonomy, but practical examples can show how limited this solution remains.

It seems therefore that a strict hierarchical segmentation model is not enough to describe the richness of musical structure.

4.2 Connectivity of the RSN

Surpassing those important limitations requires a change of paradigm. In order to formalize clustering of notes without forcing one taxonomy out of others, instead of focusing on the separability between notes, as traditional segmentation model would do, we propose to focus on the connectivity between notes, based, here also, on the RSN.

A weight, called syntagmatic weight, could be associated with each connection between two notes. The introduction of fuzziness allows to transcend a purely binary decomposition of the structure, and offers multiple ways of deciphering the organization depending on the weight threshold chosen as point of view. This syntagmatic network is a generalization of the hierarchical segmentation model, which corresponds to a special case with binary syntagmatic weight (0: no connection, 1: connection).

These interconnections between notes can be understood not only as the skeleton of what we considered as segments, but also as indicators of longer-range connections between notes that, in

the traditional representation, would belong to separate segments. This would hence represent the interconnections between segment anchors, but also more subtle interconnections as well.

The syntagmatic weight between two notes can in a first step be based on the actual distance between these two notes along the various musical dimensions. Assigning such weight to successive notes of monodies would enable to reconstruct the rules stated in segmentation models such as in the GTTM (Lerdahl & Jackendoff, 1983) and in the LBDM (Cambouropoulos, 2006). The next step in this study would be to generalize this analysis, beyond the syntagmatic surface, to RSNs. Syntagmatic weights would be assigned to all existing syntagmatic connections; monodic segmentation could be performed based on a summation of the weights, and polyphonic multi-layer segmentation could be studied as well.

5. Current and future works

The specification of the RSN, of their use in motivic pattern analysis and connectivity analysis is currently under study. Other ongoing research questions are mentioned in this section.

5.1 Integration to The MiningSuite

The MiningSuite is a new platform for the analysis of music, audio and signal currently developed by Lartillot (2011) in the Matlab environment. One module of The MiningSuite, called MusiMinr, enables to load and represent in Matlab symbolic representations of music such as scores. It also integrates an implementation of the algorithm that automatically constructs the syntagmatic network out of the musical representation. Modes can also be specified, in order to enable the modal analysis and the specification of the RSN. Motivic analysis can also be performed automatically.

We plan to enable the graphical representation of the analytical results in a form that would ideally resemble what can be seen on Figure 1. Alternatively, the result of the analysis can be used to output hypothetical segmentation points, represented in a dedicated representation in MusiMinr. Actual listeners segmentation can be imported as well and compared to the theoretical results.

MusiMinr also integrates a module that attempts transcription of audio recordings of pieces of music into score representations. Actually, the whole musical analysis is progressively performed, including the syntagmatic, modal and motivic analyses, in the same time as the transcription itself. In this way, higher-level musical knowledge, such as the expectation of a given modal degree or a motivic continuation, is used to guide the transcription itself (Lartillot, 2012).

5.2 Feedback of pattern discoveries in the syntagmatic network

Motivic patterns that are discovered in the syntagmatic network might reinforce the syntagmatic weight of the paths actualized by the pattern occurrences. They might also induce possible perturbations in the syntagmatic network: syntagmatic connections that were theoretically possible can be altered if the new pattern occurrences interfere through masking.

The pattern analysis is performed on the syntagmatic network during the progressive construction of the syntagmatic network itself: each new syntagmatic connection added at the end of the network induces a search for associated patterns. In this way, when a pattern is progressively detected,

- the possible continuations of that pattern, as indicated by the children in the pattern tree, can be used as guide to draw the new syntagmatic connections with the new notes;
- the new pattern occurrences may interfere in the establishment of distant connections from notes before those occurrences to the new notes currently heard.

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