

“JAZZ MAPPING” AN ANALYTICAL AND COMPUTATIONAL APPROACH TO JAZZ IMPROVISATION

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ABSTRACT

“Jazz mapping” is a multi-layered analytical approach to jazz improvisation. It is based on hierarchical segmentation and categorization of segments, or constituents, according to their function in the overall improvisation. The approach aims at identifying higher-level semantics of transcribed and recorded jazz solos. At these initial stages, analytical decisions are rather exploratory and rely on the input of one of the authors and experienced jazz performer. We apply the method to two well-known solos, by Sonny Rollins and Charlie Parker, and discuss how improvisations resemble story-telling, employing a broad range of structural, expressive and technical tools, usually associated with linguistic production, experience, and meaning. We elucidate the implicit choices of experienced jazz improvisers, who have developed a strong command over the language and can communicate expressive intent, elicit emotional responses, and unfold musical “stories” that are memorable and enjoyable to fellow musicians and listeners. We also comment on potential artificial intelligence applications of this work to music research and performance.

1. INTRODUCTION

1.1 Goals: The project aims at advancing our current understanding of jazz improvisation and, by extension, of musical creativity. It introduces and applies a musical language-mapping scheme that can support the creation of a large annotated corpus of transcribed solos, assist in the pedagogy of improvisation and serve as a reference point in human and artificial musicianship research. The utility of the approach may also extend to research in other domains that explore hierarchical sequential data and real-time decision making, such as generative modeling of natural language and speech.

1.2 Related work: Formal music analysis is usually concerned with breaking the musical surface into segments based on similarity, and with studying how these are put together syntactically as a piece of music unfolds in time, thus attributing internal cohesion [1] Semiotic analysis (paradigmatic and syntagmatic) is a typical example of a method which categorizes segments according to similarity [2] Paradigmatic analysis has been computationally modeled in the past [3], [4].

At the same time, a significant body of research literature addressing jazz improvisation has been developing over the last couple of decades. This work includes topics on jazz storytelling [5], including references on the concept by well known jazz musicians and scholars. Some [6] introduce the concept of re-telling to refer to the re-working of a standard, based on a famous recording of a master, stressing the important tension between individual voice and tradition. Others [7] explore machine learning of jazz grammars, using basic building-blocks or “slopes,” touching upon the antitheses of abstraction versus vocabulary, and attempting to codify harmonic tension.

A relevant work that focused on Sonny Rollins’s thematic improvisation [8] will be explored further, below.

Weimar’s Jazzomat Research Project [9] has produced several databases of annotated solos and licks, including the “Dig That Lick” database. Studies on the use of patterns in jazz [10], [11], have stressed the importance of auditory and motor patterns organizing into a stored menu of pattern libraries.

Researchers at the Georgia Institute of Technology have been developing robotic applications of computer improvisation [12] that are informing and are being informed by our work.

Francois Pachet in 2001 produced The Continuator, later developed in the European project MIROR (mirrorproject.eu) [13], focuses on learning sequences by linear analyses of input patterns and phrases to generate a response. Improvisations have been generated in real time based on input of musical sequences [14]. Explorations on the improvisers’ thought processes during a duo [15] have attempted to reveal the intent and the scheme or scenario behind an improvisation. Musical passage coding as “phrase” and “variation” has been used to assist a music program to acquire “common sense,” [16], while a very interesting interview of Ornette Coleman by Jacques Derrida touches on the relationship between language and jazz improvisation.¹

All the above approaches deal with a structural analysis of jazz improvisations, thus studying the jazz vocabulary

¹http://www.ubu.com/papers/Derrida-Interviews-Coleman_1997.pdf
Interview originally appeared in French in the magazine Les Inrockuptibles no. 115 (20 aout-2 septembre 1997): 37-40,43.

and syntax, but they are not progressing deeper into the semantics of the language.

Based on the above approaches, and while we acknowledge that the topic of semantics in jazz might be too complex to describe with a formal syntactic analysis, we make a first attempt in interpreting the various constituents that result from the analysis, together with their function and style in the improvisation, expanding into issues of semantics, syntactical analyses, story telling and thematic development.

1.3 Proposed outcome: The “jazz mapping” project has potential implications to machine learning and Artificial Intelligence (AI) system development. It can provide means for AI to manage in a human-like way the essential human tension among past, present, and future characterizing all decision-making. This potential can be realized through “teaching” an AI system the rules that govern annotation and how these rules dynamically interact and change when actualized as experienced present or “now”.

We will begin by identifying and adapting to jazz improvisation musical contexts basic human communication tools/codes, concepts and structures such as: question and answer/call and response, fragment, lick, phrase, thematic development, short/long, memorable or abstract, and references among phrases. A similar approach can potentially be used to explore concepts such as harmonic tension, phrasing, articulation, expressiveness, sonic character or “sound,” *etc.*, to generate jazz solos much like a jazz improviser/storyteller would, using layers of multi-reference.

A pattern database will be also created as those annotated phrases licks, fragments and patterns will have multiple uses on “describing” or “outlining” chords and chord sequences helping to address issues like originality and personal voice and different approaches of players like vertical versus linear, voice leading versus modal or free.

2. THE JAZZ MAPPING APPROACH

2.1 Constituents in syntactic analysis.

In order to analyze an improvisation through mapping we propose a novel method which consists of the following levels: Jazz improvisational structural elements and mappings, thematic analyses by defining segments, licks and phrases and annotation of syntax and structure.

In our analysis, we define 3 types of constituents, listed here by increasing duration and/or complexity:

1. **Segment**
2. **Lick**
3. **Phrase**

Each of the constituents found would carry a tag describing the function in the improvisation, such as: *response/answer, reference, or new idea*.

2.2 Definitions

Below we attempt a definition for each constituent, bear-

ing in mind that this is not a fully formal approach yet, therefore the criteria for a constituent to belong to a category are not fully explicit, and rely to some extent on the context of the piece under analysis.

Segment: very short but salient theme, fragment, angular/linear/long single note, usually one bar (*e.g.* the thematic seed in John Coltrane’s “Love Supreme” Ex.1).



Ex.1
(John Coltrane goes on to build part of his solo using this fragment in different keys).

Segment duration does also depend on tempo; visual analogue: a Lego piece or a brick.

Lick: a memorable theme usually between two and four bars (*e.g.* Ex.2, the opening in Charlie Parker’s “Now’s The Time”).



Ex.2

Lick is longer than a segment and shorter than a phrase (again, dependent on tempo, typically not longer than four bars); often musicians transpose favorite licks in a variety of keys to enhance their “vocabulary” in a certain style; can also be used as “mannerisms” to reference another performer or style; visual analogue: a larger, more salient and recognizable structure such as a door or a window.

Phrase: longer sequence of notes² that may or may not contain discernible segments or licks; visual analogue: an entire room or part of a space that can contain legos/bricks, doors, windows, *etc.*

Here is Ex.3, Dexter Gordon’s 7 bar long phrase from “Cheesecake”.



Ex.3

Additionally a constituent, according to its function, would acquire one of the following characterisations: a **response/answer** to a previous element in the same piece (reaction to an internal/local musical event), a **reference** to a previous element in the same piece (allu-

² Our initial focus on horn solos imposes a maximum phrase duration based on breath capacity, which can, of course, be exceeded when using circular breathing techniques.

sion to an internal/local event), or an independent new idea. In terms of score annotation for the mapping we use **S** for segment, **L** for lick, **P** for phrase, different colours for each one, plus **r** for reference/relationship, **a** for answer/response, while location is described with brackets.

3. ANNOTATION SYNTAX

In annotating the above constituents as a piece unfolds in time, i.e. syntactically, we developed textual annotations to describe constituents and their locations.

3.1 Location

Location is annotated as “measure number and beat number within the measure”. For example, location “1.3” means “third beat of the first measure”. Longer durations are annotated analogously. For example, an element’s duration of “1.1 - 2.4” means that the element starts on beat 1 of measure 1 and ends on beat 4 of measure 2.

3.2 Constituents and Qualifiers

Segment = **S(Index, Reference, Response)**

Lick = **L(Index, Reference, Response)**

Phrase = **P(Index, Reference, Response)**

Index: numerical order of appearance of a structural element

Reference: 1,2,3... = a first/second/third reference; 0 = not a reference

Response: 1,2,3... = a first/second/third response; 0 = not a response

If both **Reference** and **Response** are 0 the element qualifies as a **New Idea**.

3.3 Annotation Example

For Measure 1 in Sonny Rollins’s “St. Thomas” we would write **1.1 - 1.4; S(1, 0, 0)** to indicate: beats 1-4 of measure 1 outline the first distinct segment of the piece which is not a reference or response to any other element but a new idea.

For Measure 2 we would write **2.1 - 2.4; S(1, 0, 1)** to indicate: beats 1-4 of measure 2 constitute the 1st response (and not a reference) to the 1st segment, which was introduced in measure 1.

For Measures 15-17 we would write **15.1 - 17.1; S(1, 2, 3)** to indicate: the portion beginning at measure 15, beat 1 and ending at measure 17, beat 1 constitutes the 2nd reference and 3rd response to the 1st segment.

3.4 Additional definitions

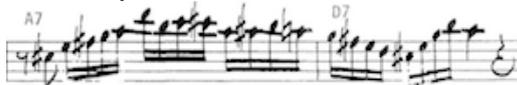
** Mannerism

A segment, lick, or phrase that exemplifies a performer’s style; a structural element that sounds like a quintessential Sonny Rollins, Charlie Parker, or any artist passage.

For example: **S(1,0,0)*** describes the piece’s 1st segment, which is neither a reference nor a response, nor a wholly new idea but, rather, a stylistic mannerism, pointing to a specific style characteristic to an artist or genre.

This designation helps differentiate between references to elements within a given solo and references to the performing artist’s “memory bank.”

The following Ex.4 is a Parker mannerism on “Now’s The Time”, that we see in a more elaborate version below at our analyses of “Au Privave”.



Ex.4

** Quote

A segment that directly incorporates a well-known and recognizable structural element from another piece (e.g. a theme from Beethoven’s 5th symphony, a lick from a Jazz standard or a well-known pop song, or another player’s favorite phrase.

The use of quotes in jazz improvisation is happening often so if the quotes are properly labelled inside a well-formed database of phrases, fragments and licks, then we can annotate adding specifically the source of the quote and a double asterisk: **S(1,0,0)****.

4. ANNOTATION EXAMPLES

4.1 Sonny Rollins solo on “St. Thomas”.

Score analyses with brackets and annotation definitions. (We also use colors to help identify the constituents Segment=green, Lick=red, Phrase=blue):

Sonny Rollins St. Thomas

37 Dmaj7 F#-7 B7 E-7 A7 Dmaj7
 41 F#-7b5 S2a B7 E-7 A7
 45 D7 Gmaj7 G#o7 A7 Dmaj7 P2
 49 Dmaj7 F#-7 B7 E-7 A7 Dmaj7
 53 Dmaj7 F#-7 B7 E-7 A7 Dmaj7 S3 L6
 57 F#-7b5 B7 E-7 A7
 61 D7 Gmaj7 G#o7 A7 Dmaj7 L3ra L7e2
 65 Dmaj7 F#-7 B7 E-7 A7 Dmaj7 P3
 69 Dmaj7 F#-7 B7 E-7 A7 Dmaj7 L8 L8a
 73 F#-7b5 B7 E-7 A7 L9 L10
 77 D7 Gmaj7 G#o7 A7 Dmaj7 L11 S2r
 81

Annotation:

- 1.1 - 1.4; S(1, 0, 0)
- 2.1 - 2.4; S(1, 0, 1)
- 3.1 - 3.4; S(1, 0, 2)
- 4.1 - 5.1; S(1, 0, 3)
- 5.2 - 5.4; S(1, 1, 0)
- 6.1 - 6.4; S(1, 1, 1)
- 7.1 - 7.2; S(1, 1, 0)
- 7.3 - 8.1; S(1, 1, 2)
- 8.2 - 9.1; S(1, 1, 3)
- 9.3 - 13.2; L(1, 0, 0)
- 13.1 - 13.3; S(1, 2, 0)
- 13.3 - 13.4; S(1, 2, 1)
- 14.2 - 14.4; S(1, 2, 2)
- 15.1 - 17.1; S(1, 2, 3)
- 17.1 - 17.4; S(1, 0, 0)
- 17.4 - 18.2; S(1, 0, 1)
- 18.2 - 18.4; S(1, 0, 2)
- 19.1 - 19.4; S(1, 0, 3)
- 20.1 - 21.2; S(1, 0, 4)
- 21.3 - 24.4; L(2, 0, 0)

- 25.1 - 32.1; P(1, 0, 0)
- 31.4 - 32.1; S(1, 3, 0)
- 32.3 - 33.4; L(3, 0, 0)*
- 34.2 - 35.4; L(3, 0, 1)
- 36.1 - 37.1; S(2, 0, 0)
- 37.3 - 37.4; S(2, 0, 1)
- 38.3 - 39.4; L(4, 0, 0)
- 41.1 - 42.4; L(5, 0, 0)
- 44.1 - 52.1; P(2, 0, 0)
- 53.2 - 53.3; S(3, 0, 0)
- 54.2 - 57.2; L(6, 0, 0)
- 57.4 - 59.4; L(7, 0, 0)
- 60.1 - 61.4; L(3, 1, 1)
- 62.1 - 63.4; L(7, 0, 2)
- 65.1 - 69.3; P(3, 0, 0)
- 69.4 - 71.4; L(8, 0, 0)
- 72.1 - 73.1; L(8, 0, 1)
- 73.3 - 74.4; L(9, 0, 0)
- 75.1 - 76.4; L(10, 0, 0)
- 77.1 - 79.4; L(11, 0, 0)
- 80.1 - 81.1; S(2, 1, 0)

4.2 Charlie Parker solo on "Au Privave".

Score Analyses:

Au Privave
 (Charlie Parker's Solo Transcription)

4 D7 D7 Am D7
 5 G7 D B7 Seg1
 9 Em A7 D7 Em A7 Seg2response
 13 D7 G7 D7 Am D7 P2
 17 G7 G7 D7 F#m B7
 21 Em A7 L2*(Manterion) Seg2response
 25 D7 G7 D7 Am D7 L3 L4
 29 G7 G7 D7 F#m B7 L4response L5 3
 33 Em A7 D7 Em A7 L6 L7
 37 D7

Annotation:

1.1 - 3.4; L(1, 0, 0)
4.4 - 5.3; S(1, 0, 0)
5.4 - 6.3; S(1, 0, 1)
7.1 - 11.4; P(1, 0, 0)
12.4 - 19.4; P(2, 0, 0)
20.1 - 23.1; L(2, 0, 0)*
23.2 - 24.1; S(2, 0, 0)
24.2 - 25.1; S(2, 0, 1)
25.2 - 27.4; L(3, 0, 0)
28.1 - 29.4; L(4, 0, 0)
30.1 - 31.1; L(4, 0, 1)
31.4 - 33.1; L(5, 0, 0)
33.3 - 35.4; L(6, 0, 0)
36.1 - 37.4; L(7, 0, 0)

4.3 Comments on the 2 solos

For this paper we analyzed 2 solos from different periods of jazz and from different players. We see a much longer solo on Sonny Rollins, as it is later hard bop period, and he is thus able to expand into thematic development, while Charlie Parker takes a much shorter solo on the blues but he is the one who presented the new bebop language that forms the basis of modern jazz improvisation to this day. He doesn't refer back to himself like Sonny was able to do later on, he introduces new ideas and also plays one of his favorite phrases on the double time that since then has become a sort of parkerism for the jazz community. We have a sense that Parker was able to play so much "music" in a very short solo, while Sonny on a longer solo creates movement, interest and innovation by his thematic development approach.

We see how Sonny Rollins uses the opening segment to built thematic development in many instances of the solo, not only as related segments, but also as part of licks and longer phrases. These elements mark a great development in the syntax and the story telling of a jazz solo.

Both players share the love of the blues, a very basic element in jazz improvisation and their both have a great swing "feel".

Many of the above segments, licks and phrases are part of the jazz vocabulary of today and we witness here the development of jazz from two masters of their art, who among others defined the language and also created a very strong personal voice.

5. METHODOLOGY DISCUSSION

5.1 Sequential information (Thematic development)

Identifying locations in time for each element provides the structural skeleton that can support future automation of such analyses and AI-system-generated thematic development.

For example a sequence may proceed as:
Segment, answer, answer, lick, related segment, answer, repeat, original segment, new lick, new segment, answer,

phrase(that may or may not contain previously introduced segments or licks), first lick reference, answer etc.

Codification of sequential development may also find applications in speech analysis and several temporal art forms.

5.2 How to call and answer

There are plenty of instances of this paradigm in improvisation. What we would learn is the transformation function that takes us from the initial structural element (such as the segment, lick, or phrase) into the response. Similarity or contrast can both form the basis of a question/answer procedure.

We also have information that describes the sequence of the responses so we could learn how the first response differs from the second, or the third, and so on. For example, in the first 4 measures of Sonny Rollins on St. Thomas we see there is an initial segment, a response segment, a 2nd response segment, and a third response segment. In this example each response has more notes than the previous. Such trends are learnable.

5.3 Transformations or referencing and embellishing

This has similarities to the call / response paradigm. However, a reference to a previous element is not necessarily a "response" but can serve a different thematic structure function.

Repeated phrases: here we either annotate as the same segment/lick/phrase, but in the case of small alterations to the original then this again is mapped as reference and answer.

5.4 Hierarchical

Three examples to look out for:

- a) Combine segments to create licks
- b) Combine licks to create phrases
- c) Freely combine all three elements

While there are instances where a lick or phrase is made of smaller elements, not every lick or phrase can be described this way. Often, licks and phrases are original and do not reference other elements.

5.5 Structural interchange

Cross-reference among the three identified structural elements provides another means of thematic development during improvisation. Our analytical approach can capture this feature through double annotation on the specific bar or bars. See, for example, the end of Lick1 and Phrase1 on the Sonny Rollins solo where he ends restating the 1st segment idea.

5.6 Voice leading concept

In be-bop, hard-bop and modern jazz styles voice leading is frequently used to end or connect licks, phrases and themes. In a more open, modal or free playing this is not so evident. Rather, harmonic tension, sound, articulation

and note density within phrases provide the most important cues. We anticipate that an upcoming multi-layered mapping will address this issue.

5.7 Emotion and creativity

Emotion: A common mechanism in music, also employed here, is creating patterns of tension and release that play with the listeners' expectations.

To what extent something can be characterized as interesting or emotional is contingent on what preceded it and what, eventually, follows. A player known for a specific style or mannerism – say, a linear approach – can inhibit expectations by switching to a vertical approach, or by inserting unexpected pauses, long notes, or sound effects. Variations such as these that increase interest and elicit affective responses are manifestations of the performer's creativity and capacity to unfold a musical improvisation as a compelling story.

5.8 Inspiration

One way to approach “inspiration” could be in terms of compelling, unexpected structures that arise out of randomness. As jazz musicians deal with randomness, if suddenly - in playing or practice - we get a structure/phrase that stands out in terms of being memorable or highly organized/structured then we recognize this as inspiration that usually becomes a new composition or a favorite mannerism.

5.9 Thematic development and multi reference

References to previous elements, whether as straight repeats or augmented, diminished, displaced, or otherwise modified, can be considered a form of self-reference. Feeding a database of such manipulations and thematic developments to machine learning algorithms can support the development of AI systems that exhibit self-referential behavior and, by extension, apparent self-awareness.

6. CONCLUSIONS

We have proposed an analytical method that supports systematic annotation of a wide variety of jazz solos and can reveal the musical language characteristics of individual players and styles. The annotated constituents per solo will eventually feed a database of musical segments, licks, and phrases that can imply and outline a specific chord or a longer harmonic progression. We anticipate that this database will enhance the “bag of tricks” of the jazz player and help the jazz educator explain jazz styles, performers' personal voices, and characteristic mannerisms.

In jazz, performers always strive to develop a personal voice that can stand next to that of the masters. The knowledgeable player or listener can usually identify, after only a few notes, a master performer who has developed language and mannerisms that are immediately evident.

A personal voice consists of sounds and sound structures with certain recognizable and personal qualities that function as a performer's signature. The mappings supported in this study can help reveal and codify these signatures and organize them into systematic categories.

Further work is required to better define stylistic constituents, flexible enough to codify a broad range of styles and personal voices. As we proceed, we will seek the insights of top jazz improvisers, worldwide, and assess the resulting database through AI machine learning and performance.

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