Annotating works for music education : propositions for a musical forms and structures ontology and a musical performance ontology

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ANNOTATING WORKS FOR MUSIC EDUCATION: PROPOSITIONS FOR A MUSICAL FORMS AND STRUCTURES ONTOLOGY AND A MUSICAL PERFORMANCE ONTOLOGY

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ABSTRACT

Web applications and mobile tablets are changing the way musicians practice their instrument. Now, they can access instantaneously thousands of musical scores online and play them while watching their tablet, put on their music stand. However musicians may have difficulties in getting appropriate tips and advice to play the chosen piece correctly. This is why we conceived a collaborative platform to annotate digital scores on tablets in previous work. However, we noticed that the current Music Ontology (MO) do not allow to tag these annotations appropriately. Thus, we present in this paper a proposition for a Musical Forms and Structures Ontology (MFSO) and a Musical Performance Ontology (MPO) based on music practice. A construction methodology and a model are first detailed. Then, a practical use case is presented. Lastly, inherent theoretical and practical difficulties encountered during the ontology framework's conception are discussed.

1. INTRODUCTION

More and more musicians share their scores and performances on dedicated Web platforms such as free-scores.com or musescore.com. Meanwhile music applications dedicated to scores management are ported to tablet devices (Tonara™, Musescore™, Finale Songbook™). However, musicians still do not dispose of appropriate tools to demonstrate their know-how on these scores: how to play this difficult part? Which fingering should I use? This is why we designed a collaborative score annotation service working on tactile tablets [1]. It allows users to illustrate abstract scores with multimedia content showing tips, exercises or questions directly linked to the concerned notes on the score. We also proposed a matching analyzer to automatically determine a score difficulty level [2]. But in order to suggest relevant annotations to performers, we need to tag the latter appropriately. Indeed, musical know-how is contextual: it relates to a specific piece with its structure and mood. But most techniques can be reused in similar contexts with appropriate adaptations. Thus, correctly contextualized annotations could be reused on different pieces sharing similarities (genre, composer, patterns, etc.). It would also enable complex queries on instrumental issues (for instance: how to play scales? how to produce a soft but expressive sound? what is the best strategy to learn a piece by heart?).

We could rely on social tags created by users (i.e., Folksonomies [3]). However, as noted by Sordo in his experiment on musical genres and moods [4], the emerging vocabulary is not always reliable, especially on very specialized terms. Considering our educational context, reliability and accuracy are essential. These led us to a controlled vocabulary based solution, with extension and adaptation possibilities according to the considered case.

To do so, we propose to extend the existing Music Ontology (MO) [11] with a Musical Forms and Structures Ontology (MFSO) and a Musical Performance Ontology (MPO), through a global Semiotic Annotation framework (SA) (Figure 1). While the MO is dedicated to musical resources and events description for databases, the MFSO focuses on musical works structure analysis, and the MPO on performances and instrumental techniques. However, if the MO and MFSO can be used to relate objective facts about music, the MPO deals with subjective approaches of a given piece. This is why we embed it in a SA. We explain and justify the use of this Sign-based framework in the next section. We then present our ontological propositions in the third and fourth section. A simple use case is detailed in the fifth section. Lastly, we discuss the difficulties we encountered in our attempt to organize musicological and practical instrumental terms.

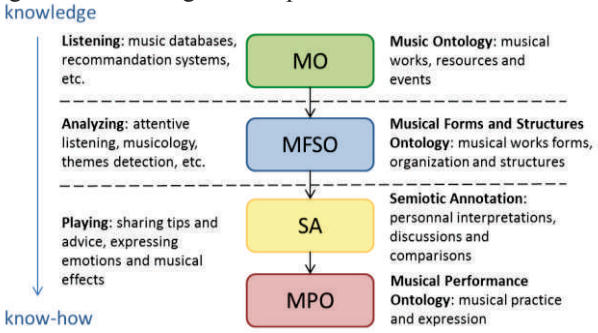

Figure 1: Musical Ontologies global organization and roles.

2. SEMIOTIC ANNOTATIONS ON WORKS EXTRACTS

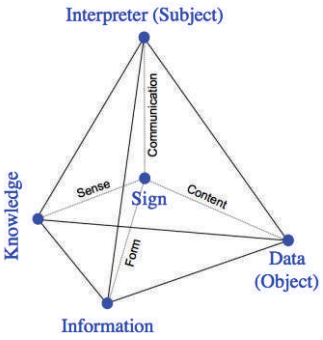

Figure 2: Sign tetrahedron.

Music, as any other artistic field, deals more with interpretations than with formal knowledge. What makes it interesting is that different artists produce different performances, somehow recognizable, even if they play the same piece. But explaining these differences and how to produce them is a delicate task. Common formal representations are not suited to do so for two main reasons. The first one is that textual descriptions cannot really convey emotions and gestures, even if they are important for search engines and knowledge bases. The second one is that they are not adapted to share subjective interpretations. For instance, the comment "I think that the 53421 fingering is more supple for small hands" is difficult to represent accurately into a machine language for the time being.

To overcome these issues, we propose to manage Signs rather than Knowledge. A Sign is a subjective communication object composed of a *content* (images, gestures, writings, sounds), its *form* (structure, organization, context) and its *sense* (interpretation, meaning) from a *subject* point of view at a given time [5]. For instance, a symbol is a particular type of graphical Sign, i.e. a form shared among a group of people. But a Sign can also be a simple gesture (e.g., a nod), with various meanings according to its context (historical, or cultural). In artistic fields, where practical know-how is essential, Signs are essential to communicate different interpretations. To manage Signs in an information system, we link each of their components to a digital element. Contents can be embedded in multimedia *data* (audio, video), form can consist in its contextual *information* (metadata, localization, selection), and sense consists in *knowledge*, represented by a textual comment or a semantic description for the machine (i.e., tags from a structured vocabulary). As shown on Figure 2, the Sign object can be represented as a tetrahedron [5].

We define a Semiotic Annotation (SA) framework to capture these Signs on collaborative annotation platforms. Figure 3 presents the proposed model for Semiotic Annotation. To insure its integration to the current Semantic Web, the SA model is linked to top-level ontologies. The FRBR ontology allows addressing creative works and their different parts. Indeed, to create contextualized annotations, we need to address precise parts of the discussed *Work*. A *WorkPart* can be any entity which is a part of another entity. We note that a *Work* or a *WorkPart* exists independently from its different *Expressions* and *Manifestations*. For instance, the first *Verse* (*WorkPart* resource) in the *Frères Jacques* canon (*Work* resource) can be discussed without reference to a particular performance of the tune (*Expression*), recorded on a particular

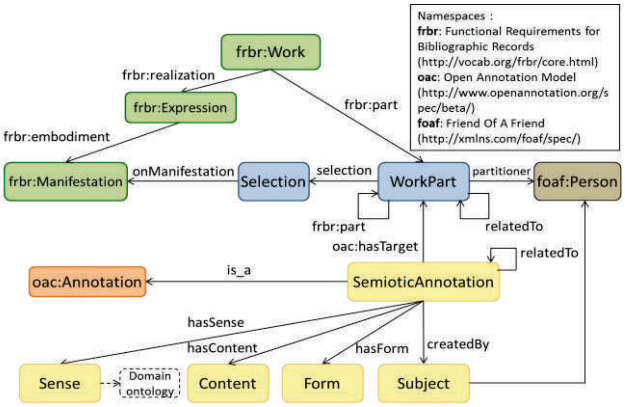

Figure 3: Semiotic Annotation model.

album (*Manifestation*). This is why we introduce a *Selection* concept to isolate the concerned *WorkPart* on any embodiment of a *Work*. For example, in the musical field, it can be:

- an extract of a MusicXML score: $[n_1,n_2,\ldots,n_n]$, where n_i are <*note*> elements defined by their bar number m_i and their order of appearance k_i in this bar (m_i,k_i),
- an area of a PDF score: $[(x_1,y_1),(x_2,y_2),\ldots,(x_n,y_n)]$, where each (x_i,y_i) defines a summit of a selection polygon on the area of the score,
- an extract of a video performance: $[t_1,t_2]$ where t_i is a timecode of the video and $t_1<t_2$.

Naturally, a *WorkPart* resource can be composed of other *Workpart* resources thanks to the *frbr:part* relation. We also take into account the fact that different users may identify structures differently on a given piece. For instance, different musicologists will not necessarily identify the same structures, according to their respective interests (global structure, harmonic, rhythmic patterns or themes expositions). We thus introduce a *partitioner* relation to specify the person who extracts and names the part. This person is not necessarily the one creating the annotations afterwards, as structuring pieces and annotating them can be distinct activities. Our model also allows to link similar parts. To do so, the *relatedTo* relation can be specialized into more specific relations to indicate how different parts relate to each other (see application to the musical field in the next part). To name the part appropriately, a taxonomy may be helpful according to the considered field (e.g., the Musical Forms and Structures Ontology in the case of music). Once the part has been clearly extracted and identified, it can be annotated. Thus, a *SemioticAnnotation* concept is proposed, including the different components of the Sign (content, form, sense, according to a subject) presented previously. The sense component can be linked to a domain ontology in order to provide a semantic description of the SA for further processing. Of course, the subject is the creator of the SA, which conveys his personal interpretation. Our SA is perceived as a specialization of the *Annotation* concept from the Open Annotation Model already in use in several applications (Utopia[1], YUMA[2] framework). However, the SA is more centered on interpretation comparisons. This

[1] http://getutopia.com/index.php, visited on the 06/05/2013.
[2] YUMA Universal Media Annotator : https://github.com/yuma-annotation/, visited on the 06/05/2013.

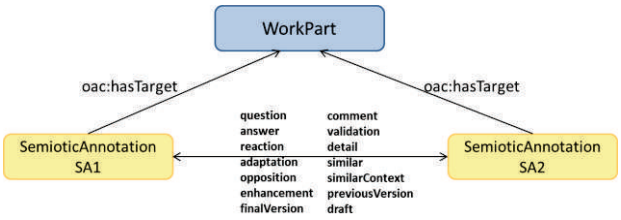

Figure 4: Relations between two Semiotic Annotations.

is why we also define relations to characterize adaptations, oppositions, and enhancements of SA. A SA can also simply be a reaction to another SA, such as an answer to a question, or a comment. Users can also keep a trace of their thought process by using versioning mechanisms on their annotations. Indeed, constructing an interpretation is generally an iterative process, where the subject enhances his performance with training and feedback. These relations are detailed in Figure 4. The main purpose of such annotations is to steer, organize and share helpful know-how emerging from practical cases.

This model can be applied to the musical field by replacing the *frbr:Work* concept by the more specialized *mo:MusicalWork* concept. The *WorkPart* concept will thus become the *MusicalWorkExtract* concept (which is not part of the current MO). But in the musical field, it is important to name the detected parts when possible. For instance, a user could identify a *Chorus*, a *Verse*, a *Fugue Theme*, a *Variation*, a *Leitmotiv*, a *Bass* part, a *Canon Verse*, a *Solo*, a *Musical Bridge*, etc. This is why we propose a conceptual model for a Musical Forms and Structures Ontology.

3. A MUSICAL FORMS AND STRUCTURES ONTOLOGY

Not to be confused with its genre, the form of a musical piece refers to its global organization and instrumentation [8]. For instance, the concerto form has three movements and features a solo instrument. A form sometimes implies the presence of significant structures. For example, a fugue necessarily contains a main theme, which will be exposed at each voice, and then developed, inversed, transposed in successive stretti. Besides, most basic structures have a type but not necessarily an explicit name (e.g., phrases, motifs, scales, arpeggios). While musical genres and moods are regularly studied in the MIR literature (for instance [6] or [4]), musical forms and structures are less discussed. Indeed, the latter are rather addressed in musicological contexts and remain unexploited in music recommendations systems and scores sharing communities. Thus, we design a basic framework for a Musical Forms and Structures Ontology (MFSO) to back up our Musical Performance Ontology with appropriate musicological terms. As noted in an analog work on a Musical Genres Taxonomy [6], achieving objectivity is a difficult task in a musical context. Concerning forms and structures, even specialists do not agree on some terms (see discussion). This is why we only provide high-level concepts for the time being, which are easier to differentiate, are well documented in musicological treaties such as [8] and largely used by musicians.

Our MFSO is thus designed to characterize any musical work and its extracts (Figure 5). A Musical Work can have a Musical Form (e.g., Sonata, Fugue, Song, Canon, etc.). This form can be linked to a characteristic genre (e.g., Fugues and Sonata are generally associated to classical music), but there may be exceptions (e.g., classical structures in symphonic rock). As pointed out previously a form can also be linked to its characteristic structures. These two links (*typicalOf* and *hasStructure*) do not aim at restricting the annotation possibilities, but rather at suggesting appropriate terms to the annotator, from basic metadata. For instance, the title of the piece may indicate its form (example: "*Sonata KV545*" by Mozart) which allows the annotation service to suggest appropriate structures to the user (example: *Exposition*, *Development*). But a musical extract does not necessarily have a name. This is why all named structures inherit from the generic *MusicalWorkExtract* concept. A *MusicalWork* resource can contain several *MusicalWorkExtract* resources. These extracts may be imbricated thanks to the *frbr:part* relation. A musician can detail how an extract is written with the *contains* relation: is it a whole *Phrase*, a *Motif*, a simple *Scale,* or a *Sequence* of *Chords*?

A musical extract can also be labeled. Musicians generally structure a piece by associating alphabetical labels to its different parts. This notation (or codification) allows to clearly distinguish repeated parts (example: ABABC, or ABAB'C meaning B' is almost like B). The *label* relation allows us to link our work to [9], which proposes notations conventions for structure labeling of musical extracts. We insist on the distinction between a notation and an annotation: a notation is a codification (i.e., a representation) of an object, while an annotation is a comment on an object. Thus, they are not related a priori, even if an annotation content can consist in a notation fragment.

The *relatedTo* relation allows to link distinct extracts. It can be specialized in order to express that an extract *introduces*, *concludes*, *imitates, transposes, ornates* or *accompanies* another one. These relations can be automatically associated with specific named structures. For instance, a *Variation* necessarily relates to a *Theme* and should be associated to it via the *variation* relation. Other automatisms can be implemented if a MusicXML representation of the piece is available. Indeed, notes, chords, scales and arpeggios can easily be extracted using the el-

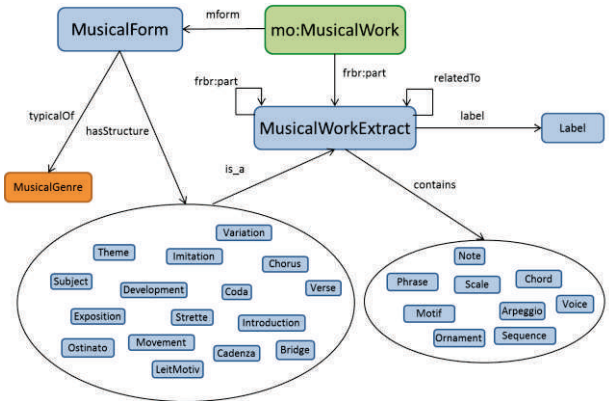

Figure 5: MFSO conceptual model.

ements names (e.g., <chords>) or by detecting regular structures (e.g., ascendant or descendant thirds sequences for arpeggios). Undefined regular patterns are more delicate to automatically identify, even if some works exist on this issue [10]. Some work has also been done on detecting Fugue structures [12]. Now that the part has been extracted and named, it can be annotated.

4. A MUSICAL PERFORMANCE ONTOLOGY

Our Musical Performance Ontology (MPO) aims at tagging Semiotic Annotation appropriately in a musical education context. It intervenes in the sense component of the SA (see Figure 7) to specify what themes are treated by the subject on the annotated extract. This organization has been chosen because the MPO deals with subjective interpretations and advice (emotions, expression, fingerings) rather than verifiable facts (artists, tracks, concerts), as the MO does. Embedding the MPO in a SA resource allows musicians to discuss their interpretations and possibly enhance them. Tagged SA can then be exploited by learning agents to answer complex queries, discover interesting resources, link similar SA, generate exercises or suggest appropriate SA to help a student to learn a new piece. For the time being, our proposition is not meant to be instrument-specific but is highly influenced by our experience at the piano and guitar. However, it is possible to extend it according to other instruments requirements.

The MPO conception methodology is inspired by the Archonte methodology [7]. Recurrent linguistic units were extracted from recorded piano lessons. These units were classified by an identity and differentiation process and each obtained class was labeled (see Figure 6). We then noticed that each label could be associated to one of the main activity of music practice: listening, playing and learning. Thus, we used these three activities to design our MPO concepts tree. This ontology can be used to semantically describe a Musical Expression (listening activity), an Instrumental Technique (playing activity) or an Assimilation Method (learning activity). Naturally, these three concepts are related: an Instrumental Technique produces a Musical Expression but requires an Assimilation Method to be handled by a learner (Figure 7). Besides, the sociologist Megan Winget also highlights Expression and Technique as essential annotation types in her study on musicians' annotation practices [13].

"We will study Espièglerie from Kabalevski. During the learning(6), we should try to keep the playful and light-hearted tone(1) of this little piece. The main work(6) is based on fifths sequences(5).

Concerning text learning(6), there are several parts(5) to consider in this work. There is the first part(5) where the left and right hand(7) play the same notes, namely two fifths(5) (plays(9)). For the right hand(7), we will develop(9) all notes but for the moment, it is better to play(9) only the fifths(5) like this, so that the notes are rapidly assimilated(6) (plays the fifths). One should pay attention to the 2-5 fingering at the left hand(7), which allows to get livelier and lighter detached notes(1). Here is what you should obtain (plays the part), here both hands(7) play at the same time(5).

That's all for the first part(5). This should be rapidly assimilated(6), with the right nuances(4)(1). I played it slowly(3), but it should not be a problem to play it at the right tempo(3) after repeating it 3 or 4 times(6) (plays the fifths at the right tempo). It should be played naturally(6)(1), and by heart(6) as soon as possible because it is rather difficult(6) to move on the keyboard and watch the score(7)(8) at the same time."

1 Sound 2 Harmony 3 Rhythm 4 Dynamic 5 Structure 6 Assimilation 7 Gesture 8 Support 9 Relation

Figure 6: Piano lesson analysis example: extraction and classification of significant linguistic units.

The *MusicalExpression* concept regroups all concepts which deal with musical writing (*Rhythm*, *Harmony*, *Structures*, volume and tempo *Dynamics*) and its resulting *Sound*. Various sound features can be described, such as pitch, duration, timbre, mood and articulation (i.e. legato, staccato). The Structure concept regroups elements from the MFSO previously presented. Indeed, the SA may discuss specific elements inside the selected part. For instance, a musician can extract all occurences of a leitmotiv in a given musical work. This naming task is realized at the *MusicalWorkExtract* resource level, thanks to the *Leitmotiv* concept from the MFSO. An other musician can then annotate one of the occurences and insist on one of its intervals requiring more attention than the others. This time, the structure identification is at the SA level, but still requires the *Interval* concept defined by the MFSO. This is because the second structure identification is more a personal approach of the piece and will not necessarily catch the attention of a musicologist as it does for a performer, who has to "animate" the piece. This approach gives more flexibility to the users, by allowing them to distinguish high level and meaningful structures (theme, phrases) from basic elements (note level). Different relations exist between these musical expression concepts but were not represented in Figure 7 for readability purposes. For example, Duration and Rhythm are strongly related, as extending a note duration (e.g., a fermata) has an impact on the overall rhythmic organization around the note. Identified structures can also be linked to their harmonic (*hasHarmony*) and rhythmic (*hasRhythm*) features. The Harmony concept can be linked to the Chord Ontology[1] to specify the chords at stake in a standardized notation.

The *InstrumentalTechnique* concept allows the musician to tag any instrument-related technical matter. It deals with gestures, movements, fingerings and positions

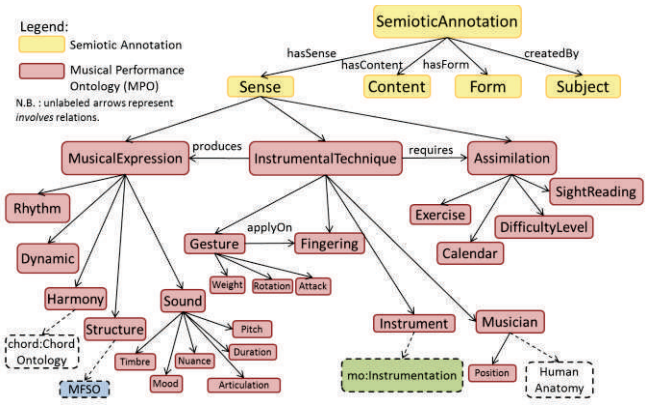

Figure 7: Musical Performance Ontology conceptual model.

[1] http://www.omras2.org/ChordOntology, visited on the 06/05/2013.

which are essential to produce the desired musical expression. As can be seen in Figure 7, an Instrumental Technique involves a musician's limbs or articulations (arms, hands, wrists, etc.) and a part of his instrument (on the piano: the keyboard, the pedals, the white keys, the black keys, etc. in singing: the vocal cords, the lungs, the mouth, etc.). The *produces* relation allows to link a technique to its resulting musical effect. In practice, the *Fingering* concept will certainly be the most used one, as it is one of the most important information for sight-reading musicians. If a MusicXML score of the piece is available, a fingering can be associated to a copy of the annotated extract (MusicXML 3.0 supports <fingering> nodes). Using copies instead of the original MusicXML file allows musicians to propose several fingering solutions for a single part. The idea is to clearly distinguish the basic abstract notation (MusicXML notes, provided by editors) from the concrete annotations demonstrating musical know-how (SA, provided by musicians).

The *Assimilation* concept deals with educational mechanisms, to help a student to handle an instrumental technique. In particular, it aims at providing a framework to create exercises based on rearrangements of the original score. For instance, piano teachers often reduce a part's difficulty by dividing it into smaller parts (i.e. intervals). These elements are repeated three or four times and then grouped by two, by three, etc…gradually increasing the difficulty. We could thus generate the corresponding score for each step of the exercise. Other educational mechanisms can be described in the Assimilation concept: beats counting, sight-reading methods, work calendar, learning by heart, etc.

To have a better understanding of how this ontology can be used and for what purposes, we propose a simple use case in the following section.

5. SA, MFSO AND MPO USE CASE

We propose a fictive use case to study how the proposed SA, MFSO and MPO models can work together. A musician wishes to annotate a score with the following assertions:

- "Here is an occurrence of leitmotiv A. I label it A1."
- "Here is an other occurrence of leitmotiv A. I label it A2."
- "A1 and A2 are almost similar, except A2 is a transposition of A1."
- "Both are based on the following rhythm: eighth – sixteenth triplet – quarter."
- "Beware of the articulation on A1's first note: it is staccato. It must be done with the whole arm to prevent a too sharp attack and prepare for the next position. It is also possible to lightly increase the volume on the ascendant arpeggio. But always keep the solemn mood of the piece."

Figure 8 represents the identified RDF[1] triplets. We highlight the fundamental distinction between the studied objects (the piece and its extracts, described with the MO and MFSO) and their interpretations (semiotic annotations, described with the SA and MPO). The relation between the two leitmotiv occurences (transposition) allows to deduce the type of A2. It also allows to duplicate the explanations given for A1 on A2, as long as tonal dependant concepts are not involved (which is the case here). The "Rhythm URI" resource can be linked to an appropriate rhythm notation resource (e.g., a MusicXML short fragment). Common articulations, dynamics and characters can be suggested in a list to facilitate the semantic description input. The description of the arm gesture remains brief, but will enable to return this annotation for requests such as "how to play staccato?". The content and form components of the SA were not represented in Figure 8 which focuses on semantic description, but can be added by the user. Typically, the staccato gesture should be demonstrated with a video resource (content component). The form component allows the user to select different ways of indexing his annotation. But did the musician use the appropriate terms to describe his interpretation ?

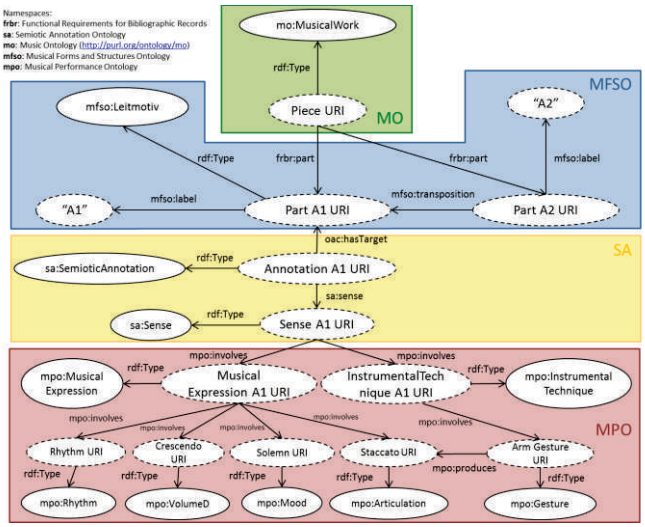

Figure 8: SA, MFSO and MPO use case example.

6. DISCUSSION

As noted earlier, using appropriate words in music is a complex issue, mainly for subjectivity and context reasons. Naturally, musicology also aims at clearly defining terms and analysis methods in this field. But sometimes, musicologists themselves do not agree on appropriate terms to designate structures. For instance, there is a "French school" and an "Anglo-Saxon school" with distinct methods, vocabularies and notations customs.

Indeed, the concept of "rule" in music is complex. There is a framework (mainly the tonal system in occidental music), a history, a culture, an aesthetic which were built over time and various influences, but no definite rule. Thus, the line between form, genre and style can be thin in many circumstances.

Some works exist in order to clarify the manipulated terms meanings and to prevent confusion in musical writ-

[1] Resource Description Framework.

ings, such as the GDRM[1] initiative at Laval University. But the most important factor is the context of use. For example, the "pedal" can either designate a long bass note, or a part of the piano. This example is especially interesting because, even if the two meanings are distinct, they are somehow related and can explain why the same word is used: indeed, the piano pedal do help to produce a bass pedal in some cases. Both meanings thus imply the idea of a "long resonance". For the time being, we propose to overcome this issue by making a distinction between the concept and its common designation. For the pedal example, we define two concepts: *BassPedal* and *PianoPedal*, having both the designation "pedal", corresponding to the way they are commonly called by musicians.

The difficulty also lies in the interrelation of the defined concepts. As seen in the use case, musicians rarely address one theme at a time, as all musical elements interacts with each other, and the musician should have control on each of them while playing. Providing an extensive semantic description in such case is very difficult. This is why we rely on common concepts and try to establish simple relations between them. But more specific relations can only emerge through intensive use of the annotation platform. This is why we rely on an iterative construction of our descriptive model [14].

Thus, our collaborative annotation platform aims at fostering fruitful debates to help musicians confront their ways of analyzing and practicing music.

7. CONCLUSION

In this paper, we proposed a Musical Forms and Structures Ontology (MFSO) and a Musical Performance Ontology (MPO) to annotate performances and scores semantically. These ontologies aim at extending the standard Music Ontology with musicological and musical know-how concepts. To do so, we first introduced a Semiotic Annotation framework to allow users to describe personal interpretations of musical works and then introduced our MFSO. This allows musicians to name precisely the musical extract to annotate and its role in the work. Musical expressions, techniques and assimilation methods can then be described thanks to appropriate concepts and relations from our MPO. This work notably aims at building a music learning agent which can help musicians to answer complex queries, discover interesting knowledge among large digital scores collections, generate exercises or suggest appropriate SA to help a student on a new piece.

Naturally, perspectives for this work include testing it with musicians of all levels, which will allow us to refine and extend our proposition. To do so, a collaborative semiotic annotation platform for mobile tablets is currently being developed.

[1] http://www.mus.ulaval.ca/roberge/gdrm/, visited on the 06/05/2013.

8. REFERENCES

[1] V. Sébastien, P. Sébastien, N. Conruyt, "@-MUSE: Sharing Musical Know-how Through Mobile Devices Interfaces", *5th Conference on e-Learning Excellence in the Middle East,* Dubaï, 2012.

[2] V. Sébastien, H. Ralambondrainy, O. Sébastien, N. Conruyt, "Score Analyzer: Automaticaly Determining Scores Difficulty Level for Instrumental e-Learning", *Proceedings of the International Conference on Music Information Retrieval*, ISMIR, 2012.

[3] T. Vander Wal, "Folksonomy", *Online posting*, No 7, 2007.

[4] M. Sordo, "Semantic Annotation of Music Collections: A Computational Approach", PhD thesis report, Universitat Pompeu Fabra, 2012.

[5] N. Conruyt, D. Grosser, R. Vignes-Lebbe, "Knowledge Discovery for Biodiversity: from Data Mining to Sign Management", *International Congress on Environmental Modeling and Software*, Leipzig, Germany, 2012.

[6] F. Pachet and D. Cazaly, "A Taxonomy of Musical Genres", in *Content-Based Multimedia Information Access Conference (RIAO)*, Paris, 2000.

[7] B. Bachimont, *Ingénierie des connaissances et des contenus, le numérique entre ontologies et documents*. *(Tr.: Knowledge and contents engineering, digital technologies between ontologies and documents)*, Lavoisier, Paris, 2007.

[8] A. Hodeir, *Les Formes de la musique (Tr.: The Forms of Music)*, Presses Universitaires de France, 2012.

[9] F. Bimbot, E. Deruty, G. Sargent, and E. Vincent, "Semiotic structure labeling of music pieces: concepts, methods and annotation conventions", in *Proceedings of the International Symposium on Music Information Retrieval*, vol. 2, 2012.

[10] O. Lartillot: "Une analyse musicale automatique suivant une heuristique perceptive" *(Tr.: An automatic musical analysis based on a perceptive heuristic)*, *3ème Conférence Internationale Francophone sur l'Extraction et la Gestion des Connaissances*, EGC 03, Lyon, 2003.

[11] Y. Raimond, S. Abdallah, M. Sandler, and F. Giasson: "The Music Ontology", *Proceedings of the International Conference on Music Information Retrieval*, ISMIR, 2007.

[12] M. Giraud, R. Groult, F. Levé, "Detecting Episodes with Harmonic Sequences for Fugue Analysis", *Proceedings of the International Conference on Music Information Retrieval*, ISMIR, 2012.

[13] M.A. Winget, "Annotations on musical scores by performing musicians: Collaborative models, interactive methods, and music digital library tool development", *Journal of the American Society for Information Science and Technology*, vol. 59, no. 12, pp. 1878-1897, 2008.

[14] N. Conruyt and D. Grosser, "Knowledge Management in Environmental Sciences with IKBS: Application to Systematics of Corals of the Mascarene Archipelago", *Selected Contributions in Data Analysis and Classification*, pp. 333-343, 2007.