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# Toward algorithmic composition of expression in music using fuzzy logic

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# TOWARD ALGORITHMIC COMPOSITION OF EXPRESSION IN MUSIC USING FUZZY LOGIC

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## ABSTRACT

This paper introduces the concept of composing expressive music using the principles of Fuzzy Logic. The paper provides a conceptual model of a musical work which follows compositional decision making processes. Significant features of this Fuzzy Logic framework are its inclusiveness through the consideration of all the many and varied musical details, while also incorporating the imprecision that characterises musical terminology and discourse.

A significant attribute of my Fuzzy Logic method is that it traces the trajectory of all musical details, since it is both the individual elements and their combination over time which is significant to the effectiveness of a musical work in achieving its goals.

The goal of this work is to find a set of elements and rules, which will ultimately enable the construction of a generalised algorithmic compositional system which can produce expressive music if so desired.

## Keywords

Fuzzy Logic, Music Composition, Musical Expression, Algorithmic Music.

## 1. INTRODUCTION

This paper outlines concepts being used to construct a new theory of a musical work, which explicitly considers expressiveness. This will ultimately inform the development of a new compositional tool which can be implemented in any instrumental format: existing or newly designed physical or virtual instruments. There remains considerable work in refining the model, and ultimately build the Fuzzy Logic compositional system.

My concern is to reduce the number of micro level compositional decisions I need to make, through the use of an algorithmic compositional system which can produce expressive music if so desired. In order to do this I need to determine what compositional elements contribute to expression, and the means by which these elements combine to produce expressive music.

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The algorithmic compositional system I am developing is based on Fuzzy Logic principles both as an analytic tool to derive inputs to the system, and also ultimately drive an automated Fuzzy Logic decision making/control system. My concern is to build a system which can produce aesthetic results, that is, works of art, from new compositional ideas and uses of technology.

Significantly, in this conceptual model, ambiguity in the music itself is maintained while Form is replaced by synchronicity of unfolding processes. During conventional music analysis, two things occur which remove ambiguity. The first is the requirement that those elements considered significant (such as a chord) to be precisely and uniquely defined. The second is that some elements of the music are considered not worth analyzing, yet this introduces a very subjective element into music analysis.

The goal of my conceptual model is to develop a means to implement expression in algorithmic music applicable across all genres of music, including acoustic music and computer music.. This could potentially become a completely new compositional method explicitly incorporating expression, or simply a new way of thinking about music that will allow the incorporation of expression into other algorithmic music.

It is evident that although the term "expression" is used continuously and widely in connection with music. Examples range from the name of this conference "New Interfaces for Musical Expression", or in numerous books and articles on music ranging from an essay on Mozart Operas [3] to a book on teaching composition [11] to a history of the string quartet [10] to the current article on 'Expression' in *Groves Online* [4]. Yet determining what the word actually means becomes a foundational problem when viewed from the composer's perspective.

## 2. CONTEXT

### 2.1 Expression in Music

The current article on "Expression" in *Groves Online* [4] clearly articulates the fundamental question regarding the use of this terminology. "In the simplest sense expression is applied to elements of a performance that depend on personal response and vary between interpretations. It is not clear how this use of the term relates to the concept that occurs in some music criticism...What does it mean to say that a piece of music has expression...?"

The problematic use of the word in musical discourse, and its confusing status in relation to compositional input is exemplified by items in other well known music dictionaries.

[12] [20]. While other musicologists extend the expressive role of composer unambiguously beyond that of determining rhythm and pitch, to include Form as an expressive device [3] [10].

Finally, Roger Scruton in *Groves Online* categorically states that it is impossible to give rules for expression because all the features of music are responsible for its expressive powers, so cannot consider factors in isolation. "It is therefore difficult to say, in advance of a particular case, which features can be altered with impunity, and which are vital to the effect." [21].

Scruton's summary provides clear support for my Fuzzy Logic Compositional Model which is inclusive of all musical features. Consequently, my work is premised on the basis that it is possible to generate rules for expression through using my Fuzzy Logic method.

## 2.2 Aesthetics

Musical art is a sounding phenomenon, taking place through time, it is neither the score itself, nor its initial concept. Consequently, experimental methods that explore new compositional ideas or uses of technology do not necessarily, in themselves, produce aesthetic results. Once tools have been invented, ways of using them to create works of art need to be developed.

This aesthetic requirement provokes a number of questions including issues concerning what music intrinsically requires to be intelligible, meaningful, coherent and expressive?

"Music as it appears to the analyst and the listener might not be quite the same thing. The relationship between the two is one of the most problematic issues...in music analysis" [8]. Or as Susan McLary puts more graphically: "How is it that particular images and responses are invoked by specific musical details, yet examining scores and pitch class sets does not lead to the discovery of meaning." [14]. There are, however, many attributes of Fuzzy Logic which make it a very useful method for unpicking some of these knots.

## 2.3 Methodological Issues

Discussion about music, music theory and analysis, including its techniques, its description, critiques, and instructions to performers are very often described in words. Common musical notation is an attempt at precision, but even some elements of notation are vaguely defined. While words themselves have relative meaning, there is no absolute meaning of 'loud' or 'cantabile' or < or  $\curvearrowright$ . Fuzzy Logic has been formulated specifically to deal with the imprecision and 'vagueness' which is present when using natural language descriptors.

A significant feature of music is that the aesthetic outcome is often more than the sum of its technical elements. Indeed, what is the role of timbre, attack, duration, decay, articulation, spatialisation, register, texture, voicing, entries and timing, rhythm, tempo or meter? What does musical form, structure, or process contribute? In fact, it is often the means and details of the interactions between the distinct elements which significantly influence the effectiveness of the whole work. This means music is, technically, a non-linear system. "Non linear systems are systems that cannot be mathematically described as the sum of their components." This behaviour can be observed across a variety of disciplines including biology and economics as well as physics. [1]. It is important that the modelling methodology allows for all these attributes while itself being rule bound, with evolutionary decision making, thus providing for variation in the elements and their combination over time. Fuzzy Logic is good for modelling

non-linear systems as little prior knowledge of the original system is required [13].

Clearly, music is an excellent domain in which to apply Fuzzy Logic. The requirements set out by Babbitt [2], that any musical theory be logical, coherent, useful, and intelligible are also met by Fuzzy Logic Principles.

## 3. LITERATURE REVIEW

Very little work has been done in the detailed application of Fuzzy Logic to modelling music composition, although there are several papers which outline the need for this work, without providing a rationale for using Fuzzy Logic as a methodology [24].

Milicevic has published a series of papers for example [16] [17] Each paper is a reframing of the same idea as new philosophical frameworks become available. One of his papers uses some elements of Fuzzy Logic as the means to advance his argument [18]. His concept of pattern matching as data is input is very similar to Fuzzy ART [7], even though this is not specifically mentioned by Milicevic.

Several composer/programmers have incorporated Fuzzy Logic into their work [6] [9] [22]. Although the software only deals with a small number of very specific musical elements, this work can potentially be developed into complex algorithms for a large range of musical elements. Yet, more significantly, these composers have not engaged here with the concept of modelling musical systems from an aesthetic perspective.

## 4. PROTOTYPE THEORETICAL MODEL

### 4.1 The Composer's Viewpoint

The framework outlines the range of decisions made by a composer when starting and continuing work on a new piece of music. This framework and its information flows is shown in Figure 1.

This framework allows for assessment at several levels, the construction of a broad range of Western music through two lenses simultaneously. Firstly, the detailed elemental perspective, that is the construction of the individual sound events in each piece of music. Secondly, the time domain perspective, that is how all these elements, and their variations, change and combine over time. Composers already do this kind of multidimensional thinking as an intrinsic part of their work. What differs from composer to composer and style to style, is the amount of, and which details in one or other of the dimensions they concern themselves with, the remainder being left to compositional algorithms.

The terminology I am developing has been generalised away from traditional analytical terms which originate from notational foundations. My terminology covers the chief characteristics by which sound itself is shaped and processed through compositional decision making. Terms, such as 'articulation: discrete', which describe the elemental details of the music, have been used to generalise characteristics across both acoustic and computer music domains. Thus the term 'sound events' is used instead of 'note' so that the palette of sounds available in computer music, which are likely to be unpitched, and a-rhythmic, can be accommodated. It is likely, however, that further refinement of both terminology and model will take place as more music is analysed using these principles.

The framework starts from the pre-definition of a sound source, i.e. initial timbre, has been identified, then two possible types of treatment can occur. The first set of treatment decisions relate to the segmentation of the timbre itself, both through time (for example, creating rhythm) and through frequency space, or register (for example, only using the middle octaves of the piano, or using a hi-pass filter). The second set of treatment decisions made by the composer relate to changes which are externally imposed onto the timbre. That is the changes have no origin in the timbre itself. These include changes to the density of the sound (for example, by placing a solo passage in a concerto, or by making the spectrum of a sound more complex), changes to the amplitude levels, and changes to the location of the sound source in performance. By implication these factors together describe the texture of the music, and in their entirety will also determine the Form.

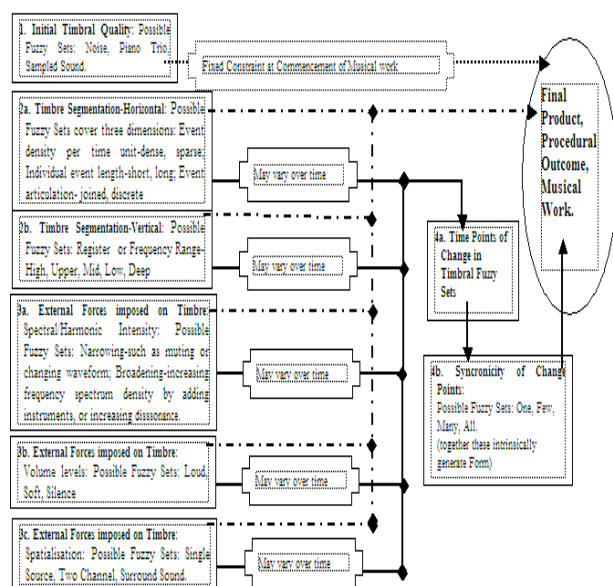


Figure 1: Conceptual Model of Composition

## 4.2 Musical Form as Process

It is tempting to fall into the traditional theoretical mode of searching for, and identifying, Form, as a significant structural mould into which the musical elements are made to conform. However, Form can be reconceptualised as simply reflecting the processes by which both the individual sound events, and the relationships between these elements, change over time.

While typical terminology on Form implies an unspecified time domain, the difficulty in defining formal sections in so many pieces of music indicates that finding a generalised way to describe how elements and combinations vary over time may be more useful, particularly for algorithmic composition of expression in music. Consequently, identifying these processes and interactions which create the evolutionary trajectory of the music as the details unfold (which means deriving the connective grammar) becomes another significant goal of theoretical modelling of a musical work.

Other theorists, for example Meyer [15], have suggested that process is a significant part of musical expression. At this meta-level of process, the Baroque theorists [5] [19] [23] were also in accord when it came to particular musical genres such as

the Lament, where the expressiveness was thought to arise from the changing harmonic relationships which evolved as the melody line and chorus moved in relation to the repeated ground bass.

A significant feature of my analytical model is the inclusion of the time points of change in all the various attributes, as a preliminary to an overall assessment of how much change is occurring in the music from time to time. The rationale for measuring the amount of change arises from the conceptual framework of both the compositional process and the resulting product, which underlies this theoretical method.

The significant point is the organising principles, themselves, are constant across all types of music, but the emphasis varies from one types of music to another. Various styles or genres can be distinguished by examining which treatments are significant in the organisation of that music. The organising principles, which can be viewed at least three different levels to allow possible significant patterns and interrelationships to emerge.

There is the primary level, or the detail of how the sounds are actually placed through time, then there is the second, meta-level, of the patterning over time of the various attributes of those sounds. Finally, then, there is the meta-meta-level of the timing of the changes in attribute patterns both individually and in relation to each other. From a practical perspective, from the listener's point of view, actual musical Form is produced by the way these changing patterns materially interrelate over time. This then is the final step of this model, which groups the changes into Change Fuzzy Sets relating to the total number of concurrent changes and consequent significance of the changes as they occur in relation to one another over time.

## 5. FUTURE WORK

The prototype model of a musical work is a tentative first step, which has already highlighted some important issues which may require detailed investigation in order to allow my research to progress to a useful and functional conclusion in the form of a compositional method. These issues include: the further refinement of an appropriate feature set and terminology, as well as their interaction through a connective grammar, to allow implementation through a Fuzzy Logic control system.

At this stage, the model of a musical work makes no comment on the amount of expressiveness, or otherwise, in a particular piece of music. However, the model has been developed with the view to future examination of the contention that expressiveness is influenced both by the actual musical elements themselves, as well as the amount and significance of changes over time.

## 6. CONCLUSION

The goal of my work is to find a set of elements and rules, which will ultimately enable me to construct an algorithmic compositional system which can produce expressive music if so desired. In order to do this I need to determine what compositional elements contribute to expression, and the rules by which these elements combine to produce expressive music.

In conclusion, it is clear that music composition is an excellent domain in which to apply fuzzy logic. As discussed previously, musical discourse is filled with imprecise terms. The most striking thing about Fuzzy Logic is its ability to

contain, and work with, imprecise or 'vague' concepts, hence its immediate applicability to musical discourse.

Although score based analysis is an established method, it focuses primarily on pitch and harmony, while either ignoring or giving secondary attention to other musical elements. However, my Fuzzy Logic method traces the trajectory of all individual musical details and their interactions. This is important since it is both the individual elements and their combination over time which are significant to the effectiveness of the music in achieving its goals. My Fuzzy Logic method takes the actual state of affairs at any moment, with all its ambiguity, as its primary building blocks, creating the Form as overall trajectory of the combination of these building blocks. This means that the conceptual model when fully developed will be easily implementable into a generalized compositional decision making system using Fuzzy Logic controllers.

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