"… Or does it actually tell time? Time-related methodological reflections for music information systems "

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Abstract

After having been involved in music information management design for 14 years, I am still searching for the ultimate design. Thus, presently, my work has involved looking at the methodologies used for designing systems and data structures. Obviously the central question before starting to design any music application is how to represent music internally and furthermore, how to represent time. In order to understand the complexity of these questions, it can be helpful to initially look at music representation schemes outside of the digital world: music notations or text encoding in the pre-computer age. A look at current available schemes will show how much of this functionality is presently supported and functional and timing aspects of music representation schemes are defined. The pros and cons of specific design choices and methodologies are outlined. This paper is part of this work and looks specifically at issues around temporal aspects of music representation.

Keywords: notation, data structure, representation, time

1. Representations of time

The representation of time inherently influences our understanding of music and the creation processes in making music. Different notions of time have been defined in the recent past, amongst them a) musical time being a subset of real time, with similar behaviour and function (Marsden, 2000); b) musical time being different from real time: real time being composite, and fragmentary, as well as heterogeneous and musical time being perceptible. (Langer, 1953; Kramer, 1988; Honing, 2001; Christensen, 1996); c) Mathematical, logic and computational models (Rescher & Urquhart, 1971; Galton, 1987; Van Benthem, 1983; and Gabbay, Hodkins & Ryenold, 1994); and d) with a differentiation between tempo and time, specifically from a performance research perspective (Clarke, 1999; Gabrielsson, 1999; and Honing, 1993)

Pragmatically seen, there are differences between the time in real life and time in the realm of music. Time in real life, or how we understand time, is linear never-ending progress,- if we ignore Langer's arguments of fragmentation due to unconscious time spans present in our daily lifes. Time within the domain of music includes the notion of having different times running simultaneously and within each other and dependent or independent of each other. This time can be relative or absolute, but both perceived within a work and not within a lifetime of the person experiencing this time. In this way, "musical time" can be seen to be a subset of our experienced real time: it has similar characteristics as our time, but it is being used in a more abstract way and with a notion that composers and listeners and performers can "play" with it in the variability available and allowed to them. Or as Langer describes it: "The primary illusion of music is the sonorous image of passage, abstracted from actuality to become free and plastic and entirely perceptible". Notions that music has an explicitly made time structure, something which in real life we only experience implicitly, is often enumerated: "Music makes time audible, and its form and

continuity sensible"(Langer, 1953). Basil de Selincourt who wrote an essay in the 1920s about "Music and Duration": "Music is one of the forms of duration; it suspends ordinary time, and offers itself as an ideal substitute and equivalent.(…) Music uses time as an element of expression; duration is its essence." (Langer,1953) The notion of duration - not time - being the essence of music, and with it the notion of a sequence of discrete events, "time as a pure sequence (…) ranged in infinite 'dense' series by the sole relation of succession", can be seen as a slightly different perception of time. Although both perceptions of 'time as a sequence of durations' and 'time as a continuous flow of events' can happily live beside each other, this slight difference is not only perceptible when devising new presentation standards for music, but also becomes subconsciously or consciously influential when composing music. In our understanding and creating of music, this slight difference is as small (or as large) as the difference in meaning of the terms "time" and "tempo". This can become a major influence when participating in any sort of musical activity. For instance, if comparing US and European compositional culture in the last century, one could see a difference in the perception of time within music and the compositional process, the Anglo-American culture reflecting more perceptions of internal time, the European tradition rather reflecting external time (Boehm, 2006). Honing (2001), possibly influenced from the more American tradition mentioned above, in his article "From time to time: the representation of timing and tempo" makes a distinction between time as an attribute of musical events, the timing and the tempo. In order to cater for performance data, as well as the usual 'pure logical music information', timing and tempo, and the differentiation of these, necessarily have to become important. His "expressive timing" can include aspects of musical structure, such as jazz swing, or the typical slowing down at the end of phrases, such as found in music from the romantic period. Honing states that "in music performance there is a close relationship between expressive timing, global tempo, and temporal structure. One cannot be modelled without the other".

This cultural divide between seeing time as an external attribute (tempo, temporal curves, temporal lines) and seeing time as internal attribute (recursive structures) is also reflected in the programming philosophies of this culture. American research communities more often produce systems which implement time as an external attribute with concentration on the performance aspects of time (Dannenberg, 1993; Todd, 1991; etc) and from Europe emerge systems catering rather to a more serialism influenced and 'note-based' music. (Hoos, 1998; Ossenbruggen, 1995; etc). This possibly too generalised idea does not quite represent reality but helps in understanding the two different notions of implementing time, described in the following sections.

2. The design and implementation of time

Looking towards our common music notation, and how it has managed to present time with static non-temporal symbols unambiguously, one can see that it has a relative, not an absolute, representation of time. All time related symbols are relative to each other (expression marks, accents, durations, bars) with one major exception being the metronome indications. Mälzel applied for a patent of his metronome in 1816, a time where the fascination of clocks and timekeeping devices was at its highest popularity (see Sobel, 1996). The metronome itself represents a subset of real experienced time, and is able to present different times or different tempos of times. It also represents an absolute reference for the time within a piece of music. It makes the relative time symbols relate to one possibility of an absolute time. When the metronome mark changes, all executions of temporal symbols change accordingly. But besides this example of absolute time in our common music notation, all other traditional temporal symbols tend to be relative. There are

a number of interrelating collections of symbolic signs providing a complex interaction of information about timing, durations and sequence which can result in different musical meanings when put in different graphic locations.

When designing new music representation, the design of time becomes one of the most difficult and interesting tasks. Key decisions have to be made: should time be defined as an internal attribute of the musical entities? Or as an external entity with links between musical objects? And is it to defined as a sequential or a recursive entity?

3. Time as an external or internal attribute

The design of a music data structure with time as an internal attribute provides a clean and easy way of encapsulating the primary characteristic of musical elements; their 'time-based-ness'. Furthermore, one has to decide whether to use absolute or relative time, both providing their own advantages and disadvantages. On the other hand, using time as a separate object and hooking it up to musical actions can be a very effective and efficient way of implementing time. This design promises a very effective and easy manipulation of the time elements (speeding up or slowing down a performance) or storing (and thus consequently analysing) different versions of the time line, i.e. different performances. Moreover, different performances have other differentiating attributes, where it is useful to separate out time as a major aspect. Several systems have used implementations of external time very successfully for this purpose.(Loy et alii, 2001) Another advantage is that the time objects, or the time line, can become the reference for all other actions, thus making this design very useful for more multi-media systems, as it can provide a synchronization reference for external data in other established formats (SMPTE, 1994; SMIL, 1998).

However, although a separate time entity can have advantages in specific use contexts, it may be seen to lack a certain elegance of design and consequently attraction for reusability. Thus it often is not even considered as a possibility: most musicians conceptualise music as a time-based medium, but one in which the time-based characteristics are almost impossible to be separated from the other elements of music. We see a score to be a representation of music, a score which is two- dimensional and does not include time explicitly as a representational symbol. We use a non-explicit symbolic representation of music inclusive of timing aspects, which points toward the fact that we accept time to be an inherent character of music. This has only been challenged by 20^{th} century music and it's very general notion of what music is. So there is the tendency, when designing an adequate music representation, to use the more traditional principle of time intrinsic music. Apart from the philosophies and ideologies behind designing a music data representation structure adequately, the separation of the representation of time from other aspects has problems of maintaining the links between the time objects and the musical objects themselves, making it an extremely cumbersome structure to update or expand. Nevertheless, when desiring a common reference point or wanting to emphasize and maximize the efficiency of specific time-related manipulations, or possibly enable the storage of several time lines to one collection of musical events, as in performance related information, this structure can be extremely powerful.

4. Time recursive or sequential

With both of the above options of representing time, as an internal or external attribute, one may chose to use a recursive or a sequential model. All combinations are theoretically possible, but it tends to be easier to design and conceptualise a recursive structure with time as an internal attribute, and a sequential structure with time as an external attribute, although the decision might

be based primarily on a philosophical notion of how we perceive music. It seems very straightforward to implement time as a sequential structure; even more so when choosing to use relative time instead of absolute time. When designing in a sequential view, our perception of music as on a primarily horizontal plane (melody) is emphasised and consequently, the handling or manipulating on a horizontal line is fairly simple. Inserting elements or deleting elements in this scenario is easy, although it may be problematic when wanting to use musical elements from a later time - before the early musical elements have been created.

This is a fairly well known problem of music editors or notation packages, where very often the formatting is problematic when creating notes further down a page or a system before "filling it up" from left to right. This indicates problems of using simple double, or even worse but rare nowadays, single linked lists for the implementation. Although these problems can be solved through implementing additional behaviour or methods, the fact that it is not inherent in the structure often makes it more difficult to expand functionally into this direction. The notion of time as a recursive entity is not being implemented very often, although we see more recursive structures being used in functional languages or languages such as Haskell which tend to point towards recursive structures more than other languages.

5. Conclusion

Music itself can be seen to be an audible made version of time (Langer, 1953) Music uses time as an element of expression and thus musical time, as a metaphor of real time, can be used consciously to express notions of real-time, and used as a creative element by composers and listeners and performers or as Langer states: "the primary illusion of music is the sonorous image of passage, abstracted from actuality to become free and plastic and entirely perceptible"

My abridged guide to musical time would be as follows: Musical Time can be linear or not (circular, spiral, recursive(?)); Musical Time can be simultaneous (different streams); Musical Time can be heterogeneous (time, tempo, duration); Musical Time can be composite and including itself; Musical Times can be interdependent of each other; and Musical Time can be relative or absolute (within a work). Time can be represented as an internal attribute of time or as an external attribute of time. Implementations using internal time have the potential to be clean and easy for encapsulating primary characteristics of musical elements and thus tend to be easier to expand and update than external time implementation. The latter, however, is very effective for easy manipulation of the time or temporal elements, or storing and analysing different performances (Loy, 1985), or as a synchronization reference for external data (multi-media). Time can be represented as a sequential structure or recursive structure. Sequential time structured tend to be easier to be used with external, relative or absolute time or time, but they tend to emphasise the horizontal plane (melody). Manipulations on the horizontal line are simple, but insertion of later elements (temporal or not) can call for more complex routines. Recursive implementation of temporal aspects tend to be used more in languages which support recursiveness, such as functional languages or Haskell. The relationship between time, tempo, rhythm, duration and their representations in notational or digital form are complex. Philosophically seen, "musical time" could be seen as an abstracted metaphor of real-time, time made explicit and experiential, plastic and perceptible. The perception of the Gestalt of musical time will have consequences for the design of systems dealing with time-based media.

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