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"Icon Notation for Electroacoustic and Computer Music"

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Background

Electroacoustic and computer music (ECM) achieves freedom from several restrictions which were naturally built-in in other types of music. The various aspects in which ECM departs from other types of music are:

1. Pitch: - ECM requires freedom from the discrete 12 half-tone per octave scale, so that continuous pitch is possible. Physically, this means continuous change of frequency.

2. Timbre: - ECM requires freedom from the fixed timbres constrained by the set of available acoustic instruments. It needs the ability to produce combinations of timbres, including continuous transformations between timbres in a single tone which develops and changes in time.

Since the physical specification of timbre is quite complicated, the translation of this requirement into physical terms involves many parameters, depending on the method of sound synthesis.

Notational Problems

The freedom of ECM from restrictions accepted in other types of music means that the Conventional Musical Notation (CMN) can no longer serve effectively ECM. This freedom creates problems of adjutment to another way of thinking about music and to the way it can be written. New ways of writing ECM is needed, so that it can become a basis for mental imaging in the thoughts of composers and musicians, and for perfoming in real time.

Notation for human apprehension of music can never provide all the immense amount of information contained in the physics of sound. Thus, every notation system must be some shorthand compromise, emphasizing only the aspects considered important to its users . As is well known, even the CMN is a shorthand form of writing music, providing detailed information only about pitch and duration. Articulation and dynamics are only hinted at, and the timbre is defined simply by naming an instrument.

Consequently, in the search for a new notation for ECM, the most important aspects for ECM were chosen for the real time representation. Other aspects are defined at the initialization part of the notes, and are only hinted at in the real time representation.

It was recognized that since timbre and its development in time is so important in ECM, its association with pictorial icon forms, which can change in correspondence with the timbre, is highly desireable, because the human eye is very sensitive to such pictorial forms. Musicians can learn, after some training, to associate timbre and timbre features with the corresponding icons.

It was also recognized that the musical icons should represent some physical reality associated with timbre specification, rather than being defined arbitrarily. The new feature in the suggested icon notation is that amplitude modulation (AM)function is considered as the most important feature for timbre definition, and the conversion of this function to polar coordinates forms the icon. Next are the frequency modulation function (FM) and wave function (WF) which are added to icon. The icons can be placed in the page somewhat similar to the way notes are written, where vertical position denotes pitch and horizontal position denotes timing.

At this period of the computer revolution, it is natural that any system of notation should make use of computer graphic facilities to aid the pencil-and-paper graphics especially when graphics includes physical curves. Moreover, once the graphics is computerized, it can control the generation of sound via the computer ports.

Technical Aspects of the ICON notation

The principles of the ICON representation of notes and the way they are written are listed in the following:

1. As is common, the ECM notation of a musical piece consists of two main parts: the initialization part which consists of preset definitions of parameters, and the real time part which includes the time dependent development of the music.

2. Time dependence is denoted by horizontal movement from left to right, like in CMN. Time units can be marked on the horizontal axis and also by vertical lines, as bar lines as in CMN. The horizontal coordinate of the icon origion determines the exact timing of note beginnings. Time scale can be either denoted by fractions of seconds, or by the usual duration units used in CMN, like whole notes, half notes, etc., together with the metronome number.

3. Pitch is denoted by height of the icon origion in the vertical position, like in CMN. However, there is no preference of special notes, as in CMN, where the seven "white key" notes are preferred by having each a position on the staff, whereas the other five "black key" notes are ad hoc denoted by shifting them up or down relative to the "white key" notes.

The pitch scale can be marked by parallel horizontal staff lines like staff lines in CMN, except that the number of staff lines is not necessarily five, and heavier lines can denote reference pitches like borders between different octaves. The pitch can be chosen continuously in the vertical scale with microtonal marking, for precise specification of pitch, or else the pitch scale can be expanded by zooming of windows. The pitch can be denoted inside the icon by either the frequency in units of Hz, or by the usual musical names with microtonal markings if required.

4. AM Amplitude envelope (ADSR) function, as a very important distinctive timbre function, forms the closed icon shape by transforming its cartesian time dependence into polar coordinates, as shown in Figure 1.

In these coordinates, the amplitude is represented by the distance from the origion of the icon, called also the radius vector (RV). The time dependence of the amplitude envelope function is represented by the polar angle (PA).

Typically, the icon is "kidney" shaped, because the amplitude starts from a value of zero at the start of a tone, with zero PA and zero RV. At the end of the tone the value of the ampliutde is again zero, with the PA of a full rotation of 360=0 degrees and zero RV.

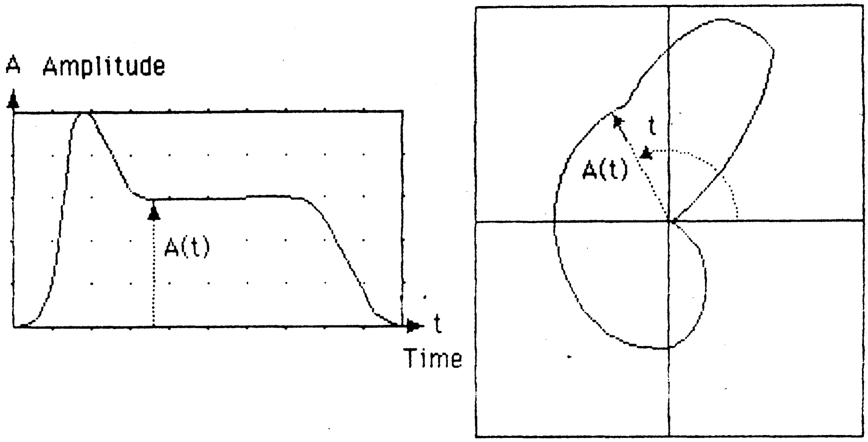

Figure 1.

Points of importance on the amplitude envelope fuction, like significant points of an ADSR function, can be specially marked.

There is a problem with drawing icons for notes of different durations. Obviously, the ADSR function changes with the duration of the note, and so does the shape of the corresponding icon. It is recalled that tone duration is measured from the beginning of the attack part of the ADSR function until the transition point between the sustain and the release parts. The release part cannot be considered part of the duration, as shown in the Figure 2.

Because of physical reasons, for notes generated by acoustical instruments, only the sustain part changes with duration, whereas the AD-R parts of the are unchanged. It is concluded that the AD-R parts are the invariant characteristic of an ADSR function, and we adopt it also for ECM.

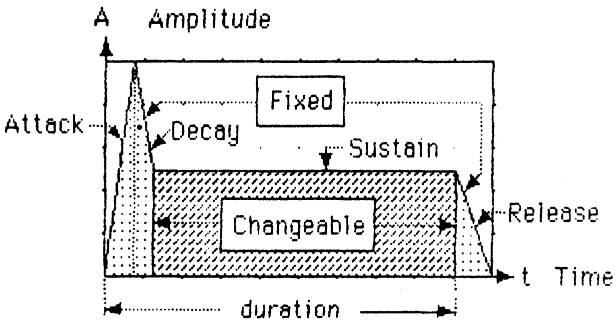

Figure 2.

Sometimes it is advantageous to associate a fixed form of an icon with a given ADSR, even though the total duration of notes can change, because this helps to memorize the connection between the icon and the specific ADSR. If it is decided that indeed one icon should describe all note durations associated with a given ADSR, then the icon describing the given ADSR function is drawn actually for only one single tone duration (e.g. a quarter note duration). Other durations of notes should then be denoted by additional means.

5. Duration of a note in time scale is represented by the length of a horizontal line segment, which is drawn from the icon origion to the right direction, as shown in Figure 3. Again, the note duration excludes the release part of the ADSR amplitude envelope. The time interval between notes can be also noted on the same line section as an extension of the note duration, if so desired.

6. The volume of a note can be represented in two alternative ways:

(a) All ADSR curves are normalized according to their maximal points, and then all icons have about the same size, since their maximum RVs are equal. The volume is then represented by either the conventional piano-forte-crescendo-diminuendo symbols, or by the thickness of the duration line segment, or by marking the dB value of the volume.

(b) The ADSR curves are not normalized and their relative vertical value represents actual volume. Then icons of different volumes corresponding to the same ADSR appear as similar icons but of different sizes.

7. The FM function is denoted as a time dependent cartesian curve, drawn on the duration line, which serves as the zero deviation reference from the centre frequency of the note, as shown in Figure 3. A special frequency deviation scale is marked vertically in units of Herz, or of half tone, or by microtones.

8. The waveforms of notes can be denoted in either of two ways:

(a) A certain set of prefixed waveforms are defined at the initialization part of the notes. And then each icon in the real time part is marked by the wanted waveform.

(b) The time dependent waveform is described by a cartesian curve to the left of the icon (Figure 3., or by its frequency spectrum.

9. Notes of different pitches and timing are drawn on the staff so that their origions are placed according to their pitches and timing. Thus, chords can be formed by writing their icons on the same vertical line.

10. Superposition of sounds of the same pitch but of different timbres can be represented by either of two ways:

(a) Superimposing the different icons with the same origion, where each one is drawn with a different line type (i.e. full, dotted, dashed, etc.) or color.

(b) Drawing the icons on two parallel synchronous staffs, as in a musical score.

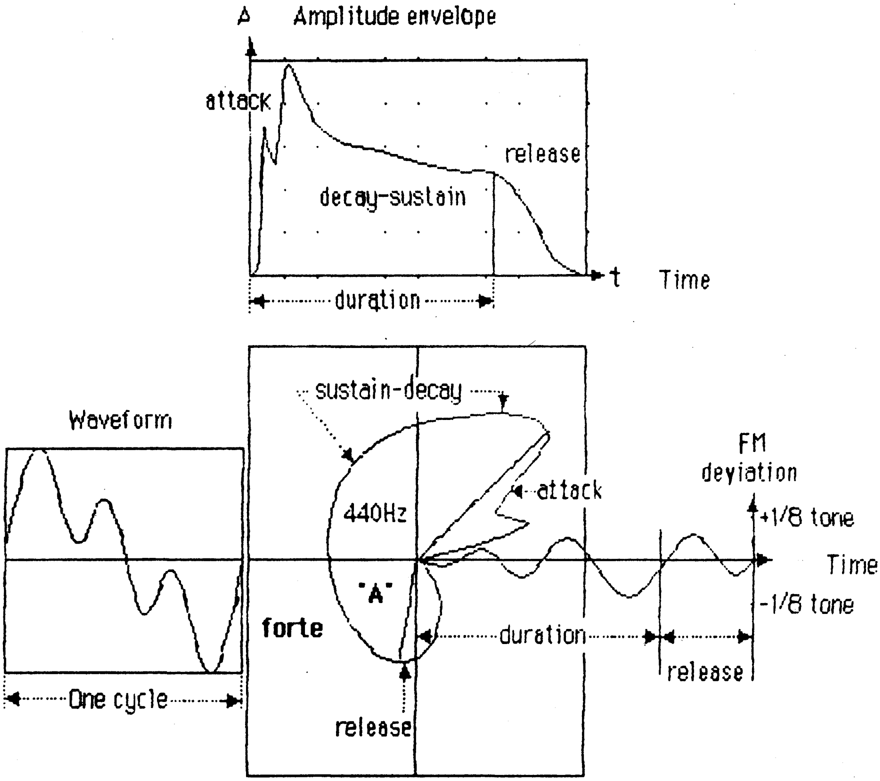

Figure 3.

Implementation

The ideas about notation presented here are intended for implementation for both pencil-and-paper and interactive computer graphics. Practical experience in using the proposed notation for sound generation and composition will teach which features should be adopted.

Acknowledgements

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