

O n
New Approaches In Electroacoustic Music Notation
T A L M A R K (C)

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Musical notation is a graphical representation of music . Therefore, each type of notation should be based on some sort of mapping (or correlation) between the acoustic perception of sound and their visual symbolism perception .

Analysis of the various notations which have been developed in the past, points out the clear co relation between the acoustic domain and the visual domain. Each musical trend demanded a particular notation for its representation, on the other hand, each notation method impacted the musical development to comply with it.

With the development of contemporary music, with all of its moves (concrete, electronic, stochastic etc.) a new notation to describe the musical ideas became a must. Due to the lack of such notation, various composers experimented with different types of ideas , but, with no success. Thus, the amount of creativity in these areas of music decreased .

The amount of data incorporated within a musical note is enormous . Also, the number of different types of possible sounds in contemporary music is immense. Furthermore, composers generating new sounds to be used in their pieces , are confronting the problem of how to define, specify and generate the various sounds . Therefore, without proper notation method, the limitations of human memory , and cognitive processes, eliminate the musicians from organizing sounds to a complete musical fragment, which has been generated and experienced in some other contexts .

Notation , provides possibilities to refer to previous sounds (single or structures, simple or complex) via symbols. Thus, enable the composer to operate in more natural close terms of composition process, as well as to convey ideas which is vital for mutual fertilization .

In order to overcome the enigma, a notation based on associative, easy to perceive, graphical symbolism, which is based on the physical acoustical parameters of the sound, is thus required. A possible approach, is the use of icons, which are graphical clear representation of the sound, based on the physical data, and reproducible .

At first, the composer will have to study the correlation between the Icon and the musical sound corresponding to it. Once, the composer is familiar with it, he may use it in his pieces. Because , the eye is more sensitive to small changes in visual forms, Icons variations and corresponding timbres, may thus be noticed more intuitively.

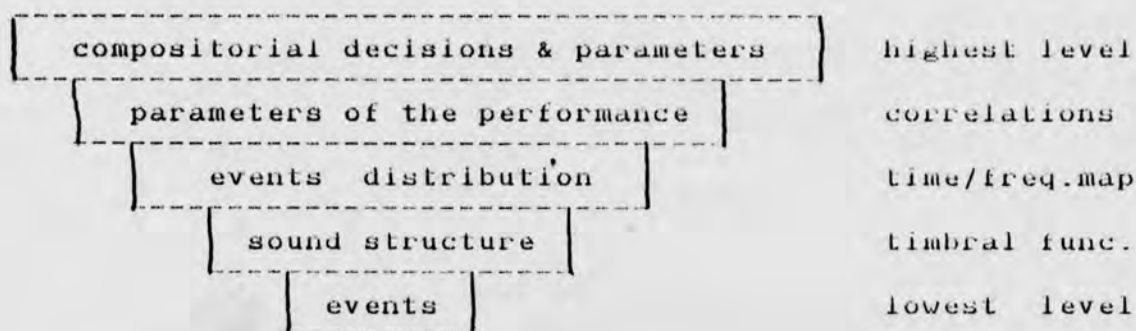
The Icons may be described by handwritings or computer device, however, the advantage of such representation is in the amount of association of multi function within one symbol, thus, the composer may "think" in those terms.

The main perceptual characteristics of the musical sound are its pitch, duration, volume and timbre (colour). These characteristics are the perception, i.e. the interpretation which the mind provides to the acoustic data heard by the ears. The amount of correlation between the physical parameters of the sound, which may be measured by instrumentation, and the perceptual characteristics, is low. The sound is not perceived as a set of parameters, but rather as a complex accumulated entity, which is context dependent.

The "Acoustic Model", attempts to provide feasibility to define physical parameters of the sound by other parameters. Thus the ultimate model, shall provide it via the perceptual characteristics. The present technology provides various models, from the basic end (additive syn.) to the upper end (FM Syn.)

Analogously to the "proper" "acoustic model", there is a need for a "proper" "composition model". The compositorial process is based on the compound of both the analysis activity and the creative activity. The creative activity is dominate, but the analysis activity is important not only as a personal feedback and criticism, but as circumspection of the generative process, e.g. data filtering during the creative process, due to compositorial decisions in the higher level (shape, style, structure etc.) impacting the lower level parameters, including the timbre, nuances etc. The composition model implemented in the system, should provide the composer with the possibility to work in the general structures level and the specific sound level simultaneously, with transfers from each other and contextual correlation between them.

A possible model might look like



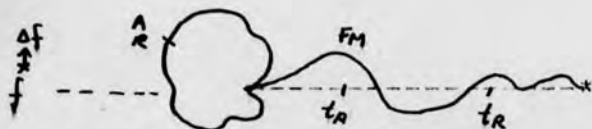
A new Icon notation system is herewith proposed, based on the physical acoustical parameters of the sound, as follows:

- (a) Amplitude envelope - The amplitude envelope of the sound is mapped from a Cartesian coordinates to polar system, including all the classical portion i.e. Attack, sustain and release. The radius vector is proportional to the amplitude, and the angle to the time, while 360 degrees equal to the whole "time life" of the particular sound.
- (b) In addition, alongside the Icon, further symbolism is detailed representing further characteristics of the sound, e.g. the basic waveform, timing, FM, etc.
- (c) The main frequency of the sound is determined by the location of the Icon in the vertical (logarithmical) axis (which represents frequency axis).

For example:

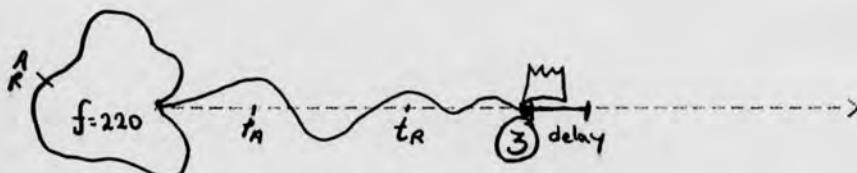


- (d) The interesting parts (such as the attack and release) which contain rapid fluctuations, may be too short in comparison to a sustain containing less information. Therefore, an option to detail the attack release portion only is provided. In this case, a discontinuity might be encountered in the shape.
- (e) A line alongside the Icon, provides a tail representing the actual time duration of the sound. In addition, it provides the FM description based on the main frequency as detailed in the figure



- (f) In this way, Icons of same sounds, which differ in volume only, will look alike but, in different size - or, better yet, all Icons shall be in a unit circle. The volume shall be described via means of the dense of the line.

- (g) Per each sound the operator shall attach a line at the end of the sound line which shall be proportional to the period of the delay between repetition of the sound, alongside with a number in a circle defining the number of repetitions.



Once the operator has defined the sound he wants to work with and saved them properly, he may built the "piece" as a structure in one of the following methods :

- (a) The surface shall have two coordinates, the horizontal shall be the linear time, and the vertical the frequency (in a logarithmic scale). The operator may at his discretion "plant" the icon of a specific sound in the time/frequency domain, i.e. when it starts and in what initial pitch.

The operator will be able to change and modify the "places" of the basic sound, thus hear the complex sounds and change the structure at his will without too many operations.

- (b) While playing in "real -time", the operator may have a display of the process in one of the two ways :

- * On board the static display a "flying dot" shall display the current time.
- * At the middle a "window" shall display the current time, and the complete structure shall move along from right to left as the music proceeds. Each sound at its frequency line will have a circle proportional to its amplitude, plus, an arrow to indicate any frequency diviations or modulations.

- (c) In addition the operator shall be able to control the whole structure , providing new infrastructure and correlation between the Icones/sounds. One of many shall be the "Patching" technique . The patch shall be denoted via an arrow sign with multiplication factors.

The System for Notational environment is based upon various programs combined into an integrated system, based on two computers : The Apple IIe and the IBM XT. There is no technical need for two computers. However, originally the system was based upon an Apple IIe with a Mountain System Oscillators Card. But, it was found out later that the Apple is not enough, thus programs have been further developed on the IBM. Due to the fact that an oscillators board was not available on the IBM, plus the amount of software available and operational on the Apple, it was decided to utilize both of the computers and to connect them to each other.

The input devices to the system are:

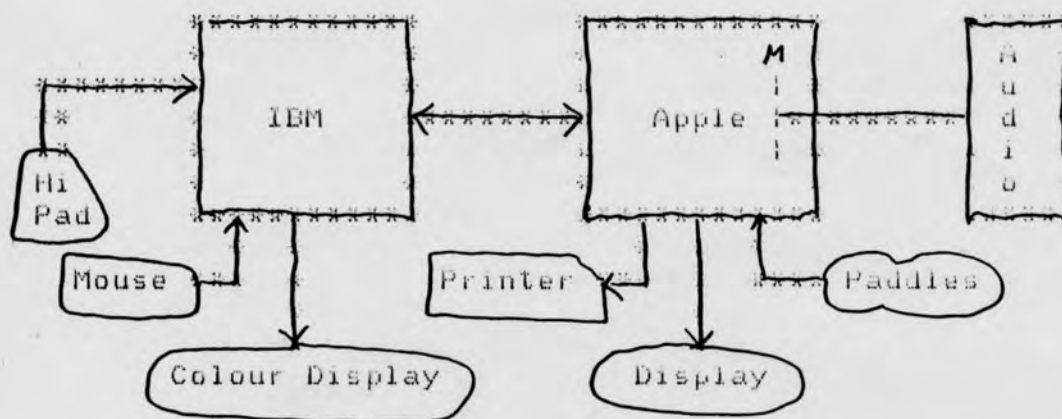
- * Optical Mouse/Tablet, referred to as Hi Pad
- * Microsoft Mouse
- * Paddles (2)
- * Joystick
- * Keyboard

The output devices of the system are :

- * Monochrome Display
- * RGB Display
- * Hardcopy Graphic Printer
- * Oscillators Board - Mountain Inc.

The communication is performed between the computers via RS232c Channel. The communication to the Oscillating Board is via DMA, and to the Printer via Grappler+ parallel interface.

Schematically the system is as follows :



The Apple IIe Programs

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The programs within the Apple IIe provide the operator with options of generation, study, and composition of sounds. The operator interacts with the system via its keyboard and paddles (or joystick) and the system provides an instance feedback of sound (through the audio system) and graphics (through the display). The three main portions of the system are :

- * Editor - through which the operator creates various kinds of waveforms, envelopes, FM modulations, sound parameters e.g. pitch, volume etc. and may listen to them interactively, thus study the impacts of the various parameters on the sound. (see detailed functions available in this mode later). The system allocates per each item the relevant "icon" including provisions for library store / retrieval .
- * Play - Through which the operator may change dynamically the parameters of the sound generated and edited. The operator may at his discretion select sounds from a library, and create "harmonics" for several sounds to be heard simultaneously (as one chord) . (see detailed functions available in this mode later). This mode may be entered from each point in the editor mode.
- * Compose - Through which the operator may create and compose a sequence of sounds already generated in the previous modes of operation. The operator may select the timing of each sound / chord e.g. its initial time, length and correlation to other sounds. The existing sounds may be transferred to different time correlation, between the sounds and each one for itself (extend or contract). In addition while creating the "melody" the operator may change the basic parameters of the sounds e.g. pitch, volume etc. (see detailed functions later).

In each of the following modes detailed above, the operator may perform one of the following functions :

- * draw/describe the graphical information he wishes
- * play the sound eventhough not all of its parameters are defined. (Utilizing defaults)
- * get a hardcopy of the relevant "icon" and/or graphic representation, plus any parameters or data needed
- * see the amplitudes and frequencies of the sounds generated while they are played in real time.

The IBM Programs

The IBM programs are divided to three groups :

- * Draw - Provide capability for the operator to draw whatever he likes in free format utilizing a Hi Pad digitizer which is actually an optical mouse, thus the operator may prepare various sounds by handwriting and utilizing the pad for inputting the data to the computer. While the operator draws the display provides a direct feedback of what is received in the computer.
- * Sound Def - Provide the operator with capability to generate various sounds, including capability to construct overtones. The operator may at an interactive way design the structure of overtones of the basic sounds (up to 100), and the system shall smooth, generate the sound needed etc. The operator may enter also non periodic harmonics, thus create interesting colorfull sounds. The system provides the operator also with a capability to analyze the overtones from any waveform drawn. (see further details later)
- * Sound Process - Provide the operator with options to allocate the sounds defined before in the time and frequency domain , plus correlations between the sounds.

In addition, in each of the programs, the IBM or the Apple the operator has in addition an option for transformations. Each of the parameters of amplitude, frequency and time are actually taken from the value generated through a table driven function. In the normal mode the function is the unity conversion thus the actual and calculated values are the same. But, the operator may do one of the following :

- * change the rate (slope) thus impact the resolution of the sound generated. The operator may select higher resolution with smaller range or , smaller resolution with wide range , or any combination.
- * change the sign of the slope, thus causing inversions of the sound. e.g. increase of a calculated amplitude shall cause a decrease of the amplitude of the generated actual sound etc.
- * change the transfer function causing interesting compositorial effects on the material. The composer may prepare some sounds and then use the same structure but with some transformation function and listen to the "new" sound generated.

Detailed description of the Apple Programs

THE EDITOR

The editor provides capability to operate on four items :

- * Waveform
- * Envelope (amplitude)
- * Frequency Modulation
- * Conversion

Waveform

The operator may create a new waveform in one of the ways :

- * Recall a pre defined waveform from a library
- * Recall a pre drawn waveform
- * Draw a new waveform
- * Get a new waveform from external source

The Operator may at his discretion change, modify, combine, redraw, etc. each portion of the basic waveform. Thus is able to reshape it the way he likes. Then, the waveform can be stored in a waveform table for usage later on, or be saved on disk , or printed on a hardcopy. During the whole process, including the shape, reshape, "cut and paste", the operator may listen to the sound relevant to the particular waveform edited.

Envelope

The operator may create a new envelope in one of the ways :

- * Recall a pre defined envelope from a library
- * Recall a pre drawn envelope
- * Draw a new envelope
- * Get a new envelope from external source

The Operator may at his discretion change, modify, combine, redraw, etc. each portion of the basic envelope. Thus is able to reshape it the way he likes. Then, the envelope can be stored in a envelope table for usage later on, or be saved on disk , or printed on a hardcopy. During the whole process, including the shape, reshape, "cut and paste", the operator may listen to the sound relevant to the particular envelope edited.

The envelope may be handled in either ways :

- * Cartesian mode - all the drawing, representations, and references are in the regular mode X-Y
- * Polar mode - all the drawing, representations, and references are in the polar (angular) mode where the radius vector is proportional to the amplitude, and the angle to the time, where a whole period is equivalent to 360 degrees.

Each envelope incorporates also a "split" point to differentiate between the "attack" and the "decay"/"release" portion. Thus, from the same basic envelope many envelopes may be created dependent on the ratios between the "attack" and the "decay"/"release" which later on may be dampened by the operator.

In addition the basic volume parameter is attached to each sound with the same envelope to differ the level of loudness. The volume level may be represented either by a number (ref to Db) or by the thickness of the envelope line.

Frequency Modulation

The operator may define the function of slow frequency modulation of the sound, i.e. the delta of frequency from the basic initial pitch per time. He may define the values of the parameters and their scale.

The operator may create a new freq envelope in one of the ways :

- * Recall a pre defined freq envelope from a library
- * Recall a pre drawn freq envelope
- * Draw a new freq envelope
- * Get a new freq envelope from external source

The Operator may at his discretion change, modify, combine, redraw, etc. each portion of the basic freq envelope. Thus is able to reshape it the way he likes. Then, the freq envelope can be stored in a freq envelope table for usage later on, or be saved on disk, or printed on a hardcopy. During the whole process, including the shape, reshape, "cut and paste", the operator may listen to the sound relevant to the particular freq envelope edited.

Conversion

The operator may use this feature of conversions by editing the conversion function as applicable.

The possible conversions are :

- * Amplitude - The conversion function describes the function of the actual amplitude sounded versus the amplitude calculated by the system. Enables smoothing of the amplitudes, inversions, different gains per areas etc.
- * Frequency - Its the same as the amplitude but, for the parameter of the pitch rather than the amplitude. It may also be used for transpositions etc.
- * FM - same as above but, for the FM deltas used to add / subtract from the base frequency per time.
- * Waveform - Definitions of waveform numbers / families which is a function of the amplitude and frequency and may thus change in a non linear way.

The operator may create a new conversion table in one of the ways :

- * Recall a pre defined conversion table from a library
- * Recall a pre drawn conversion table
- * Draw a new conversion table
- * Get a new conversion table from external source

The Operator may at his discretion change, modify, combine, redraw, etc. each portion of the basic conversion table. Thus is able to reshape it the way he likes. Then, the conversion table can be stored in a conversion table for usage later on, or be saved on disk, or printed on a hardcopy.

When the system displays the frequency and amplitude of the sound while it is heard, it displays the actual ones, i.e. the amplitude and frequency after the conversion function.

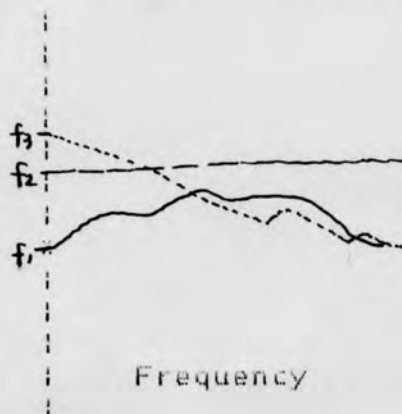
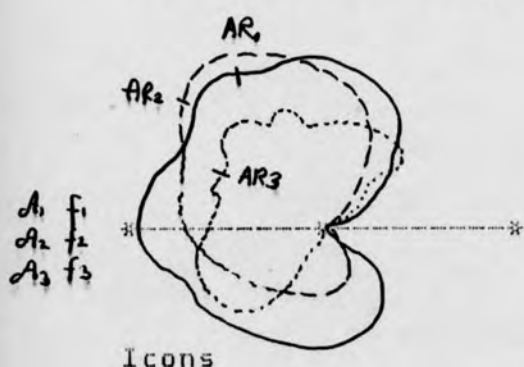
see attachment (1) for some of the functions / menues which are available in the editor mode .

THE PLAY

The play provides capability to operate and play the various pieces of sound together or, all at once. The play option includes the following functions :

- * Replay what was heard again
- * replay while changing the pitch
- * replay while changing the volume
- * display (or not) the actual pitch / amplitude while playing is performed
- * define the timers of the sound
- * monitor the play structure
- * define masking global parameters, e.g. no FM, flat envelope ,transposition, etc.
- * define a chord of icones, per each of them define :
 - its waveform
 - its envelope
 - its FM
 - its pitch
 - its volume
 - its time parameters :duration, attack,sustain, release and FM period
- * define the total time of the chord and its repetition
- * printout a hardcopy of the structure of the sound

A typical sound structure may look like the following :
(the Real Time display)



THE COMPOSE

The compose is the system's compound which provides the operator options of constructing complex sequential sounds.

The sound elements created earlier utilizing the Editor and Play options, and which are saved as waveform, envelope, FM envelope, & conversion tables, sound elements (icons), and chords of several elements "vertically" - may now be combined in a "melodic" "horizontal" pattern. The operator may define specifically per each time slot whichever elements are armed, their parameters (if changed from the original) and their correlation.

The available main functions are as follows :

- * activate - plays the piece defined
- * arm - which sound elements should be activated
- * display - which sound elements should be displayed
- * parameters - change at the time slot :
 - the pitch, the volume, the icon, etc.
- * time - defines the subject time slot
- * transpose
- * expand or/and contract the time flow
- * printout a hardcopy
- * save or reload the construction from disk

Thus, the operator may construct various structures of sound and then, change parameters and/or icons and be able to listen to the resulting sound generated in the different contexts immediately, thus tuning & modifying it with direct feedback.

See enclosed herewith in enclosure (1) the various menus available on the 3 main modes of operation on the Apple IIe.

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