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The Development of Context Sensitivity in the Midiforth Computer Music System

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ABSTRACT

This paper reports on the development in the MIDIFORTH computer music system of context-sensitive editing features, such as the ability to highlight MIDI events based on their position within a melodic or rhythmic pattern, and on pitch or other relationships to surrounding events. The software mechanism that implements this is discussed, and some examples of the musical desirability of such features are presented.

BACKGROUND

Many microcomputer-based MIDI-oriented computer music systems now exist and are readily available. Almost all of these allow the processing of MIDI event data in a fashion analogous to that found in simple word processing software. The ability to insert, delete and modify individual characters (i.e. MIDI events) is always present, while more sophisticated software will allow editing based on the principle of *contiguity* - the ability to group characters or MIDI events based on their proximity to one another. The next level of complexity consists of the ability to search for and modify events based on some *intrinsic or implied characteristic* - (Buxton et al, 1981) calls this grouping by *local attributes*. An example is the ability to search for and modify all events consisting of a particular MIDI pitch or velocity (intrinsic characteristic) or of a certain duration (implied characteristic). In the language sphere, this corresponds to the ability to search for and modify individual words, such as the "search-and-replace" feature found in most word processors. The most common extension to this sort of editing involves the implementation of relational schemes; for example, the ability to edit all notes 'greater than' (i.e. of a higher pitch) some particular MIDI pitch value, or to restrict editing to events falling only within a certain range (e.g. between middle C and F#).

However, few computer music systems - and no microcomputer-based systems except for MIDIFORTH - have investigated the development of editing based on what have been called *contextual attributes* (Buxton et al, 1981b). Earlier efforts, such as the editing features of the Structured Sound Synthesis Project (from which some of the terminology used in this article derives), were sketchy and exploratory. The development of such features in the MIDIFORTH computer music system has experienced several iterations, made possible by the extensible nature of the underlying language and operating system, Forth.

THE MIDIFORTH FILTER

The first step in the development of *context sensitive* score editing in MIDIFORTH was the implementation of a flexible system to allow editing based on a combination of *local* characteristics. The MIDIFORTH filter originated in the SSSP concept of scope, "a subset of the musical events of a score, selected according to some criteria" (Buxton 1979); that is, the restriction of some useful operation to a musically distinct set of data. In addition to the common restriction of specifying an operation within a temporal boundary (i.e. based on the principle of *contiguity*), MIDIFORTH allows the following constraints:

Any combination of:	*with:*	*and:*
pitch:	equal to:	a fixed value.
volume:	not equal to:	the next note.
duration:	greater than:	the previous note.
articulation:	less than:	the next tagged note.
pitch bender:	modulo:	the previous tagged.
after touch:	not modulo:	user defined formula.
continuous controller:	on a specified beat.	
switch controller:	not on a specified beat.	
patch change:	member of a defined mode.	
tempo change:	not a member of a defined mode.	
note number:	in the search pattern.	
position in bar:	not in the search pattern.	
tag1:	set.	
pitch interval (to following note):	reset.	
volume interval (to following note):		
duration difference (from following note):		

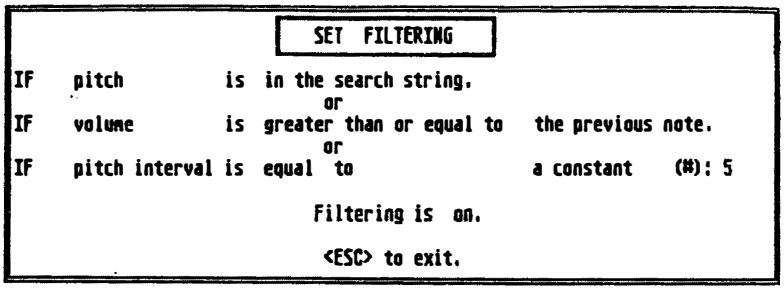
table 1

In addition, multiple selection criteria (up to three) may be employed by combining with the standard Boolean AND, OR and XOR operators; thus, for example, a transposition operation may be restricted to all notes such that:

IF volume is greater than 72
AND
IF duration is less than 48 (i.e. a quarter note)
OR
IF position is on a specified beat

THEN transpose up an octave.

A simple graphic editor is provided for the purposes of altering filter parameters (figure 1).



(figure 1)

Almost all operations within MIDIFORTH are filterable; the few excluded are those that could conceivably have no use, e.g. the DUR? operator, which returns the total duration of a portion of the phrase. Filterable operations include:

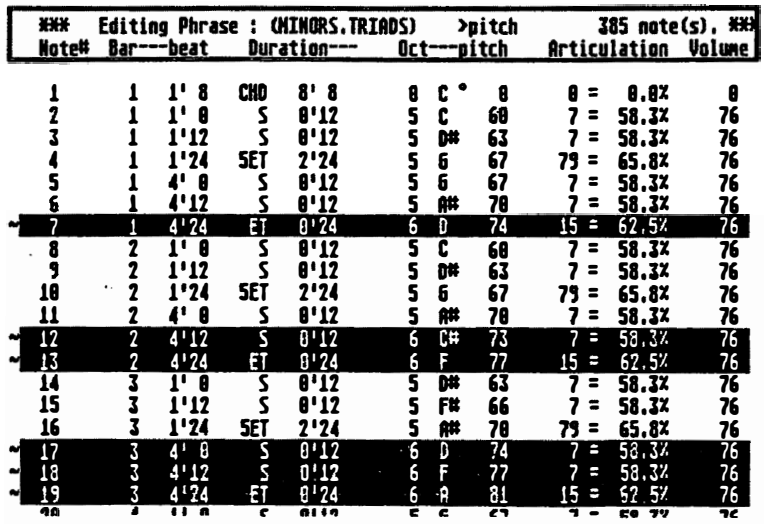
TRANSPOSE	INVERT
COMPAND	RAMP
MODALIZE	RANDOMIZE
CRAB	ROUND
INSERT	DELETE
GRAPH	LIST
COPY	all 'SET' words

table 2

In addition, a simple tool, CONDITIONS?, is provided for users to program their own music processing routines based on the system filter. CONDITIONS? is passed the address of the MIDI data as a parameter and

returns a flag indicating whether or not the filtering conditions were met.

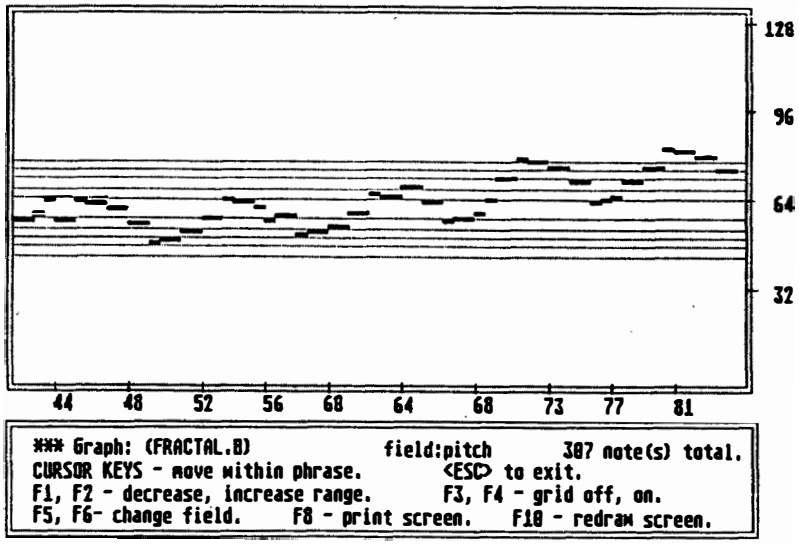
Two means are provided for viewing filtered phrases: PAGE and GRAPH. These are, respectively, the alphanumeric and graphic representations of the musical data. With PAGE, all MIDI data is displayed along with the relevant data of duration, articulation, note number and so on; the data that fall within the restrictions of the current scope are printed in reverse video (figure 2). With GRAPH, only the filtered data are shown (figure 3).



*** Editing Phrase : (MINORS.TRIADS) >pitch 385 note(s). ***

Note#	Bar	beat	Duration		Oct	pitch		Articulation		Volume
1	1	1' 0	CHO	0' 0	0	C °	0	0 =	0.0%	0
2	1	1' 0	S	0'12	5	C	60	7 =	58.3%	76
3	1	1'12	S	0'12	5	D#	63	7 =	58.3%	76
4	1	1'24	5ET	2'24	5	G	67	79 =	65.8%	76
5	1	4' 0	S	0'12	5	G	67	7 =	58.3%	76
6	1	4'12	S	0'12	5	A#	70	7 =	58.3%	76
7	1	4'24	ET	0'24	6	D	74	15 =	62.5%	76
8	2	1' 0	S	0'12	5	C	60	7 =	58.3%	76
9	2	1'12	S	0'12	5	D#	63	7 =	58.3%	76
10	2	1'24	5ET	2'24	5	G	67	79 =	65.8%	76
11	2	4' 0	S	0'12	5	A#	70	7 =	58.3%	76
12	2	4'12	S	0'12	6	C#	73	7 =	58.3%	76
13	2	4'24	ET	0'24	6	F	77	15 =	62.5%	76
14	3	1' 0	S	0'12	5	D#	63	7 =	58.3%	76
15	3	1'12	S	0'12	5	F#	66	7 =	58.3%	76
16	3	1'24	5ET	2'24	5	A#	70	79 =	65.8%	76
17	3	4' 0	S	0'12	6	D	74	7 =	58.3%	76
18	3	4'12	S	0'12	6	F	77	7 =	58.3%	76
19	3	4'24	ET	0'24	6	A	81	15 =	62.5%	76

(figure 2)



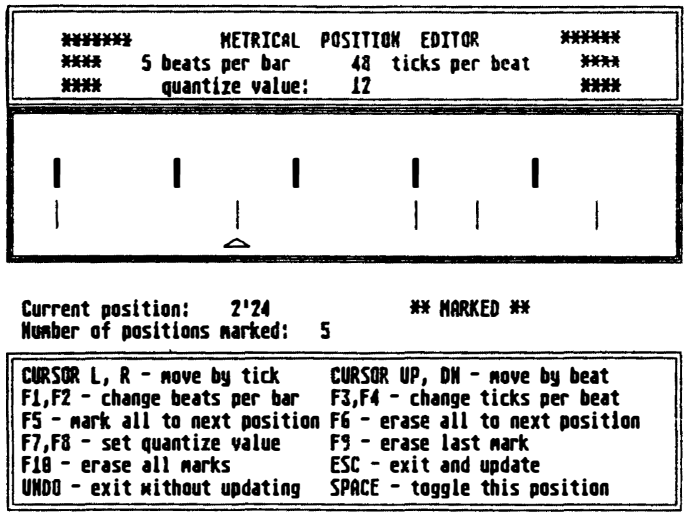
(figure 3)

METRICAL POSITION

Table 1 above indicated that filtering decisions made on the basis of a note's position within a user specified rhythmic pattern were possible. This is an extension of editing procedures into the realm of *implied characteristics*. Because the rhythmic pattern constitutes a true musical grouping, this is the first step toward true *context-sensitive* editing, even though the data obtained (i.e. the note's position within a metrical structure) are derived implicitly.

The rhythmic pattern used may be very long in order to facilitate structural as well as local editing operations. For example a length of 64 measures of 4/4 time may be chosen as the underlying metre, with editing operations constrained to notes falling within bars 48 to 52. Conversely, a single bar of 4/4 may be set as the underlying metre, with operations constrained to the second and fourth beats of the bar.

By combining such operations at different temporal scales, it is possible to build large, rhythmically complex structures from simple elements (the author is currently using this feature to explore rhythmic aspects of Joseph Schillinger's pre-computer algorithmic composition system). At present, all operations involving the use of the metrical pattern must confine themselves to a constant metre throughout the section of the score being edited. A clear need does exist, however, for this operation to be re-directed through a metre map of the score in order to accommodate changing metres. A graphic editor is provided for the purpose of editing the rhythmic pattern (figure 4).



(figure 4)

INTERVAL

All of the types of data listed above were either *intrinsic* (e.g. pitch, volume, etc) or *implied* (e.g. position in bar, note number). In order to extend the range of filtering conditions to include *contextual* attributes as well, the word INTERVAL@ (interval fetch) was added. This word, when passed the address of MIDI data as a parameter, returns the parameter interval between the data and the following note. While quite crude in terms of context sensitivity, this extension was adequate to allow editing based on the recognition of sudden changes of pitch register within a work (i.e. a large interval jump) or lack of such changes (i.e. a string of repeated notes). It also allowed users to experiment with interval-oriented composition (as in the style of later Stravinsky) where, for example, all diads constituting a rising minor sixth can be accented, or all groups moving by semitone can be made legato.

INTERVAL@ was implemented for pitch, velocity, and duration characteristics and placed within the existing filter structure to allow its combination with any of the methods of testing listed on the middle and right hand side of table 1. While its sensitivity is limited to the *immediate context* of adjacent notes, these is the first step to true context-sensitivity and has been very useful in extracting musically relevant features from algorithmically generated structures. With this system it is very easy, for example, to extract all repeated notes (pitch interval_is equal to_a constant:0 or pitch_is equal to_the next note). In addition, the implementation of INTERVAL@ for duration returns a relative rather than an absolute difference; for example, the duration interval between an eighth note and a quarter note would be .5 (their relative difference), and not 24, their absolute difference at 48 ticks per quarter note. The implications of this are far reaching; it allows the development of rhythmic motifs independent of their position relative to a metrical scheme and invariant with respect to time scale. Diminutions and prolongations are equally recognizable.

Also functioning in the *immediate context* are two of the functions listed on the extreme right hand side of table 1. These constitute the ability to compare any *intrinsic* or *implied* characteristic of a note with that of its immediate neighbour forward or backward (*the next note* or *the previous note*). A simple but extremely powerful extension of this was the ability to compare these characteristics to the next or previous *tagged* note (i.e. a note that has been marked by earlier filtering operations). This allows the establishment of relationships beyond the *immediate context*; it makes possible, for example, a selection based on the pitch of the current note, wherever it is in the bar, to the pitch of the next note that falls on a downbeat, or to the previous note that was higher than middle C and louder

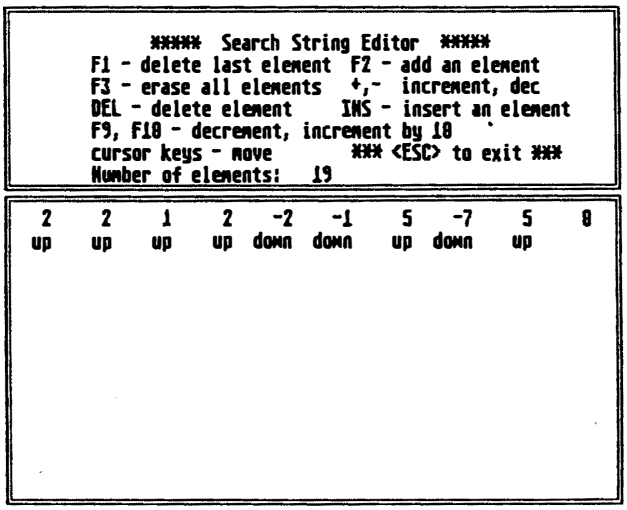
than MIDI velocity 96. In fact, since the tag markings are the logical sums of previous filtering operations, this effectively extends MIDIFORTH's context sensitivity to any (temporal) limits desired, allowing relationships between distant sections of the composition to be established and acted upon.

THE SEARCH PATTERN

The most recent software device to be added to the MIDIFORTH context sensitivity toolbox has been the SEARCH PATTERN, a list of up to 128 elements which may be used to define a musical pattern within the score. Like most MIDIFORTH operations, the test for pattern identity may be directed to any musical parameter; this allows the search pattern to be used to specify such musically desirable groupings as :

a pitch series (the original intention)
a rhythmic motif (independent of its position within the metre)
a gradation of dynamics (i.e. a crescendo or diminuendo)
a graded or patterned series of any other parameter (articulation, controller values, etc)

A very simple editor is provided for modifying the search pattern (figure 5).



(figure 5)

In order to facilitate its use in contexts other than pitch and rhythm (where a pattern may be precisely defined), the search pattern may be

generalized into a series of values representing, not precise intervals, but simply movements 'up' or 'down' from the previous value. This makes the recognition of dynamic patterns such as crescendi and diminuendi, for example, much less sensitive to local details when searching for membership in long patterns. It also makes possible the recognition of diatonically transposed pitch patterns. For example, it has been found that for pitch patterns longer than two or three notes this method is quite accurate in recognizing only legitimate members after a diatonic transposition.

FUTURE DIRECTIONS AND CONCLUSION

The directions in which such systems should proceed in the future include: more sophisticated forms of context grouping - for example, harmonic groupings, which are not adequately dealt with in the MIDIFORTH system. Schenker-style harmonic and melodic prolongations are likewise true musical groupings that potentially provides a great deal of information about the structure of the work. More sophisticated pattern matching, of the type found in many text processing programs, is a clear extension. For example, wild cards where the number of elements is variable would be very useful musically. Another fairly simple but musically useful extension would be the ability to specify diatonic intervals - e.g. where '2' means either a major or minor second, depending on position within the scale.

Most of the musical relationships described in this paper have involved only two (or at most four) notes, although under some circumstances those notes might be widely separated in the composition. A very desirable addition would be the ability to make decisions based on *large-scale contextual characteristics* of a group of notes, such as the average pitch range (register) in the current phrase, or the long term trends in dynamics, ignoring local variations, that might indicate membership within a crescendo or diminuendo. Some provision has been made for this in the MIDIFORTH system with the ability to compare the current note with a user defined formula (see table 1). This formula can access the musical data through well defined system constructs and act upon it in these ways.

While there is clearly still a great deal to be done, the concepts implemented in MIDIFORTH constitute a true beginning and the first few steps in the direction of greater musical intelligence and power in the realm of computer-assisted composition. Whatever directions future systems may take, it is clear that the ideal is a sort of pattern and context recognition approaching the subtlety and sophistication of the

human mind. This, of course, brings us into the realm of artificial intelligence, and into contact with the long-standing debates regarding the feasibility of its objectives.

ACKNOWLEDGEMENTS

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