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D. PERFORMANCE RULES FOR COMPUTER CONTROLLED PERFORMANCE OF CONTEMPORARY KEYBOARD MUSIC

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Abstract

A computer program for synthesis of music performance, originally developed for traditional music using an analysis-by-synthesis strategy, is applied to contemporary piano music as well as to various computer generated random music. The program consists of rules that manipulate the durations and sound levels of the tones in a context-dependent way. When applying the rules to this music, the concepts of melodic charge and harmonic charge, which have been found useful for generating, e.g., crescendos and diminuendos in performance of traditional tonal music, is replaced by chromatic charge and used for similar performance purposes. The music is performed on a CASIO sampler controlled by a Macintosh 2 microcomputer. A listening panel of five experts on contemporary piano music or electro-acoustic music clearly preferred performances processed by the performance program to performances mechanically replicating the durations and sound levels nominally written in the music score.

Introduction

Music composed by algorithms and performed by computers sometimes sounds dull and lifeless, presumably depending on the absence of the many long- and short-term expressive variations normally produced by a human performer. While long-term events can be introduced in the performance in many ways, e.g., by means of hand movements recorded by various devices, well-controlled short-term events are more difficult to introduce. In this article, we will show that both long- and short-term rules developed for the performance of traditional, tonal music can be used also, with slight modifications, for improving the performance of contemporary, atonal music.

The starting point was a rule system which automatically converts a music score to the equivalent sound sequences (Sundberg & Frydén, 1984). It contains a number of performance rules, which, alone or in combination, have been found to improve the musical quality of the performance (Thompson, Friberg, Frydén, & Sundberg, 1986). Originally developed for one-voice melodies the rules have recently been modified so that also polyphonic music can be automatically performed (Sundberg, Friberg, & Frydén, 1987).

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The purpose of the present investigation was to explore the possibilities of using these performance rules in the novel framework of non-tonal music either written to be performed by musicians or generated and performed by computer. The presence of an underlying tonal harmony constituted a requirement for two of the rules. As in much contemporary music, harmony in the traditional sense is missing, these rules had to be reformulated. Thus, a modification of these rules was required.

It could be assumed that the rules would work better with music intended to be performed by musicians on traditional instruments, since the rules were developed for this kind of music. Computer music, by contrast, is often not intended to be performed in this way. Therefore, it was considered interesting to try the rules on both these types of music.

Rules

A group of five rules, all with contexts consisting of a few notes only, was selected from the performance rule system. In general, these rules were assumed to be the strongest candidates for this music. They operated on the amplitude and duration parameters and were, thus, directly applicable to piano performance. In addition, as a substitute for the rule reflecting harmonic progressions in traditional music, a new rule was formulated which worked with a LONGER CONTEXT.

A subset of eight rules was used in the experiment;

(1) The shorter the softer shortens the notes in proportion to their duration.

(2) Tempo increase in ascending melodic motion shortens notes occurring in a sequence of rising pitch intervals. The effect of the rule is to make the shortened notes sound as if they aim at the "target" note terminating the ascending motion.

(3) The shorter the shorter increases the contrast in duration by making short notes relatively shorter.

(4) Lengthening of shorter note at halved duration reduces the contrast in duration in cases when a short note is preceded by a note of twice its duration and followed by a longer note.

(5) Lengthening of extremely short notes adds duration to very short notes surrounded by longer notes, whereby the preceding note is shortened by the same amount.

(6) Chromatic-charge is an equivalent to the melodic and harmonic charge previously used for tonal music. Each note is assigned a charge value that is inversely proportional to the note's chromatic distance to the following note, if needed transposed to the same octave. Then, a mean value filtering with a window containing five notes is applied. The resulting average is then used for increasing the sound levels and durations of the notes. In this way, the rule generates crescendos and diminuendos.

(7) Micropauses in leaps insert very short silent intervals in melodic leaps. The duration of these micropauses is proportional to the width of the leap.

(8) Synchronization of voices applies in compositions containing more than one voice. The synchronization is achieved by either synchronizing all notes occurring on the first beat in each bar or, better, by devising a synchronization voice, constituted by the shortest notes which occurs, at each time, in the score (Sundberg & al, 1987). In addition, a threshold of 50 msec was applied for a note's minimum duration. The duration of a note must surpass a minimum duration in order to be perceptible. This rule is similar to certain duration rules used in speech synthesis (Carlson, Friberg, Frydén, Granström, & Sundberg, 1987). Also, an amplitude and duration normalization procedure was used keeping the average sound level and the total duration of the piece constant.

These rules were tested by the authors on various pieces of contemporary music. For reasons to be discussed later, the quantities by which the rules affected the performance had to be increased as compared to what normally applies to traditional music. The quantity of each rule was chosen depending, among other things, on the character of the piece. When the resulting performances seemed musically appropriate, a formal listening experiment was carried out, in which five subjects, all working professionally with this kind of music, were asked for their preference.

Listening experiment

As mentioned above, we used two different kinds of music; music composed for piano and computer-generated random music. Seven examples were selected (see Table I).

Random algorithms were used for composing the last four pieces in the Table. In the compositions with quantized durations, only three different durations were permitted. In the compositions with non-quantized durations, a total of 27 different durations were permitted and sequences of more than two notes of the same duration were not allowed.

Models for the composing algorithms were taken from a survey by Dodge & Jerse (1985).

P. Boulez: First eight measures of Piano sonata.
A. Webern: Third piano variation op 27
I. Xenakis: Extract from Herma.
WN+Q: White Noise frequency variation with +Quantized durations.
WN-Q: White Noise frequency variation with non-Quantized durations.
PN+Q: Pink Noise frequency variation with +Quantized durations.
PN-Q: Pink Noise frequency variation with non-Quantized durations.

Table I. Music excerpts selected for the listening experiment.

Three different setups for the quantity of each rule were used; one for the Webern piece, one for the pieces by Boulez and Xenakis, and one for the computer generated melodies. Most of the quantities of each rule were the same in all the rule setups. They were about two or four times their normal values previously used for traditional music. The largest difference between the setups occurred in rule 3 (the shorter, the shorter) for the Webern music, where the quantity was increased eight times as compared to the other setups.

The music examples were arranged in pairs on a digital test tape. In each pair, the same excerpt was played one time with and the other time without application of the rules. The order of pairs and the order within pairs were randomly selected. The task of the listeners was to select which performance they preferred in each pair. The subjects were asked to pay attention to the performance as a whole and to disregard single "bad" notes.

For the piano music examples, it seemed essential to use a realistic sound that was easily associated with a human performer, while for the non-piano examples, it appeared more logical to use a purely synthetic sound that was not associated with any conventional instrument. Therefore, the sound used for the first five excerpts was that of a sampled piano as produced by a Casio FZ1 sampler. For the last four examples, a purely synthetic sound on a Yamaha FB01 synthesizer was used.

The pair-wise comparison was preferred, as it was considered essential not to raise too high demands on the subjects; a test where the musical examples appeared in a totally random order and where the subjects assessed the musical quality of the performance would be more demanding.

The subjects were two professional pianists specialized on performance of contemporary music, and three composers of electro-acoustic music. They found the task fairly simple since, in most cases, they readily heard a difference between the two performances.

Results

PIANO SOUND	WITH RULES	WITHOUT RULES
Webern	4	1
Boulez	4	1
Xenakis	4	1
WN-Q	5	0
PN-Q	5	0
SYNTHESIZER SOUND		
WN-Q	5	0
PN-Q	4	1
WN+Q	5	0
PN+Q	5	0

Table II. The number of subjects preferring the versions played with or without application of the rules.

As can be seen from Table II, there is a clear preference for the rule-generated performances in all cases. The preference is slightly more evident for the random melodies. This is surprising in view of the fact that the rules were developed for music played on conventional instruments.

Discussion and Conclusions

The present investigation showed that performance rules developed for traditional tonal music improved the performance also of contemporary, atonal music. Only few rules could not be applied for various reasons. The revisions of the rules were small but probably important.

In atonal music, there are no chords in a traditional sense. As a consequence, the notions of melodic charge and harmonic charge become meaningless. In an early stage, we tried performances where the melodic and harmonic charges were simply omitted. These performances seemed to suffer from a lack of long-term events, and the music gave the impression of an aimless wandering. As soon as the chromatic charge was introduced, this disease was cured. We find it interesting that music performance seems to need events embracing, and thus marking, the formation of greater blocks.

In random generated music, wide leaps are very likely to occur, while long sequences of small melodic intervals are rare. In traditional music, on the other hand, melodic movements along the scale are frequent. The new rule that increased the sound level in sequences of small intervals may serve the purpose of marking emphasis, which would be appropriate; in all types of communication it seems important to emphasize the unexpected elements (Carlson & al., 1987).

Another modification required for this application of the rules was that the quantities needed adjustment, as mentioned above. Most of the rules had to be exaggerated in order to produce the desired effect. Also, in some cases the amount of a rule had to be altered between different pieces. The reason for this is not known. However, the following explanations seem likely.

First, we used merely six rules while the complete rule system now contains 14 main rules. When introducing a new rule in the system, we often observed that a reduction of the quantities of the existing rules is necessary in order to avoid exaggerated effects. A small number of rules would then entail the need of increasing the quantities of these rules.

Second, it is possible that contemporary music calls for a more overt marking of musical events than traditional music. For reasons of style, it would be more difficult to detect the musical structure in contemporary music than in traditional music. For example, it would be more difficult to predict the continuation of a series of tones. It is possible that this leads to a need for increased quantities of the rules.

One of the reasons why the rules had a better effect on the random melodies may be that the pieces composed by a human composer already contains more of the special interesting quality that performance may enhance. In any event, a deadpan performance of the humanly composed pieces seemed more acceptable than when the same type of performance was applied to the randomly composed pieces.

The present listening experiment was carried out with experts only, that is, composers and pianists. A possible question is to what extent the results hold true also for a typical audience at contemporary music concerts. Our assumption is that these two groups of listeners do not disagree to any greater extent; for example, it seems impossible that a successful pianist could maintain ideals not shared by his audience. The reason why we chose experts as listeners was to avoid the greater number of subjects.

In the experiment, we have shown that the rules improved the performance. On the other hand, our method does not allow us to conclude that our rules are optimal; for instance, we cannot exclude the possibility that a random distribution of expressive variations would not produce a comparable improvement of the performance. On the other hand, at an early stage during the development of the rules for marking chromatic charge, we tried to make crescendos where the average chromatic charge increased. The musical effect of this was unsatisfactory, however, and the opposite formulation of the rule was clearly preferable.

This speaks against the assumption that random distribution of crescendos is a musically possible alternative.

It is an interesting finding that the same rules were successful in contemporary music as in traditional music. This supports the assumption that these rules are not style dependent, but may work even for other types of music. This is not to say neither that no other rules are needed for improving the rule system, nor that there are no style-dependent rules. The fact that the rules worked also in contemporary music suggests that they can be assumed to introduce qualities to the performance that have a more general value. However, the underlying mechanism is not well understood. It is possible that the effects of the rules introduce sound patterns that allude to extra-musical frameworks of reference, leaning on the listeners' experience of speech, motion etc.

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