NEW TECHNIQUES FOR TEACHING MUSICAL INSTRUMENT PERFORMANCE

Martin Lamb
Structured Sound Synthesis Project
Computer Systems Research Group
University of Toronto
Toronto, Ontario
M5S 1A1

ABSTRACT

Computer graphics are used to provide visual feedback about two different aspects of keyboard performance: the accuracy of cross-rhythms and the independence of finger velocity. The system is centered around an LSI 11/02 microcomputer and uses a cheap, cursor-addressable text terminal for real-time visual feedback. A microprocessor-based organ keyboard linked (via the LSI 11/02) to a synthesizer provides real-time acoustic feedback about finger velocity. The system is designed to be used by musicians with little previous knowledge about computers.

Two skills often required of professional keyboard players are the ability to perform cross-rhythms and the ability to intentionally play simultaneously with one hand, two or more notes of different loudness. A cross-rhythm occurs when one hand plays a melody of n notes of equal duration while the other hand plays a melody of m notes of equal duration, where m and n are coprime. For example - playing 4 notes in one hand while playing 3 notes in the other.

A good pianist will need to play some notes louder than others, when playing contrapuntal music (i.e. music in which several tunes are happening at the same time), such as a Fugue by J.S. Bach. (In a Bach Fugue it is not uncommon for one hand to play 3 notes at a time, each note being part of a different tune.) This difference in loudness helps to bring into focus the tune that the performer wishes the audience to hear. One way of doing this is to have each finger descend with a different velocity - faster for notes with prominence, slower for notes of less importance.

Both of the above skills are acknowledged by musicians as being difficult to acquire. Part of this difficulty can be attributed to a rather intriguing phenomenon: music students tend to hear the sounds that they intend to produce, rather than what is actually played. This self delusion is an occupational hazard aptly described by Maazel (1980).

At present, the only available aids for overcoming the "wishful thinking" problem are the discerning teacher and the tape-recorder (or videotape recorder). It is impractical (and perhaps inhibiting) to have a teacher listen to one's practice. Unfortunately, recording devices do not always solve the problem, since the same bias may be present in the ear of the listener as when practising (the author has observed this with incredulity).

The use of graphics to provide feedback about aspects of performance, effectively clarifies any confusion about those aspects in the aural dimension. Lamb (1979) describes the use of such feedback for teaching keyboard skills such as trilling and articulation. However, Lamb's (1979) computerized teaching aid (see also Lamb, 1978, and Tucker et al., 1977) only provides feedback after the musician has played the music. By contrast, the aid presented here provides feedback during performance. In general, feedback about a skill is more effective the sooner it is received after the performance of the task (Fitts and Posner, 1967). By providing real-time feedback, the aid presented here also allows the performer to more quickly experiment with different strategies for acquiring cross-rhythm and finger-independence skills.

The feedback about cross-rhythms is provided as follows. The screen is divided in two - the upper half contains a "comb" with its "teeth" pointing downwards; the lower half contains a comb with its teeth pointing upwards. The upper comb contains equal-sized gaps, the number of gaps being the same as the number of notes in the right hand's rhythm pattern. Similarly the number of equal sized gaps in the lower comb is the same as the number of notes in the left hand's rhythm pattern. Because the combs are the same length, the relative positions (in time) of the notes in the cross-rhythm can be clearly seen. Figure 1 shows how the screen would appear for 3 notes in the right hand being played against 2 notes in the left hand. The vertical "teeth" of the combs represent the ideal positions in time of the notes. At the tip of each tooth is an arrow pointing to it, representing the actual position in time of that note. Thus, if a note occurs too soon in the cross-rhythm, its arrow will be displaced to the left by an amount proportional to the timing error. Figure 2 depicts the feedback about such an error.

The program starts by asking the user to type the numbers of notes in the right-hand and left-hand parts of the cross-rhythm (the maximum number of notes in any one part is seven - a constraint imposed by the resolution of the screen). The "combs" are then displayed on the screen (see Figure 1). Feedback starts after the user has played once through the cross-rhythm on the organ keyboard (the music is audible during the playing). Feedback continues as the user repeats the cross-rhythm over and over again, each hand playing one note (any note) at a time. The program automatically takes into account any changes in the overall speed. The sensitivity of the feedback is adjusted by stroking an Allison slider (Allison sliders are described in detail by Baecker, 1979).

Feedback is provided about finger velocity as follows. The organ keyboard (Fedorkow et al., 1980) is represented on the display as a row of sixty minus signs - one for each note. When a key is depressed, the corresponding minus sign is erased and redisplayed at a position directly beneath the initial position. The faster the key is depressed, the further down the screen the minus sign is displayed, and the louder the note is sounded by the synthesizer (Buxton et al., 1978).

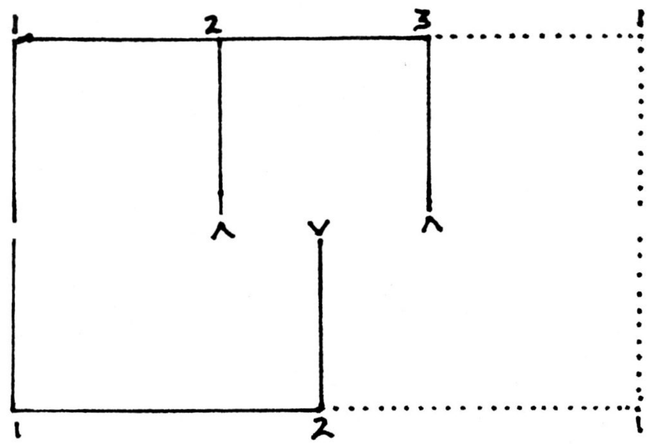

FIGURE 1 The screen display as the user is about to play 3 notes of equal duration with the right hand while playing 2 notes of equal duration with the left hand. Figure 2 shows what happens next.

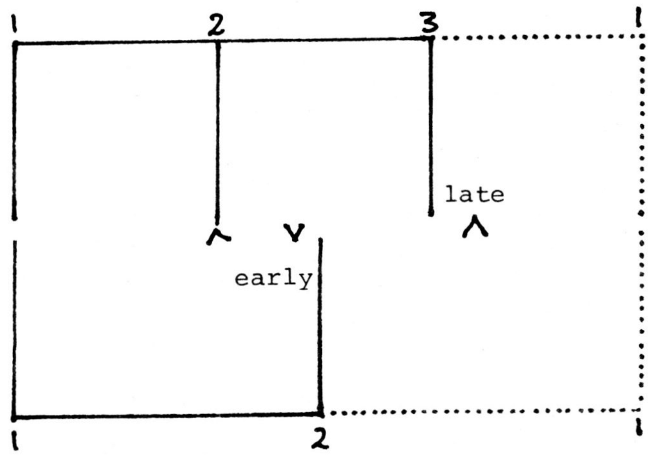

FIGURE 2 While playing a 3-against-2 cross-rhythm, the student sees from the positions of the arrows that the 2nd note of the group of 2 is being played too soon, and the 3rd note of the group of 3 is being played too late. (The words "early" and "late" have been added to the figure.)

This is how the screen looks when two notes (one quiet and one loud) are being played:

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           -
     (quiet)

                         -
                   (loud)
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(The words have been added, and not all the 60 minus signs are shown here, because of space.) The range of the loudness response of the synthesizer is adjusted by stroking an Allison slider (see Baecker, 1979). The greater the loudness range of the synthesizer the more audible is any variation in key velocity i.e. a series of notes with uneven key velocities will sound most uneven. In this way, the acoustic feed-back exaggerates irregularities in the player's touch.

By "magnifying" the errors in tasks which require fine adjustments, both of the above programs can increase the precision of a musician's performance (cf. Helson, 1964).

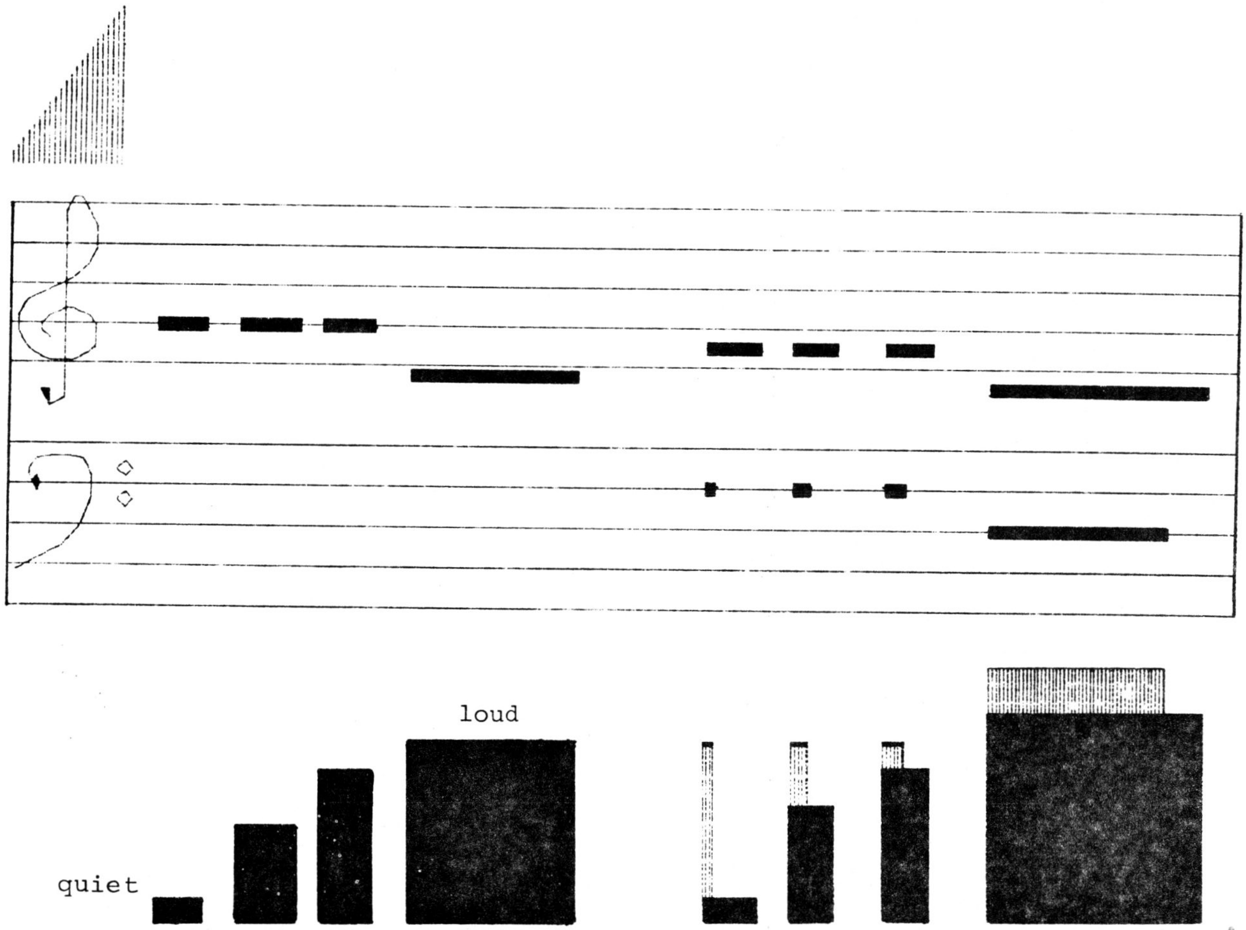

FIGURE 3 The MOD notation for the start of the theme from Beethoven's Fifth Symphony is displayed on the colour screen, immediately after being played on the computer's organ keyboard. The height of the block beneath a note indicates its loudness. When more than one note is played at once, the shorter blocks (displayed here in solid black beneath the music) are displayed in the foreground. (As explained in the text, each note and its block beneath have the same colour, coded according to the key velocity. Above the clefs, the colours are displayed in order of increasing "loudness", as a memory aid.)

In order to compare the relative loudness of successive notes, music which is performed on the keyboard is then displayed on a screen. This colour screen is attached to an adjacent PDP 11/45 computer which is connected to the LSI 11/02. The notes are displayed in a modern notation (called MOD, for short) and are coloured according to key-velocity. In this notation (see Figure 3), each note is represented by a block whose length is directly proportional to the duration of the performed note. Pitch is indicated by position on the staves. Typed commands may also be used to cause the music to be played back slowly. This has the effect of "magnifying" details of rhythm in the musician's performance. Lamb (1979) documents the use of (monochrome) MOD notation together with slowed-down playback, for improving the articulation, synchronization and rhythm of piano students.

The addition of colour to MOD notation allows one to "see" the loudness of notes. However, since only 16 colours are available, only a qualitative estimate of key velocity is obtained from the notation. For a quantitative indication of key velocity, a block of the same colour and length as the performed note is displayed vertically below it on the screen. The height of the block encodes key velocity, with blocks of lesser height being displayed in the foreground (see Figure 3). This display allows the musician to see what was performed, while hearing it played back by the programs.

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