Computer Games for Developing Musical Skills

by

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ABSTRACT

Four programs which bring much of the excitement and motivation of computer games to Computer Assisted Instruction are presented. The games focus on different aspects of musical creativity and are intended to develop the musical skills that are latent in every individual.

In one game, musical concepts are modeled graphically in ways that encourage the player to explore melodic shape and transformations such as transposition, augmentation, diminution, retrograde, and inversion. Other games investigate timbre, form and orchestration, enlivened by auditory feedback and interactive animation. The user interface is simple enough for children to use, and powerful enough for composers to work with. The four games, when linked together, represent a powerful and novel use of the computer in music education.
A new addiction is affecting today's children - computer games. In video arcades and on home computers, pliable minds concentrate on shooting down space invaders, or bouncing balls about the screen. Can some of this addiction be channelled to better use, for improving the child's education perhaps?

This paper presents four computer games which are designed to teach children aspects of music while they play. The four games combine techniques of graphical animation with sound effects (ingredients common to all arcade games) to present concepts relating to musical form, timbre, and orchestration. In the most complex game, the player experiments with pitch and melodic shape, and with transformations such as transposition, augmentation, diminution, retrograde and inversion. Each game focuses on a different aspect of music. When linked together, the four games collectively form a powerful compositional tool.

The users for whom these games are intended are children aged at least 5 who have had little or no formal musical training. Because Payent et al. (1975) reported that some children experienced frustration when using LOGO due to their inability to type fluently, we do not use any typing in our games. Communication between child and computer is mostly by means of gestures, via a graphics tablet.

The games can be regarded as a form of "Alice in Wonderland" in which the player (Alice) changes focus (by nibbling biscuits labelled "eat me") to view the world from a larger or smaller perspective. For example, in the game "MUSIC JUJUZ" the player manipulates musical phrases or fragments to form a well-known tune. By changing focus to zoom in on a specific phrase, the phrase appears to grow and fill the entire screen. The player finds herself in the game "MUSIC-TIMBRES" in which melodic shapes are manipulated to form musical fragments or phrases. Further explorations lead to the game "TIMEKI-PAINTING" in which the child orchestrates music using preset timbres. By changing focus to zoom in on a specific timbre, the graphical display of that timbre appears to grow and fill the entire screen. The player then finds herself in the game "SOUND FACTORY" in which sine waves are combined, and an envelope is manipulated so as to produce different timbres.

When "shrinking" back to the preceding game, the newly treated timbre or musical fragment replaces every instance of the old one (that was focussed on). By successively shrinking and growing between games, the child can explore different aspects of music (and compose). The games are linked as follows.
Before describing each game in detail, mention should be made of our pictorial representation of music. Lemberger (1974 and 1975) has found that children do not all perceive rhythm in the same way. Some children focus on the starts of notes, others on the note-durations. The music notation that we have developed, attempts to reconcile these differences by representing each note as a triangle whose vertical position (on the stave) represents pitch, and whose length is proportional to the duration of the note. In this way the visual focus of a note—the left hand end—corresponds to the auditory impact of the note—the "ictus". The thickness of the triangle corresponds to the loudness of a note, and colour is used to encode its timbre. The ease with which children take to this notation is indicated by the author's experiences with a similar notation when teaching keyboard skills to young piano students (cf. Lamb, 1979; see also Lamb, 1976).

MUSIC BOXES

In this game, the player assembles musical fragments into a complete piece of music (e.g. a well-known tune—in figure 1 the target tune is "Twinkle Twinkle Little Star"). The screen is divided into a command list, a menu of musical fragments, and a work area (see figure 1). The work area is initially empty, beneath each musical fragment is the command "PLAY". The game begins with the player pointing to one of these PLAY commands. This causes the adjacent musical fragment to be played on a synthesizer (cf. Lupton et al, 1975). By pointing to, and pressing, a button on the cursor puck after positioning the cursor (i.e. movable crosshairs on the display) over a command or target on the screen (this technique is fully explained in Lupton, 1976).

After listening to each of the fragments in the above manner, the player is prompted to point to any one of the fragments. Doing so causes the selected fragment to float up to the top left corner of the work area. Pointing to other fragments causes them to float upwards in the same manner, coming to rest to the right of the previous fragment selected (see figure 1). Pointing to the command "PLAY" at the right of the screen, causes the fragments in the work area to be played one after the other, from left to right as displayed.

The "composition" in the work area may be edited as follows: To delete a fragment, the player points to it and shakes the cursor puck in the air. This causes the fragment to spin wildly as it shrinks to nothing. To move a group of boxes (i.e. fragments) to
the right, the user points to the leftmost bar to be moved and
pitches the cursor to the right. (Similarly, boxes may be shunted
to the left.) To pick up a fragment, the player points to it
and moves the cursor puck towards him, whereupon the fragment
moves about the screen following the motions of the cursor puck.
To put it down, the player merely points to where it should be
placed.

In the above manner, the player experiments with different
sequences of fragments. The musical effect of each experimenta-
tion may be heard as often as desired.

MUSIC DOODLES

To start, the student points to the word DRAW, which causes a
quill to appear on the screen. The student then sketches a curve
with the quill, whereupon the programs play music whose shape
matches that of the drawn curve. While the music is being
played, a seated figure is shown listening between loudspeakers.
Next, the curve crystallizes into the music, which is
represented by triangular noteheads on the staff.

At this juncture, the player may add another melodic shape (by
pointing to DRAW and continuing in the manner just described), or
start over again (by pointing to CLEAR), or hear the music again
(by pointing to PLAY). Alternatively, the user may exit from the
game or alter music from an adjacent organ keyboard, by respec-
tively pointed to the light-buttons EXIT or PIANO. The complete
range of possibilities is indicated by the light-buttons shown in
Figure 5 (by light-button we mean a displayed word that
activates a process when pointed to; the term 'point' refers to
the act of positioning the cursor over the target and pressing
the forward button on the cursor puck, as mentioned above). Fig-
ure 5 illustrates a doolie being linked by the player.

If TRASPAN is pointed at, the quill reappears for the child to
circle a group of notes. The selected notes then float about on
the screen, moving wherever the cursor is pushed (see the hollow
triangles in Figure 4). At this point the fun intensifies: by
strokling two Allison sliders, the floating notes are made to
stretch or shrink in a horizontal or vertical direction (Allison
sliders are described in detail by Iaecker, 1979). Stroking the
left slider towards the player causes the curve traced out by the
notes to gradually flatten to a line, and then bend again in mir-
ror image. When they reach the exact inversion of the original
notes, the hollow triangles are displayed more brightly. Stroki-
ing the right slider towards the player causes the hollow trian-
gles to move horizontally closer together while maintaining their
relative proportions. More stroking gradually makes them line up
with their left edges aligned vertically, and then they move pro-
portionally further apart, in mirror image. When the notes
become the retrograde of the originals, the triangles are
displayed more brightly. Examples of such transformations are
displayed in Figure 4. Although the continuous process of
stroking and squeezing cannot be depicted here.
At any time during the transformations the user can hear
the transformed notes. This is done simply by pressing the red button on the cur-
sor puck. When this happens, the floating triangles freeze on the
screen and the listening figure appears (see Figure 4) while
the notes are played at the pitch they are floating at on the
stave. To mix the floating notes into the score, the user simply
points to the place in the music where they are to go. After
being pixel in, the notes continue to float about until the user
either 'throws them away' by lifting the cursor puck off the
graphic tablet, or else pushes them off the edge of the screen,
whereupon they disappear and the light-buttons reappear.

Throwing away the floating notes (by lifting the puck) also
causes the notes originally selected to disappear. This allows
notes to be moved or deleted. When drawing with a quill, the
user is assumed to have finished when nothing further has been
drawn for two seconds, after which the programs proceed to play
the curve or float the contracted notes. The player can always
undo anything (by pointing to UNDO) or preserve the existing
music (by pointing to SAVE), and retrieve it later (by pointing
to RESTORE).

Two features make the user interface unusual: no typing is
required, and all the commands are complete in themselves (i.e.
no extra information needs to be specified when issuing a com-
mand). The use of such commands has two benefits: it is impossi-
ble to enter an incomplete command, and there is no confusion
about the position of any operand within a command (for a
thorough discussion of interface design see Martin, 1972).

**TIMBRE - PAINTING**

In this game, a musical score is orchestrated. Two screens are
used: one for loudness, the other for timbre. A graphics tablet
and Allison sliders are manipulated by the player. A high-
resolution monochrome display depicts the six available timbres
positioned around the music to be orchestrated. Figure 5 shows
how each timbre is symbolically represented in two parts. The
lower part depicts the amplitude envelope. The adjacent upper
part comprises the amplitude histogram of its overtones. An
adjacent 256x256 pixel colour screen shows the same picture as
the monochrome display but with each timbre replaced by a
coloured paint pot. Six different colours are used - one for
each timbre. On the colour display, the music is initially
displayed in white on a black background, with triangular shapes
being replaced (due to resolution) by rectangles of the same
length.

To orchestrate a group of notes with a particular timbre, the
player first points to the corresponding paint pot on the colour
screen. This causes a paintbrush of the same colour as the pot
to appear on the screen (in place of the cursor). Whichever
notes the player now points to are coloured the same colour as
the paintbrush (which moves about on the screen following the
movements of the cursor puck). To hear the result, the player
points to the command PLAY. Painting with a particular timbre continues until another paint pot is pointed to (whereupon painting resumes in the new pot's colour) or the command BACK is pointed to, when the latter occurs, a large arrow is displayed directing the player to the adjacent semitone terminal.

To change the loudness of a note or group of notes, a curve is drawn enclosing the desired note(s) on the monochrome display. Holes selected in this way are redrawn as hollow triangles. They then increase or decrease in thickness (i.e., loudness) depending on the direction in which the user is stroking the slider. The left slider gradually makes all the selected notes louder (or all of them softer) while maintaining their loudness relative to each other. The right slider sets the notes to all have the same loudness whose magnitude is specified by the stroking (see Figure 5). To hear the effect of these adjustments, the user points to the command PLAY, whereupon the entire score is played. If the rear button on the cursor puck is pressed, only the selected notes are auditioned.

In the above ways the user "paints" music with tone colours: and can adjust the loudness of the notes to highlight parts of the music.

**Sound Factory**

In this game the player manipulates the overtone and the envelope of a single-pitched sound, to try and imitate a familiar sound e.g., a whistle. Initially, only the fundamental is heard, at a constant loudness. To add an overtone, the player points to its harmonic number (in the middle of the screen) and moves the cursor horizontally to the right. This causes a bar to grow out of the box, following the motion of the cursor (see Figure 6). The length of the bar represents loudness. Particularly motivating is the fact that the timbre changes instantaneously as the player adjusts the length (i.e., strength) of each harmonic.

The pitch of the fundamental is displayed on a scale at the left of the screen (see Figure 6). To change it the player simply points to the note and then to the desired new pitch (see Figure 7). The volume is displayed on a graphical potentiometer in the upper left corner of the screen (see Figure 6). To change it, the player points to the displayed knob and slides it up or down to the desired loudness (see Figure 7). The above changes all happen to the sound while they occur on the screen. It's rather like magic.

The note's amplitude envelope (e.g., the attack and decay) may be altered as follows: The player points to the loudness contour displayed in the rectangle in the lower part of the screen (see Figure 6). This causes the sound to be heard in pulses, each pulse having the envelope displayed in the rectangle. The envelope is changed by dragging parts of the loudness contour about (see Figure 7). (By 'dragging' we mean continuous pointing to a point on the curve while moving the cursor puck). Dragging
is animated in such a way that only what makes sense is displayed. I.e. the player loses grip on the envelope when attempting to drag the curve past the edge of the rectangle, or to make a leftward kink.

In the above ways the player explores attributes of timbre, listening all the while.

**THE JAMES COMBINED**

The figures collectively depict a "grand tour" through all of the games described above. In Figure 1, the player points to EXIT FINE and then to the bottom left musical fragment, which expands to fill the screen (Figure 2). The player edits this fragment in Figures 3 and 4, transferring next to the game "TIMBER PAINTING" via the EXIT light button. The edited fragment is orchestrated and its loudnesses adjusted in Figure 5. Pointing to the top middle timbre (in Figure 5) causes it to expand and fill the right side of the screen (Figure 6). The player then changes the timbre in Figure 7. Pointing to EXIT in Figure 7 causes the right side of the screen to shrink and become the top middle timbre (again) in Figure 8. All the notes that were formerly orchestrated with the old timbre (shown in Figures 5 and 6) are now orchestrated with the new timbre shown in Figure 7. Pointing to EXIT in Figure 8 allows the player to transfer first to MUSIC DOODLES, and then to MUSIC BOXES. This causes the musical fragment shown in Figure 7 to shrink and become the bottom left box (again) in Figure 8. Notice that all previous instances of this box (see Figure 1) are now replaced by the edited and orchestrated version of the original fragment.

In the four games outlined above, a player explores or composes music by means of gestures, in an entertaining and educational manner. Prior musical training is NOT a prerequisite. Yet their performance is being received favourably by children and the physically handicapped. It is likely that educational games of this nature will influence the shape of future musical pedagogy.
ACKNOWLEDGMENTS

The author is indebted to W. Buxton and K.C. Smith for many stimulating discussions, and to L. Gonder and P. Osterbridge for their programming. This research is being undertaken as part of the Structured Sound Synthesis Project (SSSP) at the University of Toronto. The financial support of the Social Sciences and Humanities Research Council of Canada and the National Science and Engineering Research Council of Canada is gratefully acknowledged.

REFERENCES


Figure 1  MUSIC BOXES: The player points to boxes 1, 2, 1 and 3 at the bottom of the screen which replicate and "float" to the top of the screen. When REDEFINE and the bottom left box are pointed to, that box expands to fill the whole screen, as shown in Figure 2.
Figure 2  MUSIC DOODLES: By pointing to TRANSFORM, and circling the first four notes, they can be copied and transformed as shown in Figure 3.
Figure 3  MUSIC DOODLES: The player draws a doodle on the staves using a displayed quill (indicated with an arrow). These doodles "crystallize" into music (shown in Figure 4) which is played by the programs.
Figure 4  MUSIC DOODLES: After circling a group of notes to be transformed, the player shifts them to the top of the stave and listens to them in retrograde. The selected notes are displayed as hollow triangles. While they are being auditioned, a seated figure appears between loudspeakers.
Figure 5  TIMBRE PAINTING: The player orchestrates a score from a "palette" of six timbres. Each timbre is depicted as a pair of polygons, the upper one containing an overtone histogram (explained in the text), the lower containing the amplitude envelope. By stroking transducers, the player can change the loudness of notes (as indicated by the thickness of the arrowed triangles).
Figure 6  SOUND FACTORY: The second top timbre of Figure 5 has expanded to fill the right side of the screen. Here the sawtooth waveform (displayed) comprises the even numbered harmonics whose amplitudes are indicated by the lengths of the horizontal bars adjacent to the harmonic numbers.
Figure 7  SOUND FACTOR; The player is adjusting the timbre whose attributes were displayed in Figure 6. As the harmonic content is changed and the pitch is altered (by pointing to the appropriate parts of the display as explained in the text) the sound changes immediately to reflect the changes in the visual display. Similarly, the player changes the envelope by pointing to it and pulling it around, while listening to the effect.
Figure 8 TIMBRE PAINTING: After pointing to EXIT in Figure 7, the timbre displayed there shrinks to become the second top timbre above. All notes that were previously orchestrated with the old timbre at this position (see Figure 5) are now orchestrated with the new timbre.
Figure 9  MUSIC BOXES: While returning from the TIMBRE-PAINTING game via the MUSIC DOODLES game the player watches the music shown in Figure 9, shrink to occupy the bottom left box. Notice that all previous instances of this box (arrowed) are replaced by this newly composed, freshly orchestrated musical fragment.