MOVIES FROM MUSIC:
VISUALIZING MUSICAL COMPOSITIONS

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ABSTRACT
A theory of music visualization proposed by Nancy Herman postulates an association between colors and pitches of musical scales. A color raster graphics display is used to generate images of notes, chords, and chord progressions based on this theory. Temporal adjacency of notes or chords is mapped to spatial adjacency of colors, usually in a concentric pattern of squares or circles. By varying certain image parameters, different "brush stroke" effects may be obtained. Illustrations of several computer generated "musical paintings" are included, along with some original paintings for comparison.

INTRODUCTION
Since time immemorial, music and colors have individually enchanted people in their own special ways. Feeling that a color composition which was linked in some basic way to music could have an emotional effect, Nancy Herman evolved a painting style linking musical notes to colors. Many well known musical compositions were painted, each opportunity to examine visual relationships between musical tones, chords, rhythms, and time. The other goal is to visually compare works of several well known composers. To imagine mapping music into visual space, the various characteristics of sound must be considered. We shall discuss the presentation of pitch and time, and specifically omit other parameters such as intensity, attack, and timbre since they have not yet been fully investigated.

The primary tenet in Nancy Herman's artistic theory (strongly influenced by Josef Albers [1]) is that the spectral colors can be related to each other in the same way as musical tones: the value of the color (relative amount of white [2,6]) varying in the same way as the pitch of the musical tone. In each octave of twelve tones there are twelve colors (blue, blue-violet, violet, red-violet, red, red-orange, orange, yellow-orange, yellow, yellow-green, green, and blue-green) forming a cycle. Thus middle C is related to high C as, say, "middle" (value) blue is related to "high" (value) blue. It is important to note that there is no implicit claim of emotional association of blue with C (in fact any other association would be possible); rather the octave relationships of the twelve-tone scale are mapped onto the cycle of twelve colors. For each octave the basic colors are whitened or darkened to evoke the same note.

The other fundamental notion is the translation of the sequential presentation of musical tones over time to a stationary, spatially-adjacent configuration in the painting. Since the tones before and after a particular note or chord are the only ones which "touch" it, areas of color representing those tones should touch only where the respective tones do. The geometry is further defined by assuming that the viewer's gaze will initially fix on the center of a symmetrical pattern. Starting at the center with the first note or chord, successive notes or chords appear as concentric areas in a basic shape (usually squares or circles). As the gaze is drawn outward from the center, each note or chord totally surrounds the previous one.

Practical limitations in the size of a canvas preclude large musical compositions, so the temporal dimension may also be used in itself. The result is a sequence of paintings in time or,
since we began to use computer graphics, an animation in real-time synchronized to the music. In the next section we shall describe the implementation of this theory with the goal of producing such animations.

GRAPHIC IMPLEMENTATION

A color raster display is used to create "musical paintings" by computer according to the above theory. Certain limitations are imposed by this device, such as the resolution of the display (240 x 320 on our RAMTEK GX1008), and the available colors (from the 4096 possible). Another difference from actual paintings occurred with conversion of pigment color to electronic color. Finally, the order of graphical creation of the painting was varied for greater efficiency, even though it departed from the strict musical order. We shall discuss the graphical processes involved in translating this theory to computer graphics by examining pitch color selection, image format, line appearance, chord representation, and chord progression display.

Colors to represent the 24 pitches in a two octave range were (laboriously) selected to match the original pigment colors using a color selection program [3]. Once obtained, these colors were used throughout the examples illustrated here. The colors may be seen in Figures 1 and 2: Figure 1 is an actual painting of a major scale of eight pitches beginning with blue-violet in the center and progressing to a lighter (higher) blue-violet; Figure 2 is a computer generated major scale based on red-orange progressing from light (high) to dark (low).

The organization of the scales illustrates a square format for the painting. Other formats are possible. For example, actual paintings have been executed in a rectangular format (Figure 3). In the graphic implementation a rectangular format is possible (Figure 4) but less pleasing than a square format (Figure 5). Ultimately, a circular format (Figure 6) became the most flexible geometry. Part of the motivation for this decision came from the choice of radial sectors for the notes, so that the sectors maintained the same width along the entire circumference of the circle.

The appearance of Figures 4 and 5 varies in the way lines are drawn as well as the format. In Figure 4 lines are drawn one by one in a clockwise fashion, thus the center tends to "fill up" with raster points. In Figure 5, however, each line is erased prior to being drawn and no such filling can occur. Both techniques have been useful and are therefore under control of the artist. By changing the angle between successive radial lines, different textures are obtained: Figures 6, 7, and 8 show the result of increasing the separation.

Displaying a single note yields an image similar to Figure 6, 7, or 8. To draw chords the separate colors of the notes in the chord are repeated in narrow radial sectors around the circle. Figures 9 and 10 each show a two note chord. (By electronic serendipity, Figure 10 contains white -- a color not in the chord -- because it was displayed by passing the RGB video signal through an RGB-to-composite converter.)

Given a sequence of consecutive chords (a chord progression), each is displayed in concentric rings about the center. Figures 11 through 16 show various chord progressions which may be compared to an actual painting of "Frere Jacques" by Nancy Herman. Display resolution effectively limits the number of chords in one image, so either short sequences appear in one picture or a number of progressions are linked together as an animation.

THE "PAINTING" PROGRAM

The FORTRAN program which creates the computer display in circular format requires the following information:

1. Number of chords or notes (as for a melody).
2. Number of notes for each chord.
3. Notes in the chord.
4. Length of radius (to outer boundary) of each chord.
5. Number of lines in each color sector.
6. Angle of separation between adjacent lines.

The notes themselves are coded as numeric values although a simple translator could be written. The first three items should be self-explanatory. The last three produce different effects which were alluded to in the preceding section.

The length of the chord radius defines the duration of the chord relative to the succeeding chord. Since present program draws the chords outside in (Contrary to their actual temporal order), the next chord erases that part of the preceding chord which it overlaps. The width of the band for each chord is therefore implicitly defined by the difference in radii of each chord in the progression (Figures 10 through 27). When there is a "rest" in the music, it must still be specified and appears as a gap (Figures 20 through 27). This progression consists of 11 chords from Gershwin's "Our love is here to stay." (Figure 27).

The number of lines in each color segment affects the thickness of the sector devoted to each color. In general, the more lines, the wider the sector. The appearance is also affected by the angle of separation between adjacent lines (Figures 6, 7, and 8). With the other parameters constant, varying the angle results in either a "brush stroke" effect for larger values (Figures 11 and 13), or a solid color effect for smaller values (Figures 12 and 14). The final image may utilize different values for each chord since the appearance is also dependent on the radius: the larger the radius, the more pronounced the line separation for any given angle. In Figure 11 the outermost chord uses a separation angle of 1.0 degree, and the innermost 2.5 degrees; while in Figure 12 the outermost uses 0.5 degree and the innermost 1.0 degree.
FUTURE EXTENSIONS

There are unlimited possibilities for extending these experiments in the visualization of music. Among the most feasible are:

- more efficient animation of a sequence of musical progressions -- the present hand editing of video images is quite tedious.
- visualization of other musical variables such as intensity, attack, and timbre -- for example, intensity might be related to the width of a sector.
- improved interactive input, utilizing an interactive program and command parser.

As synchronization with music is desirable for animation, it would be exciting to bypass the note and chord input and transcribe the actual audio signal. This is a non-trivial task and is unlikely to be available to us for some time [4, 5]. Finally, we might propose the composition of music based on visual or temporal relationships between colors, inverting the mapping process and experiencing the painting in an audible performance.

REFERENCES

PHOTOGRAPHIC REPRODUCTIONS OF "MUSICAL PAINTINGS"

Figure 1
Scale of Blue Violet
(paint on canvas) moving up the scale, each color becoming progressively lighter as your eye moves from center outward.

Figure 2
Scale of Red Orange
(computer version) moving down the scale, each color becoming progressively darker as your eye moves from center outward.

In the case of the two scales above, each "note-color" is of equal importance. One color touches the color preceding it and the one following it and no other, as in music.

Figure 3
Gregorian Chant
This chant is an example of two "voices" or two color progressions interacting with each other. The colors are vibrating within the same set of relationships as the tones of the music which they represent. In this visualization we see the whole piece of music at once.
Format Choices

Figure 4
Rectangular format

Figure 5
Example of square format. Width of segments gradually increased clockwise to determine optimum width.

Figure 6
Figure 7
Figure 8
The pattern in each of these 3 images has been varied by specifying a different angle of deviation between each line. This was done to arrive at the most attractive format. This is an example of a one note display.
Two "note chord"

Another two note chord

Brush-stroke effect

Solid color effect

Chord progression from Rachmaninoff's "Piano Concerto No. 2"

Chord progression from Mussorgsky's "Pictures at an Exhibition"
Figure 15
A chord progression from Beethoven's "Minuet in G".

Figure 16
A chord progression from Rogers and Hammerstein's "Some Enchanted Evening".

Figure 17
A round "Frere Jacques" painted by Nancy Herman.
Various stages of the computer's "drawing" of the first line of Gershwin's "Our Love is Here to Stay"

Figure 18  Figure 19  Figure 20

Figure 21  Figure 22  Figure 23

Figure 24  Figure 25  Figure 26

Figure 27

The completed "painting"