

Some perspectives in the artistic rendering of music scores

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ABSTRACT

Inspired by contemporary arts, we strive to apply visual techniques and concepts to the rendering of acousmatic and electroacoustic music scores over new and old media. In fact, the changed role of the score in music offers the opportunity for considering it as an object of art in itself, since it can and should be shared with and be enjoyed by the audience, while maintaining its usefulness to the composer, as well as to the eventual instrumentalists. In particular, we consider lenticular media for the rendering of multiple parts scores or even of three dimensional scores. Furthermore, we consider techniques related to the perception of color contrast for the rendering of simple geometric objects, such as lines and curves, with artistic nuances. The main point brought about by this paper is a reflection on how visual art styles and graphic design can be bent to represent structural elements of the score while keeping their meaning alive and making their look pleasant.

1. INTRODUCTION

Optional in music that is to be completely performed by the computer, the disappearing graphic music score is still very valuable to the composer and to the conductor in all phases of production and performance and to the audience as a visual experience associated to the listening of the piece. Moreover, the score becomes essential when other instrumentalists join the performance and have to synchronize with the electronic music tracks.

In content and form, the very concept of score has been revolutionized by the introduction of new and somewhat arbitrary symbols or icons devised for the notation to cope with the extended means of sound control, production and performance. The visual rendering of the score is also revolutionized by the new media employed for its delivery, which also allow for animation and interaction with gestures, in which case each performer can actively contribute to modify or write the score while performing. The visual score cannot possibly capture all the details of the piece that are in the form of parameters and selection of synthesis algorithms, or of the sonic contents, which would require high-resolution magnitude and phase spectrograms. In this

context it serves more as an iconographic representation of the master plan.

Deeply influenced by the extended panorama of music events and soundscapes it has to represent, by the new media for its rendering and by the dynamicity offered by the interaction, the music score escapes from the black and white standard notation form for conductor and performers use only, to which has been relegated for many years, and becomes extremely public and open to the audience. It returns to a form of expressive art, which had been at its very origins, as it can be traced, for western music, back to the illustrative art of Gregorian chants of 9th century. The function of the score extends from the essential descriptive one to that of the public image of the piece, as an additional entertaining and distinguishing role, the captivating symbol of the piece, alongside with other forms of music and sound visualization.

This process is by no means new or very recent. Within the second half of last century, composers such as Edgar Varèse, Karlheinz Stockhausen, Erhard Karkoschka, Anestis Logothetis, Iannis Xenakis, Cornelius Cardew, John Cage and György Ligeti, to name a few, have been introducing personalized graphic notation for the new compositional needs and for organizing an otherwise overwhelming mass of sound objects available for electroacoustic music [1].

The graphics itself inspired or has been deliberately used to drive composition [2], up to the point where automatic translation of graphics to music has been conceived, e.g. in the UPIC system, [3]. Of course, the path of music being inspired by paintings, e.g. *Pictures at an Exhibition* by M. P. Mussorgsky, or of paintings inspired by music or containing music structures, e.g. *Fugue in Red* by P. Klee or the work of P. Mondrian, had already been beaten. However, the automatic, rule based, translation of drawings to music found a more essential role in electroacoustic composition. Recent perspectives can be found, e.g., in [4], in the experimental works of the S.L.Á.T.U.R. collective [5], in [6] and in the contributions by several other artists there is no room to cite here.

While all attempts to introduce a new standard for electroacoustic music notation failed [7, 8, 9], the path to artistic rendering of generalized music scores is wide open. Indeed, it was the joint venture of a composer and a technician talented in visual arts that led to the most celebrated example of music score art, which certainly is Rainer Wehinger's rendering of the score of György Ligeti's piece *Artikulation* [10]. A movie of the piece and scores together

can be watched here [11].

In this paper we attempt to reverse the process by drawing inspiration from the work of visual artists or from graphic design concepts and by employing these techniques and means of expression in the artistic rendering of scores. We show how elements of the score can be rendered using different media and styles captured from artwork. Of course, this paper can only bring about a few examples. Our hope is that these will contribute to open a wider discussion and stimulate further work on the interrelation and mutual inspiration of music and graphic composition, with the full awareness that this is neither the first nor the last discussion on the subject.

In Section 2 we consider the category of lenticular media as a support for the score, allowing for multiple views or three dimensional views of the score. In Section 3, drawing from the work of visual artists, we explore the use of graphic techniques based on perceptual illusions deriving from color contrast for the rendering of score lines. In Section 4 we draw our conclusions. Matlab code for some of the examples can be found in the Appendix (Section 5).

The images contained in this paper are most likely printed in gray scale, which hinders the appreciation of the color effects contained in them. However, the original color images should be made available in the online version of the paper.

2. LENTICULAR MEDIA

Our journey starts with the exploration of new and old media that fall in the category of *lenticular*: lenticular painting, printing and display. While the term lenticular strictly denotes the use of special lenses placed over an image to selectively display content, the adjective has been used in a broader sense to denote supports that allow for displaying different images according to the observation angle or even three dimensional views of a single scene.

In this sense, the first use of lenticular techniques in painting can be traced to the work of Gaspar Antoine de Bois-Clair (1654-1704), with his double portraits of members of the danish royal family. These were realized by painting slices of two different portraits over the two visible sides of vertically aligned bars of triangular section. He also realized a similar effect by placing interlaced strips of two pictures behind aligned thin vertical bars. Depending on the point of view (left-right), the vertical bars introduced obstacles to the sight of one or the other image, which he employed to create animation effects. The same principle is used in some of today's 3D stereoscopic video displays that do not require wearing special lenses in order to perceive depth.

Lenticular painting is emerging as a form of street art [12, 13], where fences or corrugated surfaces are painted interlacing two scenes, the sight of which depends on the direction of travel. Triple images can be rendered by painting on a grid of tetrahedrons and so forth.

In order to experiment with the use of lenticular methods in the rendering of scores we built the simple panel *Robot Head* shown in Fig. 1. This panel does not display a true score but it serves as a mock-up model to show how the

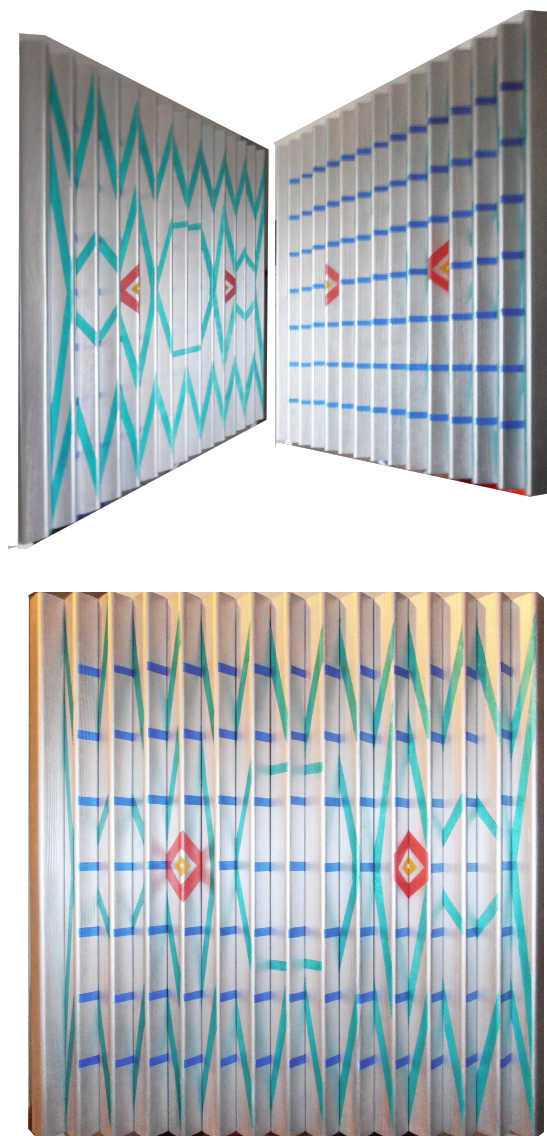


Figure 1. *Robot Head*: experimental painted lenticular panel demonstrating the display of two different parts visible by lateral observers, with the central view displaying the complete score.

score of two different voices can be accessed by looking at the panel from the right and from the left (top portion of the figure), respectively, while the central view is meant for the conductor and / or the audience to access the score of the ensemble. Since the strips of the two images appear at different depths, a three dimensional effect is also associated to each view. In the central view the two voices become already separated in perspective; color coding can be employed to enhance separation.

An alternative means for the display of the score of two voices consists of painting over two sides of a set of bars that are vertically mounted leaving gaps in between them, as shown in the example of Fig. 2. In this example the central view offers no information; painting on the front thin sides of the bars would generally disturb the lateral views. Thus, the score is visible from each side only. The



Figure 2. *Waves*: alternative means for double point of view (left-right) for the visual representation of sound objects (right hand view only displayed in the picture).

distance between the bars induces an enhanced three dimensional perceptual illusion when painted objects of the score span over a few bars, as visible in the waves, each painted on two adjacent bars. A mirror placed in the back of the structure can make the nearly central views more interesting or informative.

While lenticular painting can certainly produce good looking pieces of art, its use for the rendering of scores can be impractical for production and transportation. Current technology allows for lenticular printing, in which a set of images are sliced and combined into a single image that is either directly printed in the back of a diffraction pane or preprinted on any support and coated with a thin film acting as a diffraction grating lens. The first commercial use of lenticular printing, patented by the Vari-View company, has been in the production of flip images, often included as gadgets in products, and in the design of various advertisement panels. Using the same principle and only depending on which images are interlaced, lenticular printing is widely used today to produce 3D posters and postcards.

Lenticular printing allows for a faster and more compact alternative for the rendering of multiple part scores, which can include as many as 20 different voices printed in an equal number of frames that become individually visible at different observation angles. Alternatively, the 3D capability of the medium allows for spatial arrangement of the parts along three axes: pitch, time and voice, for example, but other less conventional spaces can be used. The score can be properly viewed without wearing special glasses. Proper view only occurs at specific sweet spots; from other points of view the arrangement looks scrambled.

Lenticular displays, essentially built by coating a normal display with a lenticular transparent foil, allow for the dynamic simultaneous display of more images that are each accessible at a different angle of observation. In that,

lenticular displays are useful for the visualization of score portions and parts synchronized with the playing of the piece. Alternatively, they can produce dynamic 3D images of the portions of the score, where again the different parts can be arranged according to the visual depth.

3. STYLES BASED ON THE PERCEPTION OF COLOR CONTRAST

In this section we explore effects linked to color perception for the artistic rendering of scores. In particular, we consider perceptual illusions generated by the contrast and closeness of complementary colors. These effects, which are easily generated by means of computer graphics, have the nice property of making simple monochromatic sets of lines look very interesting as if painted with several color nuances. This effect has been notably exploited by visual artists, one of the leading figures of this movement being Carlos Cruz-Diez.

The impressive work of this artist born in Venezuela in 1923, consists in unconventional use of color in painting or printing, as well as in the placement of colored physical objects. His work includes artistic interventions in public spaces such as pedestrian crossings, walls, airports, industrial buildings, universities and buses. His painted or printed work can be described as formed by arrays of lines interfering with each other producing various color effects [14]. These effects represent a clever variant of chromatic induction. His work can be browsed at the web site of his Foundation [15]. Part of his work belongs to the permanent collections of museums throughout the world, such as the MoMA in New York, the Tate Modern in London and the Centre Pompidou in Paris.

The effect of chromatic induction was first studied by Celeste McCollough [16]. By first stimulating the eyes for a few minutes with an image consisting of regularly spaced black lines over a colored background and then presenting a test image composed of black lines with same orientation as in the stimulus image but on white background, a perceptual illusion is experienced, where the white background now looks as if colored in a complementary tint than the one in the background of the stimulus image. Actually McCollough used a simultaneous stimulus consisting of two images placed side-to-side, formed by vertical and horizontal lines on differently colored backgrounds, respectively, and the same for the test images with white background, but the effect can be observed even with a single orientation and color stimulus. While there is no complete consensus and evidence on the origin of this effect, McCollough's conjecture that "edge-detector mechanisms in the visual system are subject to color adaptation, responding with decreased sensitivity to those wavelengths with which they have recently been most strongly stimulated" appears to be the most accredited one.

The challenge brought about by Carlos Cruz-Diez's artistic work is that chromatic induction is there observed without prior presentation of stimuli. In other words, the construction of line patterns appear to simultaneously producing stimulus and test images in the very same image.

Of course, in simple patterns, color may appear to change

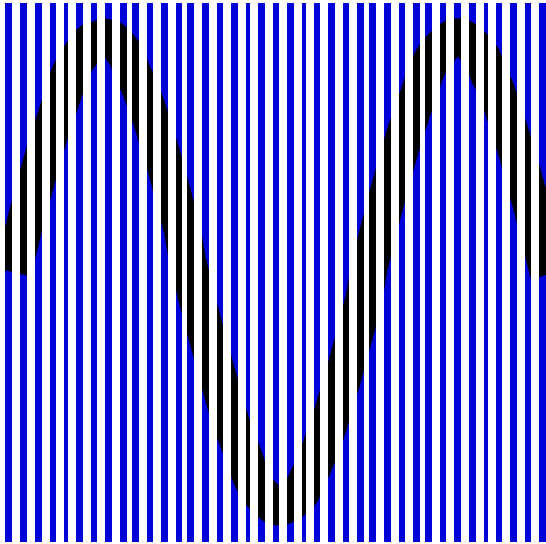


Figure 3. *Chromatic induction:* simple example of a sinusoid drawn in black over the blue lines only of a background of regularly spaced lines of alternating colors (blue and white). When looked at proper distance the sinusoid appears as if drawn in yellow over the white lines.

based on the surrounding colors. Things become quite involved when dealing with complex patterns. The undeniable observation is that a spatial variation of line patterns, which can be as subtle as a small difference in the spatial frequency of repetition or as abrupt as meeting a regular pattern of lines at a small angle, is susceptible to induce color. We must therefore conjecture that the perceptual edge-detector mechanisms adapt to patterns whether temporally or spatially presented so that suppression of the regular components occurs, thus enhancing the detection of relative variations. In a way, this is similar to the perception of sound when one listens to two sinusoids of very close frequencies: we tend to suppress the sinusoids so that the beating of the two frequencies is the most prominent characteristic we hear.

A simple example of chromatic induction is shown in Fig. 3, where we generated a regular background consisting of blue and white lines. Over the blue lines only, we plotted a sinusoid in black color. When looked at proper distance, which we estimate it to be 1000 times larger than the thickness of the lines in the regular pattern, the sinusoid appears as painted in yellow, which is the color complementary to blue. Any shape drawn in black over the blue lines will give the same result and of course one can replace blue with any other color that is not black or very dark, with the illusory sinusoid to appear in the complementary color.

In the next example shown in Fig. 4, we drew sets of black lines over a regular background composed of alternating lines of three colors: orange, blue and green. The background is visible in the top and bottom parts of the picture; one can consider this as the color basis for producing other hues by chromatic induction. The horizontal black lines are slightly more spaced than those of the background, i.e. they have lower spatial frequency. Therefore, spatially, the black lines mask varying proportions of the

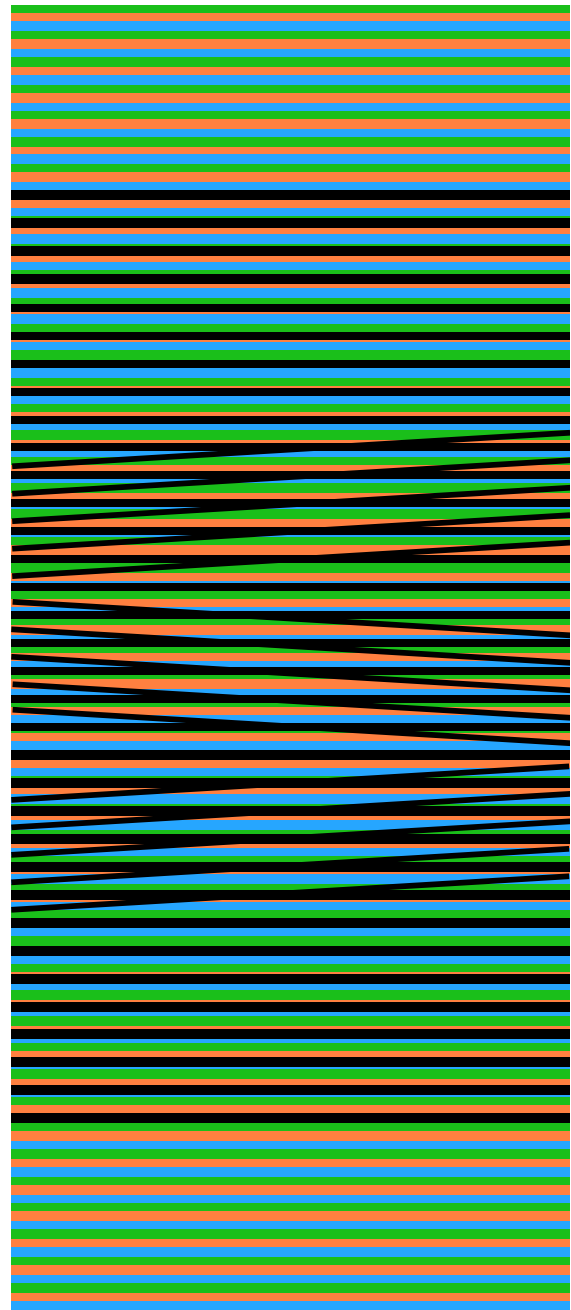


Figure 4. *Chromatic induction:* simple example of a set of black lines over a background of regularly spaced lines of alternating colors (orange, blue and green) inducing various chromatic effects.

colors in the background lines. However, due to the illusory perception of the color complementary to the locally masked one, the colors appear in altered hues and generally more saturated than the blend of the unmasked colors. In the same picture we also drew sets of lines slightly tilted with respect to the background, which also create similar effects of chromatic induction.

The overall geometry is not confined to lines and rectangles. In the example in Fig. 5 we obtained a circle of chromatic induction. In the same figure we used a slightly different color basis, visible in the middle and at the external edge of the circle. This can be useful in order to

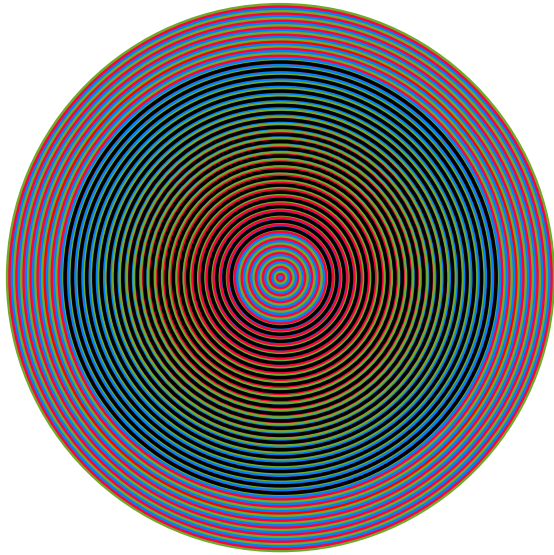


Figure 5. *Chromatic induction: A circular example.*

build scores on different shapes and / or to add particular symbols based on induction.

We produced our examples using simple Matlab scripts and graphic editor. The script reported in the Appendix (Section 5.1) builds the background color basis and horizontal lines. An app for experimenting with chromatic induction is also available [17].

3.1 Chromatic induction in scores

In this section we explore the rendering of electroacoustic music scores using chromatic induction effects as well as arbitrary symbols in an integrated graphic design.

A horizontal arrangement of the lines appears to be more convenient for the production of scores using this technique. We also remark that the chromatic induction effect is relative: spatial variation of the background induces chromatic effects similar to the spatial variation of the foreground curves. This is shown in the example in Fig. 6, where the background consists of aligned sinusoidal curves in three colors, while the foreground black lines are aligned with the mean value of one every three sinusoid. Thus, while the horizontal black lines provide a reference for pitch, the regularly spatially varying background produces chromatic effects that convey a sense of time measure in the score.

Glissandi and other melodic lines can be represented by curves or lines superimposed to the supporting structure of the score. These will interfere with the color texture and produce additional chromatic induction effects. Other elements of the score require suitable symbols or icons.

In order to demonstrate the use of chromatic induction in music scores we produced an example in which we merge the chromatic induction supporting structure with other structural elements *à la Ligeti-Wehinger*, shown in Fig. 7. Special symbols are used to denote isolated events and sonic bands. In order to produce a single figure we jammed many symbols together, which in a real score are likely to be distributed over different sheets.

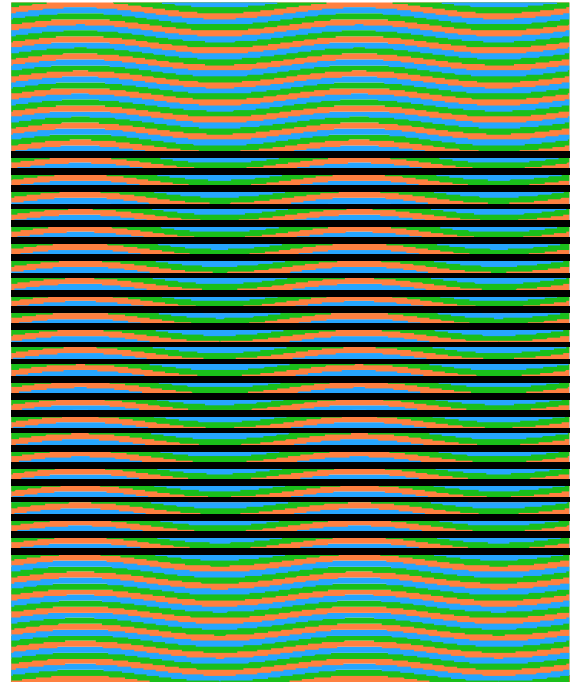


Figure 6. *Relative chromatic induction: the effect is induced by a spatially varying background rather than by a misaligned foreground.*

In our opinion, the visual effect is very satisfying and bound to catch the attention of the audience in performances, installations and editorial work, printed or online. At same time, it is not so difficult to generate scores with this method. In fact, the procedure can even be automated. The technique is quite flexible so that each score can be differently styled by changing, in the first place, the color basis used for the background, as well as the geometric structure of the background itself. Moreover, the symbols used may vary according to taste and compositional needs.

Color contrast based techniques can also be combined with lenticular painting to create color effects that change according to the angle of observation, a path deeply explored by the artists. Thus, scores produced with this technique can be lenticularly printed or displayed, the latter offering the multiple parts synchronization with music capability.

In order to have a glance at a lenticular projection of the score in our example, we simulated the effect in Matlab with the script reported in the Appendix (Section 5.2). First we arbitrarily split the score into two parts. Then we built a corrugated surface with triangular ridges. We interlaced the images of the two parts and we adapted the combined image to the corrugated surface. Although we lost much of the graphic resolution in the process of rendering in 2D a 3D object, the effect of the two-part score projection can still be appreciated in Fig. 8, where the three views – left, right and center – were obtained by moving the virtual camera view in the 3D Matlab plot.

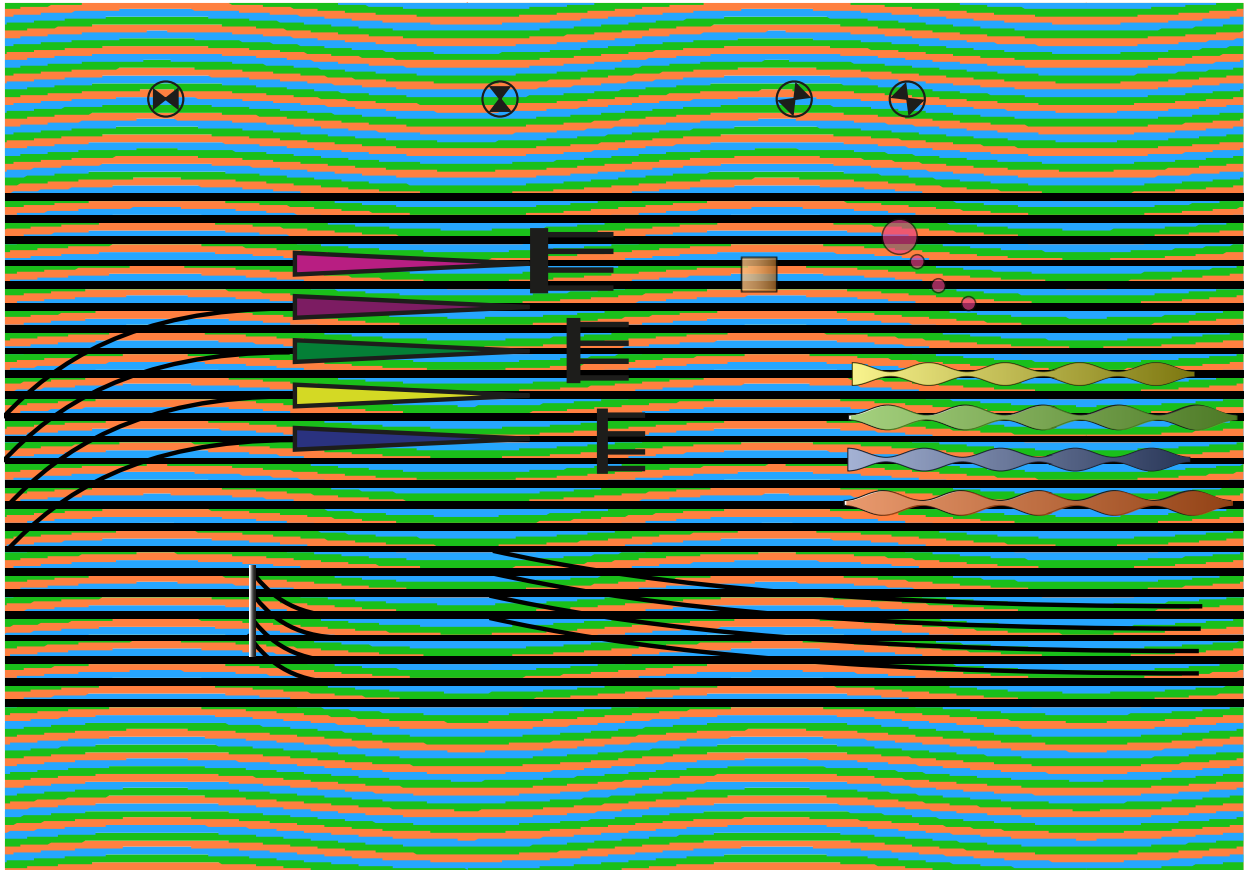


Figure 7. An example of electroacoustic music score rendered with chromatic induction effects and structural symbols.

4. CONCLUSIONS

In this paper we have explored a few representation techniques suitable for the design and display of electroacoustic music scores. While by no means exhaustive, our research drew from the work of contemporary visual artists and adapted some of the most relevant techniques and methods for the rendering of structural elements of the score.

In particular, new and old lenticular media were introduced for the representation of multiple parts in the score, where the different voices can be accessed by looking from different angles, while the central view can display all the parts together.

Furthermore, color contrast perceptual effects of chromatic induction type can be fruitfully exploited in order to represent the structural elements of the score in an aesthetically pleasant way, which is of great relevance when the score is offered to the audience as part of the performance.

5. APPENDIX: SAMPLE MATLAB CODE

5.1 Sample code to generate the score background

```
%color basis
blue=[.15 .65 1]; red=[1 .5 .25];
grn=[.1 .75 .1]; black=[0 0 0];
% number of colored lines groups
Nbargroups=39;
% total number of colored groups of
```

```
%bars
Nbars=3*Nbargroups;
% number of black bars as proportion
% of colored groups
Nblkbars=fix(2*Nbargroups/3);
% compute initial vertical coordinate
% for black bars
pntblk=fix(3*(Nbargroups-Nblkbars)/2);
% choose spacing of black bars
%(=3 same as colored groups)
perblk=3;
x=Nbars/4*[-1:.001:1];
A=1; %modulation amplitude;
% form closed contour for the patch
y=[A+1 A*sin(2*pi*x*4/Nbars) A+1];
x=[-Nbars/4 x Nbars/4];
% draw colored bars
for k=-3*ceil(A):3:Nbars+3*ceil(A)-1
    patch(x,y+k,blue,'EdgeColor','none');
    patch(x,y+k+1,red,'EdgeColor','none');
    patch(x,y+k+2,grn,'EdgeColor','none');
end
% draw black bars
for k=pntblk:perblk:Nbars-pntblk
    pos=[-Nbars/4 k Nbars/2 1];
    rectangle('Position',pos,'FaceColor',
```

```

    black, 'EdgeColor', 'none');
end
hold on
axis([-Nbars/4 +Nbars/4 -A Nbars])
set(gca, 'visible', 'off')

```

5.2 Sample Matlab code for lenticular projection

```

R=12; % number of ridges
imagleft=imread(image_filename_left);
imagrightright=imread(image_filename_right);
colorsc=256; % 8 bits per color
[ML,NL,CL]=size(imagleft);
[MR,NR,CR]=size(imagrightright);
N=min([NL,NR]); M=min([ML,MR]);
D=floor(N/R);
K=2*D; % points per ridge profile
N=K*R; % columns of output image
% set X and Z normalized coordinates
% in [-1 , +1]
X=ones(M,N); X=2*X*diag(1:N)/N-1;
Z=ones(M,N); Z=2*diag(1:M)*Z/M-1;
% build ridge profile
oneridge=[0:K/2 (K/2-1:-1:1)]*2/K/R;
prof=zeros(N,1);
% periodize profile
for k=1:K
    prof(k:K:end)=oneridge(k);
end
Y=-ones(M,N)*diag(prof);
h=surf(X,Y,Z,'EdgeColor','none');
pnt=0; opnt=0;
imagedata=zeros(M,N,CL);
% interlacing
for r=1:R
    for m=1:CL
        imagedata(1:M,opnt+1:opnt+D,m) =
            imagleft(:,pnt+1:pnt+D,m);
        imagedata(1:M,opnt+D+1:opnt+K,m) =
            imagrightright(:,pnt+1:pnt+D,m);
    end
    pnt=pnt+D; opnt=opnt+K;
end
% adapt interlaced image to ridge
% profile
set(h,'CData',imagedata(end:-1:1,:,:)
    / colorsc, 'FaceColor','texturemap')
axis([-1 1 -1 0 -1 1]);
set(gca,'Projection','perspective')
set(gca,'Visible','off')
cv=[0 -5 1]; % central view
rv=[2 -3 0]; % right view
lv=[-2 -3 0]; % left view
view(cv); % quasi central view
% otherwise use view(rv) or view(lv)

```

Acknowledgments

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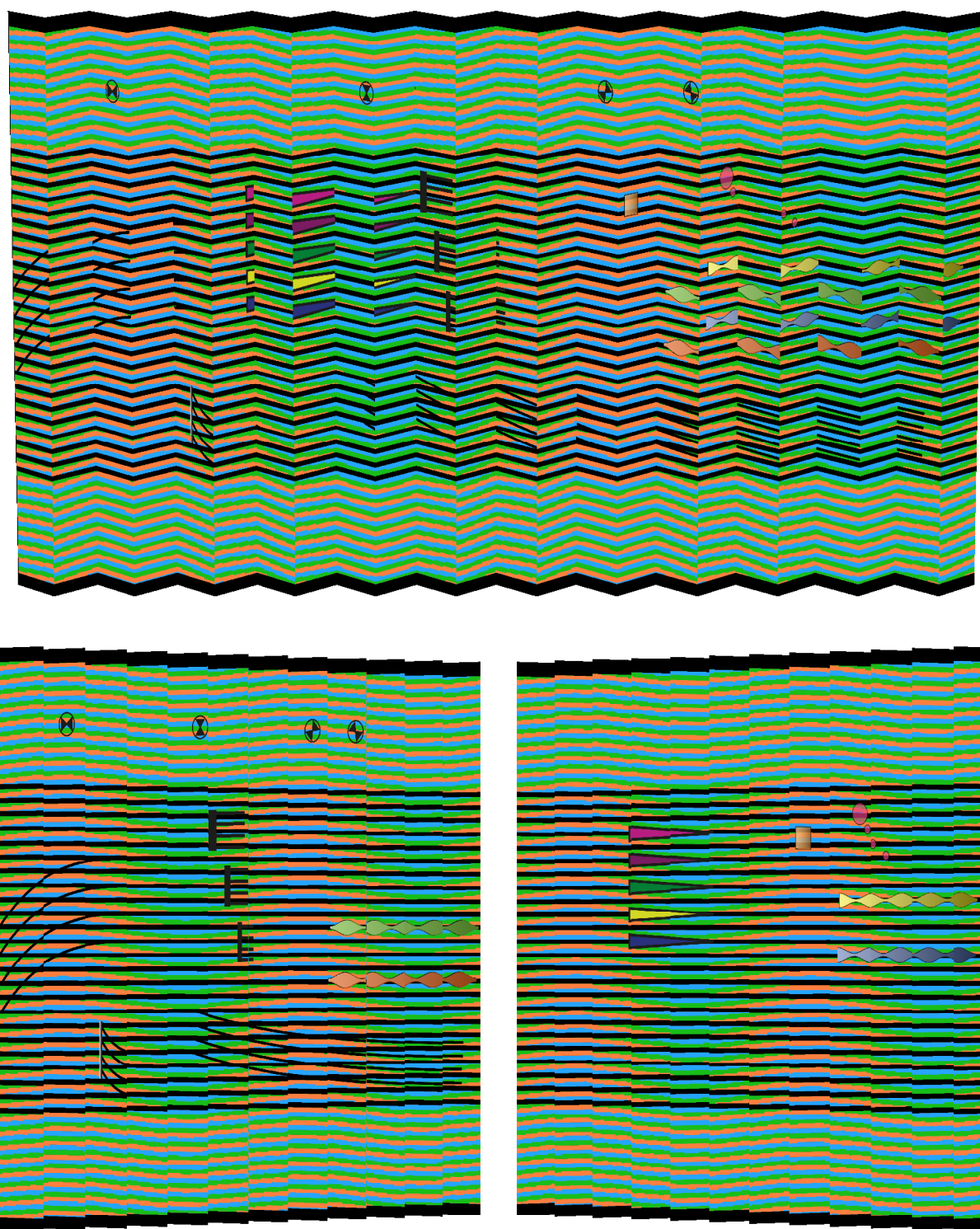


Figure 8. Views of a two parts version of our sample score, adapted to lenticular surface. Top: the central view. Bottom: left and right views showing the two separated parts of the score.